Conceptual Simplification:

an Empirical Investigation of a New Method for Analysis, Learning and Memorisation of Post-Tonal Piano Music

(Volume I)

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ABSTRACT

There is a gap in music performance, education and psychology in terms of memorisation training for post-tonal piano music. Despite the repertoire spanning over 100 years, pedagogues and professionals still lack effective tools for developing this skill. Existing research on this domain is mostly focused on observing practitioners' behaviours during practice, to understand how these prepare for a memorised performance of a selected repertoire. However, the resulting Performance Cue Theory that emerges from these studies does not provide a systematic method to assist learning, but instead, explains performers' behaviours to fulfil the given task. Furthermore, other important aspects of memorisation, such as the role of sleep for memory consolidation; influential parameters of performance practice, such as the abilities of perfect pitch and sight-reading; or the role of emotions have rarely been examined or simply omitted.

This thesis focuses on testing, extending and formalising a new method for analysis, learning and memorisation of post-tonal piano music, named Conceptual Simplification. This presents a novel implementation to musical memorisation of group theory, number theory and geometry; and the paradigms of divide-and-conquer, decrease-and-conquer and transform-and-conquer. Therefore, it builds on mathematics and computer science to improve human memory and musical performance. However, as demonstrated with this thesis, Conceptual Simplification does not require any previous scientific training to be successfully implemented and works for different learning styles and types of complexity.

From testing the parameters of perfect pitch, synaesthesia, sight-reading, emotions, sleep, mental practice, complexity and expertise; the most influential parameters for memorisation identified are perfect pitch, sight-reading, sleep and complexity. Additionally, a formal definition for complexity is formulated. Similarly, after testing different practice and performance strategies, the most effective strategies for memorisation identified are simplifying strategies and conceptual encoding strategies, included in Conceptual Simplification. Finally, it is also revealed the positive role of mental practice

for coping with performance anxiety and self-sabotage. Throughout this thesis, Conceptual Simplification is tested through a series of studies with practitioners, who range from conservatoire piano students to international performers, including observation and analysis of the author's own performing practice. The repertoire featured involves existing post-tonal and commissioned works.

Although the scope of this thesis is limited to testing Conceptual Simplification for post-tonal piano music, this method could be adapted to other instrumentalists, singers and conductors; and musical genres. More ambitious applications might involve non-musical domains, since Conceptual Simplification essentially scaffolds complexity, proceeding in a non-linear manner and avoiding time-consuming procedures. The method also presents enough flexibility for other practitioners to incorporate additional strategies, adapting it to their needs accordingly. Finally, Conceptual Simplification also indicates promising additional benefits. Concretely, in preventing performance anxiety through greater confidence and reducing the potential for injuries that usually result from repeated practice. Conceptual Simplification's systematic approach toward engaging conceptual memory and reasoning leads to more confident memorised performances, while needing less repetition during practice.

Contents

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Glossary

Chunking: The process of partitioning and grouping information into meaningful units.[1]

Encoding: The first process that undertakes memory formation, through the acquisition of knowledge. This consists in converting information into meaningful code, preferably according to the relevant expertise of the individual or pre-existing knowledge already stored in long-term memory.[2]

Performance Cue Theory: Theoretical framework that studies the role of memory cues in music performance, focusing on the different features of a memory, including its basic perceptual and conceptual components, that a practitioner attends to during practice. Also, how these evolve with learning and memorisation, and which of these remain relevant for monitoring performance. These cues are related to specific locations in the piece, allowing musicians to access them from memory at any given point.[3]

Self-referencing: Feature of a musical excerpt or piece that involves resemblant material, based on a single theme that keeps being cited in its original state or slightly varied. This lack of distinctiveness in the content can be understood as a sequential appearance of switches, taking to an extreme the challenge that the latter pose for performance and memory.

[1] Baddeley et al. (2020: 223-229), Chase and Simon (1973a; 1973b), Ericsson et al. (2017), Gobet (2005; 2015), Gobet et al. (2001), Miller (1956).
[2] Baddeley et al. (2020: 9), Robertson (2009).
[3] Some of the most relevant studies on performance cues are Chaffin and Lisboa (2008), Chaffin et al. (2002; 2009; 2010; 2021), Chen (2015), Chueke and Chaffin (2016), Ginsborg and Chaffin (2011a), Ginsborg et al. (2006a; 2006b), Lisboa et al. (2015).

Switches: A set of turning points in a musical work placed in locations that present certain similarities or self-referencing, but that resolve differently.[4] Switches can either happen within equivalent structural sections,[5] or within a section involving many variations of a motif.[6] Since musical material around switches is similar, their content is likely to be triggered by the same cue,[7] retrieving the wrong resolution and placing the performer in a different location of the musical work.[8]

4 Chaffin and Imreh (1997a: 325-326), Chaffin et al. (2002: 95-97).
5 e.g., Chaffin and Imreh (1997a: 325-326), Soares (2015: 122-123; 138).
6 e.g., Farré Rozada (2018: 35-37), Fonte (2020: 155-156), Soares (2015: 127-128).
7 Baddeley et al. (2020: 288).
8 Chaffin et al. (2002: 206).

List of Figures

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

List of Examples

Chapter 3

Chapter 4

Chapter 5

Chapter 6

List of Tables

Chapter 4

Chapter 5

Chapter 6

Chapter 7

Chapter 1: Introduction

1.1 Why Research Memorisation?

More than a century ago, Hungarian pianist and pedagogue Sándor Kovács warned that 'prodigious amounts of time and energy are wasted in attempting to memorise', it being of 'the utmost importance' to find 'useful procedures' (Kovács, 1916).[1] However, still today, Western classical musicians struggle with memorisation.[2] This is particularly true for pianists, due to both hands having similar functions and there being a remarkable amount of information to memorise.[3] Despite musical memory being extensively researched,[4] especially for pianists,[5] there is still a gap in music performance, education and psychology in terms of how memorisation should be trained,[6] particularly for post-tonal piano music.[7] Here, the term *post-tonal* identifies compositions not completely fitting a tonal framework, comprising two distinct categories: *non-tonal*, for music containing tonal elements; and *atonal*, for music without traces of tonality.[8] Hence, for a repertoire that spans over 100 years,[9] pedagogues and practitioners still lack effective tools for developing memorisation.[10]

[1] Cited in Rubin-Rabson (1937: 9).

[2] Aiello and Williamon (2004), Chaffin et al. (2002: 26-65), Fonte (2020: 77-117), Fonte et al. (2022), Ginsborg (2002; 2004).

[3] Chaffin and Imreh (1997a: 315-316), Münte et al. (2002: 473), Rubin-Rabson (1937: 5), Wulf and Shea (2002).

[4] e.g., Allen (2013), Cash (2009), Cash et al. (2014), Chaffin et al. (2002), Chaffin and Logan (2006), Duke and Davis (2006), Duke et al. (2009), Ginsborg (2017), Ginsborg et al. (2012), Mishra (2010), Mishra and Backlin (2007), Mishra and Fast (2015), Rubin-Rabson (1937), Simmons (2012), van Hedger et al. (2015), Williamon and Egner (2004), Williamon and Valentine (2002), Wilson (1983).

[5] e.g., Chaffin (2007), Chaffin and Imreh (1994; 1997a; 2001), Chaffin and Logan (2006), Chaffin et al. (2002; 2003; 2013), Chen (2015), Chueke and Chaffin (2016), Fonte (2020), Lisboa et al. (2013a; 2013b; 2015; 2018), Miklaszewski (1989), Noice et al. (2008), Soares (2015), Tsintzou and Theodorakis (2008).

[6] Ginsborg (2004), Jónasson and Lisboa (2016), Mishra (2005; 2010), Soares (2015: 11).

[7] Chen (2015), Chueke and Chaffin (2016), Fonte (2020), Ginsborg (2004), Li (2007), Mishra (2010), Soares (2015), Tsintzou and Theodorakis (2008).

[8] This is a complex area with undefined edges and requires a more thorough discussion, which is beyond the scope of this PhD. Therefore, in this thesis, "post-tonal" refers to repertoire that is post-conventional, identifying two main trends: non-tonal, when presenting some traces of tonality; and atonal, when no references to tonality are available.

[9] Auner (2017), Bunger (1973), Chiantore ([2001] 2007), Nonken (2014), Thomas (1999).

[10] Fonte (2020), Fonte et al. (2022), Ginsborg (2004), Mishra (2010), Soares (2015).

Memorisation is expected from some instrumentalists,[11] especially pianists, both during their education and at a professional level.[12] However, this area is not specifically trained at conservatoires,[13] partly because research findings are rarely implemented in educational institutions.[14] Consequently, memorisation is still a taboo that performers, including world-class professionals, struggle with,[15] being one of the main triggers of performance anxiety.[16] This leaves practitioners to develop their own memorisation procedures,[17] which are not always efficient timewise or effective under the pressure of a public performance.[18] Consequently, post-tonal music is mostly performed from the score, since standard memorisation strategies for tonal music are not always applicable.[19] Furthermore, post-tonal composers' writing principles vary, not necessarily matching those of their peers.[20]

Existing literature on memorisation strategies mostly focuses on tonal music,[21] and research on post-tonal piano music did not provide memorisation methods for this repertoire, beyond exploring its challenges and indicating general guidelines.[22] Therefore, further research is

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[11] In this thesis I refer to *memorisation* as the result of committing a musical work to a certain degree of detail to memory, allowing one to perform it fluently by heart without any assistance.
[12] Fonte et al. (2022), Ginsborg (2004), Hamilton (2008), Jónasson and Lisboa (2016), Soares (2015: 11).
[13] Ginsborg (2004), Jónasson and Lisboa (2016), Mishra (2005; 2010), Soares (2015: 11).
[14] Chen (2015), Fonte et al. (2022), Ginsborg (2004), Jónasson and Lisboa (2016), Li (2007), Mishra (2010), Soares (2015: 11).
[15] Aiello and Williamon (2004), Chaffin et al. (2002: 26-65), Fonte (2020: 77-117), Fonte et al. (2022), Ginsborg (2002).
[16] Chaffin et al. (2002: 26-65; 2008: 361), Ginsborg (2004: 123), Hallam (1997: 93).
[17] Chen (2015), Ginsborg (2002; 2004), Hallam (1995a; 1995b; 1997), Li (2007), Soares (2015: 11).
[18] Chaffin (2007), Chaffin and Imreh (1997a: 333), Chaffin et al. (2002: 116-119; 2010: 6), Fonte (2020: 118-308), Miklaszewski (1995), Mishra (2002), Nielsen (1999a), Nuki (1984), Tsintzou and Theodorakis (2008: 9), Williamon and Valentine (2002: 28).
[19] Aiello (2000), Aiello and Williamon (2004), Fonte et al. (2022), Gordon (2006), Hamilton (2008: 80), Noyle (1987), Nuki (1984), Oura and Hatano (1988), Sloboda et al. (1985).
[20] Aiello (2000), Auner (2017), Fonte (2020), Fonte et al. (2022), Noyle (1987: 84), Soares (2015), Thomas (1999).
[21] e.g., Allen (2013), Chaffin and Imreh (1994; 1997a; 1997b; 2001; 2002), Chaffin and Lisboa (2008), Chaffin and Logan (2006), Chaffin et al. (2002; 2003; 2004; 2006; 2008; 2009; 2010), Duke and Davis (2006), Ginsborg (2004), Gruson (1988), Hallam (1995a; 1995b; 1997; 2001), Lisboa et al. (2004; 2009a; 2009b; 2011; 2013b; 2015; 2018), Miklaszewski (1989; 1995), Mishra (2002; 2004; 2005; 2007; 2010; 2011), Rubin-Rabson (1937; 1939; 1940a; 1940b; 1941a; 1941b; 1941c; 1941d; 1947), Simmons and Duke (2006), van Hedger et al. (2015), Williamon and Valentine (2002).
[22] Chaffin (2007), Chaffin et al. (2021), Chueke and Chaffin (2016), Fonte (2020), Fonte et al. (2022), Ginsborg and Chaffin (2009; 2011a; 2011b), Ginsborg et al. (2012; 2013), Jónasson and Lisboa (2015; 2016), Jónasson et al. (2022), Mishra and Fast (2015), Ockelford (2011), Soares (2015), Thomas (1999), Tsintzou and Theodorakis (2008).

needed, to provide effective tools for practitioners interested in performing this repertoire from memory.[23] This doctoral research pursued this goal.

Memorisation is intrinsic to the performance of music. Performing a musical work in public requires a high level of internalisation, which is progressively acquired with learning, until the music is fully memorised.[24] Completing this thorough process is required for a successful performance, regardless of whether the music is performed from memory or from the score.[25] However, for certain repertoire, this memorisation process can be extremely difficult or not always effective under a stressful situation.[26] This thesis does not enter the debate of whether it is better to perform from memory or from the score: there are multiple reasons for choosing one option or the other, conditioned by the context and conditions of the performance. Nonetheless, for pianists, it is generally expected to perform from memory.[27] Moreover, while performing post-tonal piano music from memory is not usually required at auditions and competitions, the resulting impact of a memorised performance of such a repertoire can certainly make a difference in highly competitive environments.[28] Finally, in my own experience as a concert pianist, the same benefits of performing tonal music from memory also apply to memorised performances of the post-tonal repertoire. Some of these reasons can be a greater sense of freedom and expression, a deeper involvement and focus on the performance, further spontaneity and theatricality on stage and a more direct connection with the audience.[29] Therefore, the method Conceptual Simplification that I underpin with this thesis aims to provide an effective tool for those practitioners wanting to

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[23] Aiello and Williamon (2004), Chaffin et al. (2002), Chen (2015), Chueke and Chaffin (2016), Fonte (2020), Fonte et al. (2022), Ginsborg (2004), Hallam (1997), Hamilton (2008), Noyle (1987), Soares (2015), Tsintzou and Theodorakis (2008), Williamon (1999b).
[24] Chaffin et al. (2002), Ginsborg (2004), Sloboda (1985), Sloboda et al. (1996).
[25] Chaffin and Lisboa (2008), Chaffin et al. (2002; 2010), Sloboda (1985), Thomas (1999).
[26] Chueke and Chaffin (2016), Fonte (2020), Fonte et al. (2022), Jónasson and Lisboa (2015; 2016), Soares (2015), Tsintzou and Theodorakis (2008), Thomas (1999).
[27] Fonte et al. (2022), Ginsborg (2004), Hamilton (2008), Jónasson and Lisboa (2016), Soares (2015: 11).
[28] Fonte et al. (2022), Jónasson and Lisboa (2016), Soares (2015: 11), Williamon (1999b).
[29] Chaffin et al. (2002), Fonte (2020), Fonte et al. (2022), Hamilton (2008), Soares (2015), Williamon (1999b).

make memorisation faster or less difficult; and to assist those who might perform from the score, but still find post-tonal piano music too challenging or difficult to approach.

1.2 How this Thesis Addresses Current Issues on Memorisation

This thesis tests, extends and formalises Conceptual Simplification: a new method for the analysis, learning and memorisation of post-tonal piano music. Over the years, I developed several memorisation strategies, based on my experience and training as a pianist and mathematician. My interest in musical memory started when simultaneously pursuing a bachelor's in piano performance at the Catalonia College of Music (ESMUC), and a bachelor's in mathematics at the Polytechnic University of Catalonia (UPC), both in Barcelona, where I am originally from.[30] This required finding useful procedures to optimise my practice, thus I started experimenting with mathematical techniques for developing efficient musical memorisation strategies. Later, during my master's thesis at the Royal College of Music (RCM) in London, I organised and developed further these strategies, creating a first prototype of Conceptual Simplification,[31] based on the results of a self-case study. A summary of this version of the method is provided in Appendix A.

Therefore, this PhD permitted reconsidering how these strategies should be organised, while developing new ones with a more challenging body of repertoire, and testing these with other practitioners. As a result, a three-stage version of Conceptual Simplification was formalised, providing a systematic approach for memorisation, while also reframing the method for scaffolding learning and analysis. This thesis presents the latest iteration of Conceptual Simplification and its associated strategies, remaining open to further refinement and

[30] Thus, my native languages being Catalan and Spanish.
[31] Farré Rozada (2018).

expansion. Concretely, the method involves a two-level hierarchy: Conceptual Simplification is essentially a way of thinking and addressing metacognitive knowledge for effectively solving problems; whereas the proposed strategies are a non-fixed set of tools, which are selected as appropriate, depending on repertoire and performer. This thesis also establishes Conceptual Simplification's novel implementation to musical memorisation of mathematics and computer science. However, as demonstrated with this thesis, Conceptual Simplification does not require any previous scientific training to be successfully implemented and works for different learning styles and types of complexity.

Accordingly, this thesis addresses the principal question:

How can memorisation of post-tonal piano works be improved?

This is explored through the following sub-Research Questions (RQ):

RQ1: What parameters influence the memorisation and performance of a post-tonal piano work?

RQ2: Which practice strategies can be effective for performing a post-tonal piano work from memory?

RQ3: Which performance strategies can be effective for performing a post-tonal piano work from memory?

These questions were collectively addressed through three studies to gather data from a range of perspectives:

1) **Self-Case Studies**, in which I observed my own practice while learning and memorising a commissioned Piano Concerto written by Feliu Gasull and a commissioned solo piece written by Ofer Ben-Amots. Beyond studying the strategies implemented, I also examined how these differed within the contexts of soloist or soloist with orchestra.

2) **Interviews with specialised professionals**, which explored the strategies of expert pianists Hayk Melikyan, Ermis Theodorakis and Jason Hardink[32] in performing post-tonal music from memory. This was both to assess whether their approaches resemble Conceptual Simplification, and to identify other effective memorisation strategies. Throughout the thesis, this study is referred to as the 'Interviews'.

3) **Study with recruited participants**, who mostly consisted of advanced piano students. Participants were allocated to a control group and an experimental group, to compare the effectiveness of the participants' proposed memorisation strategies with Conceptual Simplification. Excerpts were selected from post-tonal works I had performed from memory using Conceptual Simplification. This study is labelled as the 'Study with Participants'.

The next chapter provides a literature review of relevant scholarship on memory, while Chapter 3 discusses the theory and practice of Conceptual Simplification. Chapter 4 presents the methodology, followed by the findings of the three studies described above (Chapter 5-7). The thesis concludes with the discussion (Chapter 8), and final conclusions (Chapter 9).

[32] All three pianists gave consent to be named in the thesis.

A second volume provides all appendices, including annotated scores of the commissioned works and an additional copy of the Bibliography,[33] for ease of reference.

[33] These correspond to Appendix K and Appendix L, respectively.

Chapter 2: Literature Review

This chapter reviews the most relevant literature on musical memorisation. First, an introduction provides some general context, and the substantial section 'Understanding Human Memory' discusses memory systems and processes. Then, more concise sections on expert memory, musical learning periods and memorisation strategies are presented. The chapter concludes by identifying existing gaps in Mnemonics and Performance Cue Theory,[1] arguing how these are addressed with Conceptual Simplification.

2.1 Introduction

Familiarity with the content to be learned or memorised is important. In Bartlett's ([1932] 1995) experiments, those participants with interest or advanced training in mathematics found meaning in abstract visual patterns, as opposed to others,[2] thus influencing their memory formation. Also, participants used their pre-existing knowledge to reconstruct memories.[3] Craik (1943), Weiner (1950) and Walter (1953) are the first attempts to model human memory with computers, leading to the so-called *computer metaphor* in psychology.[4] This established that humans possess a memory storage, with the capacity to introduce new information (*encode*); save it (*store*); and recover it (*retrieve*). These three stages are interrelated: how information is encoded conditions its storage, and how much of this information can be retrieved. The progressive discrimination of human memory as a conjunction of connected and interlaced memory systems challenged how this simple three-stage model operates.[5]

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[1] The term "Performance Cue Theory" is further explained in the Glossary.
[2] e.g., Bartlett ([1932] 1995: 21; 26).
[3] Bartlett ([1932] 1995: 213). See also Lewis and Durrant (2011: 343).
[4] Baddeley et al. (2020: 8).
[5] Baddeley et al. (2020: 9).

Baddeley (2012) provides the first model that incorporates non-linguistic auditory information (music, environmental sounds), based on comparisons between music and language.[6] However, its accuracy as a musical memory model remains under-researched,[7] and ignores auditory processing.[8] Evidence from Functional Magnetic Resonance Imaging (fMRI) studies suggest that musicians possess an additional system for auditory processing, resulting from their musical training.[9]

Some psychologists questioned whether human memory should be modelled in terms of *stores*, suggesting instead focusing on *processes* that vary across different memory tasks.[10] Baddeley et al. (2020) argue combining both, to study how these interact. Notwithstanding, just as the development of computers revolutionised the study of memory, artificial intelligence is again forcing us to reconsider the knowledge of the brain.[11]

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[6] Williamson et al. (2010), but also see Gordon (1997; 1999; 2000).
[7] Baddeley (2012), Schulze and Koelsch (2012).
[8] e.g., Berz (1995), Clarke (1993), Pechmann and Mohr (1992).
[9] e.g., Schulze et al. (2010; 2011).
[10] e.g., Nairne (1990; 2002), Neath and Surprenant (2003).
[11] Hawkins (2021).

2.2 Understanding Human Memory

Memorisation and long-term retention of information involve the memory systems of sensory memory (SM), short-term memory (STM), working memory (WM) and long-term memory (LTM). Memory formation also undertakes three main stages: encoding, consolidation and retrieval. All these are now discussed.

2.2.1 Memory Systems

Memory is commonly thought of as a single entity,[12] formed by several systems that are used for different purposes.

2.2.1.1 Sensory Memory (SM)

Sensory memory (SM) represents the 'immediate registration' of a stimulus 'within the appropriate sensory dimensions' (Atkinson and Shiffrin, 1968: 92), being the infrastructure for briefly storing that modality-specific information perceived from the environment. SM is *preattentive*,[13] therefore, independent from the individual's conscious attention.[14] However, SM's rapid decay might indicate its function for singling out useful information, storing it temporarily longer in STM, and shaping perception.[15] Similarly, attention paid to this sensory data conditions its progress to longer retention.[16] Neisser ([1967] 2014) defined two different SM modalities: *iconic memory*, for visual stimuli; and *echoic memory*, for auditory inputs. Similarly, Bliss et al. (1966) studied *haptic memory* for touch perception. In music performance, these relate to visual, aural and kinaesthetic memory, respectively, and are explained in section 2.2.2.1.

[12] Cowan (2008b).
[13] Neisser ([1967] 2014).
[14] Craik and Lockhart (1972).
[15] Baddeley et al. (2020: 10-12).
[16] Cowan (2008a).

SM research focused on understanding how individuals 'can briefly retain more information than they can process' (Cowan, 2008a: 25), and on determining SM's reliability. Several studies used Sperling's (1960) paradigm to explore memory features of sight, hearing and touch. Originally, Sperling (1960) studied iconic memory's limitations, illustrating how this differed from a more abstract form. His findings suggested that iconic memory might work as a photograph taken of the visual stimuli, that is only retained briefly, containing more information than the *span of attention* can process at once.[17] This *immediate memory* is limited, since more information is seen than remembered. Thus, an abstract form of memory is used, with an approximate 4-item capacity, to recall specific details.[18]

Following Sperling's work, Darwin et al. (1972) found that retention and capacity for auditory information were superior to that of iconic memory. However, later researchers questioned these results, claiming that findings from both studies were not comparable.[19] Furthermore, visual and auditory encoding differ, and so echoic memory can perform better at certain tasks.[20] Concretely, in a visual input, information is presented all at once (e.g., a musical score); whereas an aural input unfolds in time (e.g., an audio-recording). Consequently, auditory information requires a greater capacity for storing more information for longer, whereas visual immediacy allows for frequent shifts of focus and faster restore of data. Hence, available storage is constantly needed, potentially explaining why iconic memory might decay faster.[21]

[17] Miller (1956). The same author claims number seven to be a threshold for the *span of attention*. Below this number, individuals can *subitise*, that is perceiving how many items are presented, without counting; whereas above this number, individuals *estimate* (Miller, 1956: 90-91).
[18] Sperling (1960).
[19] e.g., Massaro (1976).
[20] See Cowan (1998) for a review.
[21] Radvansky (2017).

Finally, haptic memory divides into *cutaneous*[22] and, most importantly, *kinaesthetic*, which provides feedback on body position, self-movement and force. Unlike iconic and echoic memories, which produce temporal and spatial information, haptic memory processes distinct features of objects and surfaces.[23] Bliss et al. (1966) studied haptic memory focusing on finger sensibility and information's rapid decay, concluding that haptic memory retention is close to Sperling's (1960) for iconic memory. Later studies highlighted that haptic memory improves in areas with higher sensitivity for touch (e.g., the hands),[24] confirming its fast decay and comparing it to that of iconic memory.[25] This could explain why kinaesthetic memory (i.e., memorising through movement)[26] is less reliable in music performance.[27] Regardless of its modality, though, once SM's rich details are lost, categorisation of remaining information starts and transfers to the next stage of the memory chain.[28]

2.2.1.2 Short-Term Memory (STM) and Working Memory (WM)

The terms *short-term memory* (STM) and *working memory* (WM) are frequently used indistinctly in the literature.[29] For instance, Baddeley's (2012) model regards STM as the temporary store of information, while WM maintains and manipulates such information. However, the term WM is also used for either describing the role of STM in cognition or the role of attention in managing STM. These discrepancies in conceiving STM and WM contributed to confusion.[30] Recent literature seems to agree that STM should refer to the capacity of temporarily holding a limited amount of information, reflecting its storage limitations and

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[22] This can also be referred to as *tactile* (Baddeley et al., 2020: 87).
[23] Gordon et al. (1993), Lederman and Klatzky (2009).
[24] Murray et al. (1975).
[25] Shih et al. (2009).
[26] See Mishra (2004: 233; 2005: 82; 2007).
[27] Fitts (1964), Ginsborg (2004), Hallam (1997), Luft and Buitrago (2005), Mishra (2010), Squire (1986), Walker (2005).
[28] Cowan (2008a).
[29] Cowan (2008b).
[30] See Cowan (2008b) for a review.

temporal decay; whereas WM could be considered a 'mental workspace' that permits retaining and manipulating that information used in cognitively demanding activities (Baddeley et al., 2020: 13): e.g., playing a musical instrument.[31] These activities include reasoning, planning and problem-solving, but also understanding music and speech.[32] Attention and individual differences also play a role in WM,[33] and how this interacts with STM and LTM.[34] Within this framework, WM is a system that encompasses STM.[35]

However, WM capacity is limited,[36] estimated at four units, in which a unit is an item of information stored in memory.[37] Hence, WM capacity is the amount of information that an individual can temporarily manage,[38] determining the individual's capability for tasks that require both manipulation and retention of information. Alternatively, STM capacity only considers storage,[39] which Miller (1956) reformulated in terms of *chunks* instead of single items, with a capacity of 7 ± 2 units.[40] These chunks are configured through partitioning and grouping information (i.e., *chunking*),[41] according to pre-existing knowledge stored in LTM.[42] Chunking can be automatic, as a product of perception; or deliberate, by implementing it as a problem-solving strategy.[43] Accordingly, the amount of data stored in each of these chunks

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[31] See also Cowan (2008b). For instance, WM is of vital importance for writing a coherent text, allowing one to keep the thread while writing and connect the ideas to be conveyed. Similarly, reading a book and comprehending its content is also made possible by WM. Additionally, it also enables one to carry out mental calculations and temporarily hold in memory intermediate results until the problem is solved. Another example would be of assisting the successful completion of an elaborate task such as cooking, during which is important to keep the recipe's ordered succession of events, while not repeating or omitting any steps (Cowan, 2008b).
[32] Schulze and Koelsch (2012).
[33] See Cowan (2001) for attention; see Engle and Kane (2004) and Miyake et al. (2000) for individual differences.
[34] Miyake and Shah (1999).
[35] Baddeley et al. (2020: 13; 41-42).
[36] Baddeley (2003), Baddeley et al. (1975), Miller (1956).
[37] Cowan (2005).
[38] Baddeley (1992), Baddeley et al. (2020: 90).
[39] Aben et al. (2012).
[40] Miller (1956) suggests that STM capacity ranges from five to nine chunks of information. However, Cowan (2001) reviewed this, suggesting that a capacity ranging from three to five units of information might be a more accurate measure.
[41] The term "chunking" is further explained in the Glossary.
[42] Baddeley et al. (2020: 223-229), Chase and Simon (1973a; 1973b), Ericsson et al. (2017), Gobet (2005; 2015), Gobet et al. (2001).
[43] Ericsson et al. (2017), Gobet et al. (2001).

seems unlimited, since information can be *recoded* to maximise its capacity,[44] as learning and expertise progress.[45] Furthermore, the rhythmical or spatial structure in which information is presented can also influence how grouping is attempted.[46] Similarly, musicians can benefit from their training in recognising and forming patterns for effective chunking.[47]

However, Miller's (1956) proposed STM capacity was questioned, being 4 ± 1 chunks of information a more accurate measure.[48] Concretely, short-term visual memory could be limited to four units,[49] and decrease as the complexity of visual input (e.g., a musical score) increases.[50] This result is explained by understanding STM as limited but flexible storage, in which retention's quality and quantity are detrimental to each other, therefore inversely proportional.[51] For example, remembering accurately a collection of objects compromises the retention's level of detail in favour of storing a larger collection. However, pre-existing knowledge could compensate for such limitation.[52] Likewise, STM auditory capacity is influenced by *perfect pitch*,[53] which is the ability to accurately identify or produce a pitch without any given reference;[54] as opposed to recognising pitch through comparison with other pitches (*relative pitch*).[55] Perfect-pitch possessors do not encode pitches in terms of

44 Miller (1956: 93-96).
45 Chase and Ericsson (1982), Gobet (2015). In music, this *recode* process was referred to as *rechunking*, and it was described in Performance Cue Theory as 'overlaying lower level retrieval cues used in the earlier stages of practice with new, higher level cues' (Chaffin et al., 2002: 250). The same authors also describe it as 'a matter of "wrapping" a lower level, basic feature inside an interpretive or expressive cue', or to simply 'eliminate cues' (Chaffin et al., 2002: 251-252).
46 e.g., Ryan (1969), Wickelgren (1964). For example, memorising BCU Library's telephone would be easier by grouping the digits like 0121 331 5282, instead of memorising it as the single 11-digit sequence 01213315282.
47 Koelsch et al. (1999; 2002), Krumhansl (1979), Krumhansl and Shepard (1979), Schulze and Koelsch (2012).
48 See Cowan (2001) for a review.
49 e.g., Adam et al. (2017), Luck and Vogel (1997).
50 Fougnie et al. (2010), Hardman and Cowan (2015).
51 Alvarez and Cavanagh (2004), Bays and Husain (2008), Wilken and Ma (2004).
52 Baddeley et al. (2020: 60), Gobet (2015: 40), Schurgin (2018).
53 e.g., Bachem (1954), Profita and Bidder (1988), Rakowski and Rogowski (2007), Ross and Marks (2009), Takeuchi and Hulse (1993).
54 Deutsch (2013), Hedger et al. (2013), Münte et al. (2002), Takeuchi and Hulse (1993), Ward (1999). For Western-trained musicians, this is usually considered within the terms of a musical scale or the piano keyboard (Münte et al., 2002), since the stability of perfect pitch is strongly conditioned by the 'cultural conventions for tuning' music (Hedger et al., 2013: 1496).
55 Leipold et al. (2019).

sound, but using verbal memory instead.[56] This is important since trying to retain a specific tone while hearing other tones can be challenged by the corresponding interference of these subsequent tones.[57] Furthermore, verbal memory is more stable for pitch retention,[58] providing an advantage to perfect-pitch possessors in storing larger volumes of auditory information, despite having the same WM capacity as relative-pitch possessors.[59] Additionally, outstanding memory for auditory information was found in autistic subjects[60] and musical savants with this ability.[61] Hence, perfect pitch highlights an influential parameter for WM: individual differences and learning styles.[62]

The reasons why perfect pitch develops are still under speculation.[63] However, a determining factor is early musical training up to age six, approximately, after which developing perfect pitch becomes increasingly difficult.[64] This is due to 'a general developmental shift from perceiving individual features to perceiving relations among features' (Takeuchi and Hulse, 1993: 345). Such evolution is also reported in reading tasks, in which comprehension of the text becomes progressively more important than word recognition.[65] Nevertheless, Brady (1970) suggested that perfect pitch can still be developed as an adult with extensive training. Furthermore, even if perfect pitch is not deliberately trained, most relative-pitch possessors have an implicit version of perfect pitch,[66] which permits reproducing a well-known song, assessing whether a familiar musical work is transposed,[67] or identifying a piece's tonality.[68]

56 Deutsch (2013), Münte et al. (2002), Takeuchi and Hulse (1993). It was observed that possessing perfect pitch affects STM retention, but not echoic memory's decay (Rakowski, 1972; Rakowski and Morawska-Bungeler, 1987; Takeuchi and Hulse, 1993).
57 Deutsch (1970).
58 Bachem (1954), Rakowski and Morawska-Bungeler (1987), Siegel (1974).
59 Deutsch (2013), Ross and Marks (2009), Takeuchi and Hulse (1993).
60 e.g., Bonnel et al. (2003), Heaton (2003), Heaton et al. (1998; 2008).
61 e.g., Ockelford (2007b), Young and Nettelbeck (1995).
62 Odendaal (2019), Svard and Mack (2002).
63 See Deutsch (2013) for a review.
64 e.g., Cuddy (1968), Gough (1922), Heller and Auerbach (1972), Takeuchi and Hulse (1993), Ward (1999).
65 Corrigall and Trainor (2011).
66 Deutsch (2013), Saffran and Griepentrog (2001), Smith and Schmuckler (2008).
67 Bergeson and Trehub (2002), Halpern (1989), Levitin (1994), Takeuchi and Hulse (1993).
68 Sergeant (1969), Spender (1980).

Therefore, despite STM's and WM's limitations,[69] there are mechanisms that prevent immediate forgetting, by transferring the information to a more permanent LTM.[70] Others are rehearsal, which involves practising the content to be memorised.[71] Another is relying on pre-existing knowledge, which positively impacts the amount of information retained:[72] content temporally stored in STM is retrieved in the same order as learned, whereas, in LTM, that is done through association.[73] Finally, other determinant factors are motivation,[74] strategy[75] and sleep.[76]

Concretely, learning before a night's sleep contributes to better retention and to an improvement in performance, as opposed to learning at the beginning of a waking period.[77] This was explored for non-musical sequence-learning tasks,[78] and for tonal melodies and excerpts.[79] Accordingly, sleeping after learning is a useful strategy, also for musicians. Nonetheless, an even better strategy is sleeping between two learning sessions.[80] While

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69 Adam et al. (2017), Alvarez and Cavanagh (2004), Atkinson and Shiffrin (1968), Baddeley (1992; 2003), Baddeley et al. (1975; 2020: 90), Bays and Husain (2008), Cowan (2001; 2005; 2008b), Fougnie et al. (2010), Hardman and Cowan (2015), Luck and Vogel (1997), Meinz and Hambrick (2010), Miller (1956), Wilken and Ma (2004).

70 Cowan (2008b), Craik and Lockhart (1972), Shiffrin and Atkinson (1969).

71 Baddeley et al. (1984; 2020: 93), Shipstead et al. (2014).

72 Tse et al. (2007), van Kesteren et al. (2012).

73 Baddeley et al. (2020: 48-51; 175; 183-185; 247), Drosopoulos et al. (2007), Fenn et al. (2003), Ghosh and Gilboa (2014), Glenberg (1997), Hardt et al. (2010), Lewis and Durrant (2011: 344), Raaijmakers and Shiffrin (1981), Robertson (2009), Smith and Vela (2001).

74 See Dickerson and Adcock (2018), Miendlarzewska et al. (2016), Shohamy and Adcock (2010) for reviews.

75 Adesope et al. (2017), Bahrick et al. (1975), Bjork and Bjork (1992), Bower et al. (1969), Craik and Lockhart (1972), Craik and Tulving (1975), Fisher and Craik (1977), Glenberg et al. (1977), Gobet (2005; 2015), Gobet et al. (2001), Hyde and Jenkins (1973), Karpicke and Roediger (2008), Linton (1975), Mazza et al. (2016), Meeter et al. (2005), Miller (1956), Morris et al. (1977), Naveh-Benjamin and Brubaker (2019), Rowland (2014), Rubin and Kontis (1983), Soderstrom et al. (2016), Tulving (1962), Yates (2010).

76 Brown and Robertson (2007b), Cohen et al. (2005), Diekelmann and Born (2010), Drosopoulos et al. (2007), Dumay and Gaskell (2007), Ellenbogen et al. (2007), Feld and Born (2017), Fenn et al. (2003), Fischer and Born (2009), Fischer et al. (2006), Gais et al. (2007), Hardt et al. (2010), Hikosaka et al. (2002), Ji and Wilson (2007), Karni et al. (1998), King et al. (2017), Kuriyama et al. (2004), Lahl et al. (2008), Lewis and Durrant (2011), Luft and Buitrago (2005), Maquet et al. (2000; 2003a), Mazza et al. (2016), Mednick et al. (2002; 2003; 2008), Peigneux et al. (2001; 2003; 2004), Rasch and Born (2013), Robertson (2009), Squire (1992b), Squire et al. (2015), Stickgold (2005), Stickgold and Walker (2013), Stickgold et al. (2000; 2001), Verwey and Clegg (2005), Wagner et al. (2004), Walker (2005; 2009), Walker and Stickgold (2004; 2006), Walker et al. (2002), Wamsley (2022).

77 King et al. (2017), Rasch and Born (2013).

78 e.g., Balas et al. (2007), Dorfberger et al. (2007), Kuriyama et al. (2004), Walker et al. (2003).

79 e.g., Allen (2013), Duke and Davis (2006), Simmons (2012), van Hedger et al. (2015), Wilson (1983).

80 Mazza et al. (2016).

recurring practice is encouraged to develop LTM,[81] interspersing practice with sleep further improves retention in the longer term, while reducing by half the practice needed for relearning.[82] Therefore, achieving 'longer retention with less study' (Mazza et al., 2016: 1329).[83] This is possible with consolidation,[84] through which information stored in STM transfers to LTM in a more long-lasting and stable form.[85] This process is discussed later in this chapter.

2.2.1.3 Long-Term Memory (LTM)

All memory systems reviewed (SM, STM, WM) are considerably limited in capacity and retention. Nevertheless, LTM presents opposite features: it decays slowly in time, or not at all, and appears to have limitless storage.[86] LTM is generally studied following Squire's (1992a) dichotomy of *explicit/declarative memory* and *implicit/non-declarative memory*. In this, *explicit memory* indicates a conscious acquisition and retrieval of memory; whereas *implicit memory* represents non-conscious learning retrieved through performance.[87] Information stored in *declarative memory* is classified either into *semantic memory* or *episodic memory*, depending on whether this refers to facts or events, respectively.[88] *Semantic* or *conceptual memory* stores knowledge (e.g., language, patterns, sensory features of objects), general understanding of society and human behaviour, or other relevant information about one's environment, not necessarily related to a specific event.[89] *Episodic memory* collates one's experiences in time, like

81 Chaffin et al. (2010), Chase and Ericsson (1982), Ebbinghaus ([1885] 1913), Ericsson and Kintsch (1995), Ericsson and Staszewski (1989), Hintzman (1976), Mishra (2010).
82 Mazza et al. (2016).
83 See also Simmons (2011).
84 Brown and Robertson (2007b), Cohen et al. (2005), Durrant and Lewis (2009), Robertson and Cohen (2006), Stickgold et al. (2001), Walker (2005).
85 Squire et al. (2015).
86 Cowan (2008b), Craik and Lockhart (1972), Shiffrin and Atkinson (1969).
87 Baddeley et al. (2020: 13-14), Walker (2005).
88 Tulving (1972).
89 Baddeley et al. (2020: 164), Binder and Desai (2011: 527).

an autobiographical memory, allowing to retrieve specific details from these, including emotions.[90] Although semantic and episodic memories interact,[91] is still not clear how.[92] Alternatively, non-declarative memories are more extensive,[93] of which are relevant *procedural memory*, for learning how to perform certain skills, habits and actions;[94] and *implicit learning*, which is the passive assimilation of knowledge through exposure.[95] Both categories apply to the musical domain: procedural memory results from learning how to physically play a piece, whereas implicit learning involves memorising it by repetition.[96] Beyond these, learning a piece also requires developing mental and cognitive skills.[97]

The dichotomy of explicit/declarative memory and implicit/non-declarative memory also indicates an important feature of LTM: the speed of knowledge acquisition. For declarative memory, learning tends to be swift and completed in a few sessions, whereas non-declarative memory usually requires numerous practice sessions to develop and is achieved with repetition.[98] Furthermore, both LTM's subsystems are constantly combined.[99] Learning a musical work requires combining motor skill acquisition with declarative knowledge, but for developing declarative knowledge, a conscious effort is needed.[100] Finally, conscious explicit knowledge can interfere with implicit knowledge with a phenomenon known as *verbal overshadowing*. This happens when a procedural task is disrupted by an attempt to verbally describe every step and action required for successfully completing such physical skill: e.g., overthinking automatised piano-playing gestures.[101]

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[90] Tulving (2002).
[91] Baddeley et al. (2020: 208-210).
[92] Baddeley (2020), Tulving (2002).
[93] Squire (1992a).
[94] Cohen and Squire (1980).
[95] Dienes and Perner (1999).
[96] Mishra (2010).
[97] Baddeley et al. (2020: 147-148).
[98] Fitts (1964), Luft and Buitrago (2005), Squire (1986), Walker (2005).
[99] Cohen and Squire (1980), Robertson (2009).
[100] Ginsborg (2004), Robertson (2009), Robertson and Cohen (2006).
[101] Baddeley et al. (2020: 149), Schooler and Engstler-Schooler (1990). Also, Flegal and Anderson (2008) and Mackenzie (1990) provide evidence for this phenomenon in golf.

The next section explains the stages of memory formation.

2.2.2 Memory Processes

Memory formation undertakes three processes: *encoding*,[102] which is the acquisition of knowledge; *consolidation*, which corresponds to its storage; and *retrieval*.[103] During consolidation, memories are reorganised and strengthened to prevent interference and ensure long-term retention.[104] This procedure is divided into *stabilisation*,[105] which happens during wake and is triggered by practice; and *enhancement*,[106] which develops during sleep.[107] Throughout these, memory can be modified quantitatively, with an increase in performance, becoming more stable and less vulnerable to interference;[108] and qualitatively, by realising a different strategy to re-approach a problem or becoming aware of previously learned knowledge.[109] Such evolution is demonstrated by comparing different recalls in time, which measure the amount of off-line learning that happened.[110] Therefore, memory consolidation is 'determined by the time spent in specific brain states such as wake or sleep, or even certain stages of sleep' (Walker, 2005: 55).[111] Figure 2.1 summarises how these memory processes and systems interact:

[102] The term "encoding" is further explained in the Glossary.
[103] Baddeley et al. (2020: 9), Robertson (2009).
[104] Walker (2005), Walker and Stickgold (2004).
[105] On stabilisation, see also Brashers-Krug et al. (1996), Muellbacher et al. (2002), Walker et al. (2003).
[106] On enhancement, see also Fenn et al. (2003), Fischer et al. (2002), Gais et al. (2000), Karni et al. (1994), Korman et al. (2003), Stickgold et al. (2000), Walker et al. (2002).
[107] Squire et al. (2015), Walker (2005), Walker and Stickgold (2004).
[108] Krakauer and Shadmehr (2006), Robertson et al. (2004b), Walker (2005).
[109] Fischer et al. (2006), Wagner et al. (2004), Yordanova et al. (2008).
[110] Robertson (2009), Robertson et al. (2004b), Walker (2005). A definition for off-line learning is provided in section 2.2.2.2.
[111] See also Brashers-Krug et al. (1996), Fischer et al. (2002), Gais et al. (2000), Karni et al. (1994), Muellbacher et al. (2002), Shadmehr and Brashers-Krug (1997), Stickgold et al. (2000), Walker and Stickgold (2004), Walker et al. (2002; 2003).

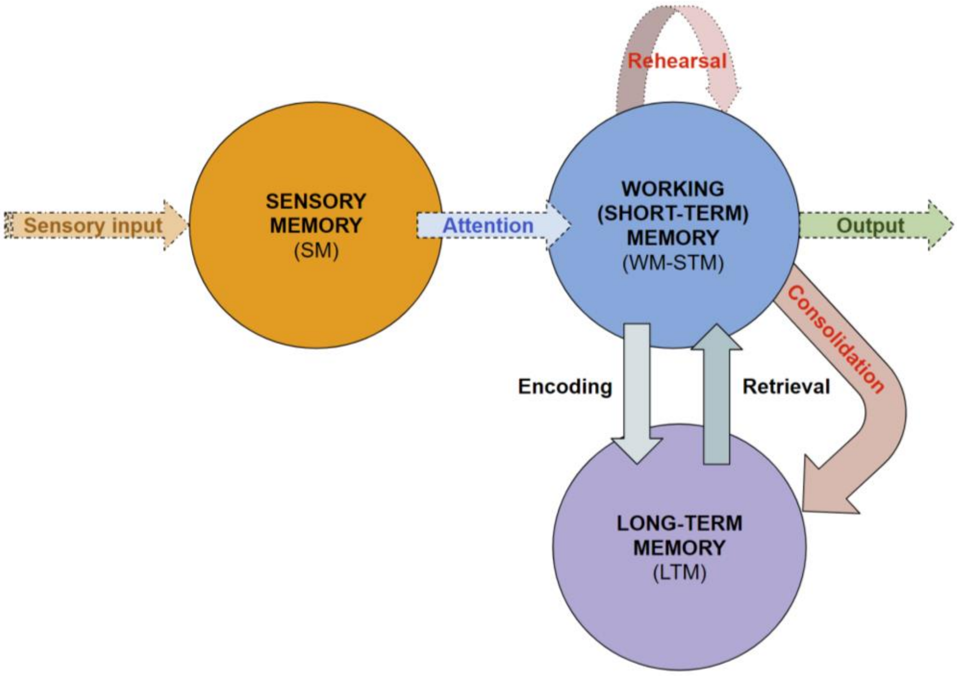

Figure 2.1: Summary of how human memory systems interact and operate.

After this overview, further details are given for each of these processes, conveying that memory formation integrates new and pre-existing knowledge. Therefore, the creation of new memories depends on 'the structural organisation of the mind of the learner', and these memories continue to evolve with time, 'even without conscious effort' (Duke and Davis, 2006: 112).

2.2.2.1 Encoding

Knowledge acquisition develops a mental map or *representation* of that content, triggering the first process that undertakes memory: encoding.[112] Information in the musical domain can be encoded in four different formats: visual, aural, tactile and semantic.[113] These are known as *visual memory*, *aural memory*, *kinaesthetic memory* and *conceptual memory*.[114] The first three

[112] Fischer and Born (2009: 1596), Walker (2005: 55).
[113] Hunt (2008).
[114] Mishra (2004: 233; 2005: 82; 2007).

correspond to the *Sensory Learning Styles*, whereas the latter is the *Analytical Learning Style*.[115] The idiosyncratic use and combination of all these depends on the individual's learning style.[116]

Craik and Lockhart (1972) proposed that long-term retention of new information is determined by the methods used for encoding it. For example, given a written tonal chord, this could be processed in three different ways: the chord's appearance (e.g., musical notation); the chord's sound; and how the chord fits within a tonality as a pattern. According to Craik and Lockhart's (1972) *levels of processing* hypothesis, these three encoding formats are remembered. However, retention lasts longer for the one involving deeper processing. Concretely, Craik and Tulving (1975) tested the equivalent for written words: participants encoded these according to their visual appearance (e.g., whether written in lower or upper case), phonological pronunciation (e.g., potential rhymes with other words), and semantic meaning (e.g., whether it fitted within a sentence). When participants were given a list that included both new and processed words, the ones they recognised better were those for which depth of processing had been greater (i.e., semantic meaning). This result was independent of the time invested. Likewise, meaningfully encoding as a pattern a given tonal chord would also imply remembering it for longer since it involves deeper processing than visual or aural encoding modalities provide.

Additional studies on written verbal content supported Craik and Lockhart's (1972) *depth of processing* principle: i.e., more elaborate encoding leads to further LTM retention.[117] However, this principle also received criticism, namely how this depth of processing should be

115 Mishra (2004: 233; 2005: 81-83).
116 Mishra (2007), Odendaal (2019), Svard and Mack (2002).
117 Most notably, Hyde and Jenkins (1973) tested it for six encoding modalities, for which both recognition and recall attempts were evaluated.

measured.[118] For instance, an encoding modality that requires more time does not necessarily translate into deeper processing since it might involve inefficient and superficial encoding.[119] Other criticism pointed towards Craik and Lockhart's (1972) assumption that levels of processing are sequentially implemented, instead of simultaneously: visual, phonological and semantic content are not necessarily encoded independently, although more attention might be paid to one of these modalities. Finally, engaging in deeper processing does not necessarily ensure a 'better performance' (Baddeley et al., 2020: 173). For example, trying to learn how to play the piano by only studying books on technique might develop expert factual knowledge without skill.[120] This latter flaw was addressed with the *transfer-appropriate processing* principle, which states that memory is better retained when the encoding mode matches the mode of retrieval, and vice versa.[121] That is studying in the way that a content shall be tested. For example, both learning how to play the piano and playing the piano should involve interaction with the instrument. Furthermore, learning according to the transfer-appropriate processing principle can also have two different modalities: *incidental learning*, in which the acquisition of information happens without knowing that this will be tested later; and *intentional learning*, which unfolds with the awareness that retention for that content will be evaluated.[122]

Nonetheless, as Craik and Tulving (1975) anticipated, seeking and engaging meaning during encoding develops a richer memory trace, making retrieval easier since elaborateness links memory to several concepts. Therefore, multiple accesses and routes are created for that information. This view aligns with Craik and Lockhart's (1972) kinds of rehearsal. *Maintenance rehearsal* represents the continuous processing of information without varying the encoding

[118] e.g., Craik and Tulving (1975).
[119] Baddeley et al. (2020: 172-173).
[120] Baddeley et al. (2020: 173).
[121] Baddeley et al. (2020: 173), Fisher and Craik (1977), Morris et al. (1977).
[122] Baddeley et al. (2020: 173), Fisher and Craik (1977), Morris et al. (1977).

modality (e.g., rote repetition). *Elaborative rehearsal* implies meaningful association of the rehearsed material with itself, or its *integration* with pre-existing knowledge,[123] which is effective for both tonal and post-tonal music.[124] Craik and Lockhart (1972) suggested that elaborative rehearsal is the most effective for ensuring LTM. Conversely, maintenance rehearsal positively impacts recognition, being less effective for successful retrieval,[125] especially when rehearsal is based on unattended repetition.[126] Likewise, attended repetition is also ineffective if iterations consist in identical reproduction.[127]

Beyond meaning, another conditioning factor for long-term retention is organisation. Therefore, understanding the order in which information is encoded and retrieved, but also how the memorised components relate to each other in forming greater content.[128] Experiments on this topic showed that when participants memorised unrelated verbal content without guidance, they used a *subjective organisation* strategy to meaningfully structure it, facilitating retrieval. Concretely, Tulving's (1962) participants improved their memory as they progressively restructured the information, each time in bigger chunks.[129] This is particularly effective when assembled as a meaningful hierarchical structure,[130] even for musical content.[131] Such subjective organisation was also observed in how performers segment music according to its formal or perceived structure,[132] and use a tonal framework

[123] Baddeley et al. (2020: 175).
[124] Fonte (2020), Nielsen (1999a), Ockelford (2011), Rostron and Bottrill (2000), Sloboda (1985; 2005), Soares (2015), Tsintzou and Theodorakis (2008).
[125] Glenberg et al. (1977).
[126] Naveh-Benjamin and Brubaker (2019), Rubin and Kontis (1983).
[127] Glenberg et al. (1977), Mishra (2010: 14-15).
[128] Baddeley et al. (2020: 176), Mandler (1967).
[129] This phenomenon was described by Miller (1956: 93-96) as *recoding*.
[130] Bower et al. (1969). Concretely, Bower et al. (1969) showed that participants who memorised using a hierarchical structure could recall 65% of the semantic content learned, whereas those that did not follow any organisation only managed to recall an 18%.
[131] e.g., Deutsch (1980), Halpern and Bower (1982).
[132] e.g., Chaffin (2007), Chaffin and Imreh (1997a; 2001), Chaffin and Logan (2006), Chaffin et al. (2003; 2010), Chueke and Chaffin (2016), Fonte (2020), Miklaszewski (1989), Nielsen (1999a), Noice et al. (2008), Rubin-Rabson (1937), Soares (2015), Tsintzou and Theodorakis (2008), Williamon and Valentine (2002).

to enhance encoding for unfamiliar contexts (e.g., post-tonal music).[133] Both of these strategies are effective for partitioning the music into meaningful chunks, but also at linking these 'into a coherent story', making it harder to forget (Baddeley et al., 2020: 179). These strategies are further discussed in the section on expertise.

Finally, another influential element for long-term retention is distinctiveness.[134] That is the presence of 'difference in the context of similarity' (Hunt, 2013: 10). Given a set of uniform data, those items presenting a distinct feature are better retained in memory, satisfying the *von Restorff effect*:[135] memory improves for distinct or isolated items amongst a list of similar items.[136] This effect is explained with two main arguments. First, one's attention and depth of processing might increase when encoding such differences. Secondly, distinct features facilitate avoiding interference with similar content since a unique cue is associated with that element.[137]

Therefore, during encoding, significant improvements are observed in the content learned. However, when these begin to asymptote, consolidation starts.[138] This second process is triggered by practice and remains active for a maximum of six waking hours.[139] Nonetheless, for successful consolidation to happen, knowledge acquisition needs to be followed by a night's sleep.[140] Furthermore, to prevent a decrease in performance due to fatigue, lack of attention or motivation, practice can be interspersed with short intervals of daytime sleep.[141] The roles of consolidation and sleep in memory are now explained.

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133 e.g., Fonte (2020), Ockelford (2011), Soares (2015), Tsintzou and Theodorakis (2008).
134 Tulving and Kroll (1995).
135 von Restorff (1933).
136 Chee and Goh (2018: 49), Hunt (2013).
137 Chee and Goh (2018), Eysenck (1979b).
138 Duke and Davis (2006: 113), Walker (2005: 54).
139 Karni et al. (1998), Shadmehr and Brashers-Krug (1997).
140 Stickgold and Walker (2013), Stickgold et al. (2000).
141 Lahl et al. (2008), Mednick et al. (2002).

2.2.2.2 Consolidation

After encoding, a slower process known as consolidation reactivates and strengthens memory in different ways, transferring such knowledge to LTM.[142] Memory reactivation and improvement either happens effortfully with practice (on-line learning) or effortlessly (off-line learning).[143] During effortful practice, the development of declarative and procedural memories is facilitated.[144] However, memories are consolidated with *off-line learning*:[145] an effortless processing that can happen during wakeful rest (e.g., mind wandering, daydreaming or other inattentive states),[146] or sleep.[147] During wakefulness, off-line learning is triggered by practice, and remains active for a certain time after learning occurred,[148] preventing 'a rapid forgetting' of what was learned (Fischer and Born, 2009: 1586).[149] During sleep, the brain selectively replays the same patterns of activity engaged during on-line learning,[150] which is known as *sleep-dependent replay*. This reactivates and integrates new memories into permanent and preestablished networks of knowledge,[151] prompting stable long-term retention by reorganising how memories are stored.[152] While wakeful off-line learning is completed within hours or minutes after practice, sleep-dependent consolidation can extend to several days and years.[153]

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142 Walker (2005: 55).

143 Mazza et al. (2016), Walker (2005). See also Brown and Robertson (2007b), Cohen et al. (2005), Stickgold et al. (2001).

144 e.g., Hikosaka et al. (2002), Verwey and Clegg (2005).

145 Luft and Buitrago (2005), Mazza et al. (2016), Walker (2005).

146 For example, between practice sessions or when no further practice is taking place (Karni et al., 1998).

147 Rasch and Born (2013), Stickgold et al. (2001), Wamsley (2022).

148 Luft and Buitrago (2005), Walker (2005).

149 See also Albert et al. (2009), Fischer et al. (2002), Korman et al. (2003), Muellbacher et al. (2002), Peigneux et al. (2006).

150 Ji and Wilson (2007), Maquet et al. (2000), Peigneux et al. (2004). See King et al. (2017) and Rasch and Born (2013) for a review on historical and more recent research on memory and sleep.

151 Maquet et al. (2000; 2003a), Stickgold and Walker (2013), Walker et al. (2002).

152 Baddeley et al. (2020: 152), Rasch and Born (2013), Walker and Stickgold (2006). See also Lewis and Durrant (2011), Walker (2005), Wamsley (2022).

153 Gais et al. (2007), Squire (1992b).

Off-line learning significantly impacts declarative-conceptual memory,[154] whose sleep-dependent consolidation depends on the task's difficulty and its emotional component.[155] Concretely, both procedural-motoric and conceptual mistakes in music performance can increase in subsequent recalls without sleep, but conceptual mistakes are 'significantly reduced after a night of sleep' (van Hedger et al., 2015: 177). This improvement is attributed to sleep-dependent consolidation, which varies depending on the individual's WM capacity[156] and how much reactivation happens during sleep.[157] Once learning starts, changes are gradually made so LTM progressively relies on a higher number of interconnected brain areas.[158] The more advanced this process is, the less vulnerable this memory is to disruption.[159] However, when a consolidated memory is reactivated again, this sometimes undergoes a process of *reconsolidation*, becoming vulnerable again until completed.[160] Nonetheless, such vulnerability might be limited to 'the extent to which the memory is enhanced during sleep' (Duke and Davis, 2006: 120)[161] and reconsolidation might also allow updating the information associated with that memory.[162] Hence, sleep plays a key role in off-line learning for memory,[163] consolidating and enhancing new knowledge learned during wakefulness.[164] Additionally, familiarity with the content accelerates consolidation.[165] In music, this is the equivalent of using tonal theory (i.e., pre-existing knowledge) when

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154 e.g., Peigneux et al. (2001).
155 See Walker and Stickgold (2004) for a review. Moreover, complexity of a task also influences sleep-based enhancement for procedural memory. Similarly, Kuriyama et al. (2004) examines how sleep-dependent consolidation is determined by the complexity of a task involving a motor skill.
156 Fenn and Hambrick (2012).
157 Peigneux et al. (2003; 2004).
158 Squire et al. (2015).
159 Baddeley et al. (2020: 283).
160 Baddeley et al. (2020: 283), Sara (2000), Walker et al. (2003).
161 See also Alberini (2005).
162 Hardt et al. (2010).
163 Rasch and Born (2013), Stickgold et al. (2001).
164 Diekelmann and Born (2010), Mazza et al. (2016).
165 Tse et al. (2007), van Kesteren et al. (2012).

memorising a piece,[166] as opposed to facing a post-tonal piece with unfamiliar composition principles and language.[167]

Sleep also positively impacts learning and resets attention for acquiring new information,[168] both after a short nap or a night's sleep.[169] Repeatedly interspersing practice with sleep can be more effective than other learning approaches in ensuring long-term retention,[170] particularly when dealing with challenging declarative content, but also with the acquisition and retention of new skills.[171] Essentially, sleep enhances memory retention in a way that less effort is needed to retrieve the same information.[172] Hence, the extra work needed for reaching a certain level of memory consolidation without sleep does not efficiently transfer into the same amount of long-term retention provided by sleep-dependent consolidation.[173] However, sleep provides a wider range of benefits,[174] beyond memory consolidation.[175] Among these, the integration of multiple stimuli and memories,[176] gaining insight into hidden solutions,[177] the abstraction of general rules,[178] creatively linking unrelated ideas and

166 Chaffin and Imreh (1997a: 316), Chaffin and Logan (2006), Chaffin et al. (2002), Hallam (1997), Halpern and Bower (1982), Mishra (2005), Oura and Hatano (1988; 2004), Sloboda et al. (1985).
167 e.g., Fonte (2020), Soares (2015), Tsintzou and Theodorakis (2008). See also Jonaitis and Saffran (2009).
168 For example, see reviews provided by Baddeley et al. (2020: 137-141), Squire et al. (2015), Walker (2005), Walker and Stickgold (2004; 2006).
169 e.g., Diekelmann and Born (2010), King et al. (2017), Lahl et al. (2008), Mednick et al. (2002; 2003; 2008). In fact, the idea that a night's sleep can consolidate memory goes as far as the Roman Empire with the rhetoric teacher Quintillian (35 – c. 96 AD). He accounts for this practice in his book *Institutio Oratoria* (c. 95 AD). See Butler (1921).
170 Cash (2009), Duke et al. (2009), Mazza et al. (2016).
171 Cash (2009), Duke et al. (2009), Kuriyama et al. (2004), Mazza et al. (2016), Mednick et al. (2008).
172 e.g., Lahl et al. (2008), Mazza et al. (2016), Walker et al. (2002).
173 Bjork and Bjork (1992), Mazza et al. (2016: 1328).
174 Cairney et al. (2011), Lewis (2014), Lewis and Durrant (2011), Randall (2013), Walker (2017).
175 Diekelmann and Born (2010), Drosopoulos et al. (2007), Stickgold (2005), Walker (2005; 2009), Walker and Stickgold (2006), Walker et al. (2002).
176 Dumay and Gaskell (2007), Ellenbogen et al. (2007).
177 Wagner et al. (2004), Yordanova et al. (2008). In this context, *insight* stands for the process of boosting understanding of a hidden pattern or rule that underlies a set of items. It typically involves developing an explicit knowledge of such pattern or rule (Lewis and Durrant, 2011: 343; Wagner et al., 2004; Yordanova et al., 2008).
178 Djonlagic et al. (2009), Durrant and Lewis (2009), Durrant et al. (2011), Fischer et al. (2006), Gómez et al. (2006), Hupbach et al. (2009).

concepts,[179] re-emerging forgotten knowledge to conscious awareness,[180] consolidating weaker spots in memory,[181] enhancing visual and auditory discrimination skills,[182] and enhancing speed and accuracy in performance.[183]

Nevertheless, sleep research on musical memory is still scarce: most studies focused on non-musical tasks, involving the acquisition of simple skills or a feasible goal in the shorter term.[184] Consequently, results are not transferable to complex skills (e.g., playing a musical instrument),[185] and the experience of learning and memorising a musical work.[186] Despite this, sleep research on musical memory reported sleep-related enhancements for learning, performance, memorisation and consolidation.[187] These findings urge reconsidering the role that sleep should have in musicians' well-being[188] and practice routines.[189] Notwithstanding, existing studies only focused on the effect that sleep-dependent consolidation can have in the short term on procedural memory consolidation of one-handed keyboard tonal or modal melodies,[190] and on motoric and abstract learning for tonal piano excerpts.[191] The latter suggests that declarative and procedural knowledge consolidate differently:[192] a finding

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179 Cai et al. (2009). Sleep research has two main separate lines of enquiring: the study of sleep and the study of dreams. In this thesis I focus on sleep, but sleep studies are also focusing on understanding the role of dreams in developing creative links between unrelated ideas or concepts, among other potential benefits. See Robb (2018).
180 Fenn et al. (2003), Fischer et al. (2006), Robertson (2009), Wagner et al. (2004).
181 Drosopoulos et al. (2007), Kuriyama et al. (2004).
182 For visual discrimination, see Karni et al. (1994), Maquet et al. (2003b), Mednick et al. (2002; 2003), Stickgold et al. (2000). For auditory discrimination, see Atienza and Cantero (2001), Atienza et al. (2002; 2004).
183 Brashers-Krug et al. (1996), Duke and Davis (2006), Korman et al. (2003), Kuriyama et al. (2004), Maquet et al. (2003a), Simmons and Duke (2006), Walker et al. (2002; 2003).
184 Grafton et al. (1995), Korman et al. (2003), Mazza et al. (2016), Spencer et al. (2006), Walker et al. (2003).
185 Karni et al. (1998), Kuriyama et al. (2004), Münte et al. (2002), Wulf and Shea (2002).
186 van Hedger et al. (2015).
187 e.g., Allen (2013), Cash (2009), Simmons (2012), Simmons and Duke (2006), van Hedger et al. (2015).
188 Banks and Dinges (2007), Walker (2017).
189 Allen (2013), Duke and Davis (2006), Duke et al. (2009), Mazza et al. (2016), Simmons (2007; 2011; 2012), van Hedger et al. (2015). See also Sigman et al. (2014).
190 Allen (2007; 2013), Cash (2009), Duke and Davis (2006), Duke et al. (2009), Simmons (2007; 2011; 2012), Simmons and Duke (2006).
191 van Hedger et al. (2015).
192 van Hedger et al. (2015: 175).

consistent with previous non-musical studies.[193] Hence, further research is needed for extending these results to memorisation and post-tonal music.

Another key purpose of consolidation is preventing memory *interference*.[194] This is when retrieving certain information is disrupted by its resemblance with other stored content.[195] In music, this type of interference is known as *switches*:[196] a set of turning points in a musical work placed in locations that present certain similarities or self-referencing,[197] but that resolve differently.[198] Switches can either happen within equivalent structural sections (e.g., exposition and recapitulation),[199] or within a section involving many variations of a motif.[200] Since musical material around switches is similar, their content is likely to be triggered by the same cue,[201] retrieving the wrong resolution and placing the performer in a different location of the musical work.[202] This problematic is theorised with the *competition assumption*, suggesting that multiple content associated to the same retrieval cue compete to prevail when that cue is activated;[203] and the *cue-overload principle*,[204] which indicates that the more content linked to the same retrieval cue, the harder it is for successfully recalling it.[205] Therefore, switches are an important obstacle for memorisation and retrieval during performance,[206] and are further discussed in this chapter and Chapter 3.

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193 Albouy et al. (2013), Dumay and Gaskell (2007), Fenn et al. (2013).
194 Walker (2005), Walker and Stickgold (2006).
195 Anderson (2003), Baddeley et al. (2020: 285).
196 Research on musical memory does not generally refer to switches as memory interferences. However, Chaffin et al. (2002: 156; 161; 211) explicitly link the term "interference" with switches, along with other cognitive processes (Chaffin et al., 2002: 37; 146; 183-184). See also Mishra (2010: 16).
197 The term "self-referencing" is further explained in the Glossary.
198 Chaffin and Imreh (1997a: 325-326), Chaffin et al. (2002: 95-97).
199 e.g., Chaffin and Imreh (1997a: 325-326), Soares (2015: 122-123; 138).
200 e.g., Farré Rozada (2018: 35-37), Fonte (2020: 155-156), Soares (2015: 127-128).
201 Baddeley et al. (2020: 288).
202 Chaffin et al. (2002: 206). For instance, such monitoring may imply inhibition of playing a certain note or using fingering that automatically takes the performer to the wrong path. The process of *inhibition* was extensively researched in psychology for correcting habits (Baddeley et al., 2020: 301-305).
203 Anderson et al. (1994).
204 Baddeley et al. (2020: 288).
205 Watkins (1978).
206 Chaffin and Lisboa (2008: 132-133; 137), Chaffin et al. (2002), Fonte (2020: 155; 161), Soares (2015: 121-125; 127; 138-139).

There are also different kinds of interference. *Retroactive interference* describes how acquiring new memories blocks the retrieval of older similar ones,[207] particularly when the acquisition of these similar memories occurs close in time (e.g., the same session). Thus, learning two tasks, one after the other, implies that the second task blocks consolidation for that task learned first,[208] reducing or even eliminating overnight enhancement.[209] The implications of retroactive interference for music learning is that if two similar components (e.g., melodies) are memorised, one after the other, it becomes harder to retrieve the first one, since the second poses an obstacle for accurate retrieval: this interference increases as the second component is further trained.[210] A more thorough review is provided in Chapter 3. Likewise, with *proactive interference*, older memories impose themselves over similar new memories at retrieval.[211] For example, forgetting a list of items over another list previously memorised,[212] or involuntary recall of internalised mistakes.[213] Consequently, interference is problematic with similar content, and when this is reproduced instead of recognised.[214]

During wake, off-line learning of procedural and declarative knowledge disrupts each other,[215] whereas during sleep these systems become independent, facilitating parallel consolidation of declarative and procedural memories.[216] Since memory interference is not a threat during sleep, the brain can freely reorganise encoded information, eventually revealing

[207] Baddeley et al. (2020: 291).
[208] The studies cited in the following footnote tested this phenomenon when learning two novel and similar tasks. Nevertheless, Balas et al. (2007) focused on studying the implications of learning a new task followed by practising a second task that was different but familiar. Their findings suggested that consolidation for a novel task can also be blocked by practising a second unrelated task, even if the latter was acquired long before.
[209] Balas et al. (2007), Brashers-Krug et al. (1996), Brown and Robertson (2007b), Cohen and Robertson (2012), Dorfberger et al. (2007), Fischer et al. (2005), Korman et al. (2003), Shadmehr and Brashers-Krug (1997), Walker (2005), Walker et al. (2003).
[210] Baddeley et al. (2020: 291).
[211] Baddeley et al. (2020: 293).
[212] e.g., Underwood (1957).
[213] Anderson et al. (1994), Baddeley et al. (2020: 299-300). See also Chaffin and Imreh (1997a: 330).
[214] Baddeley et al. (2020: 293).
[215] Brashers-Krug et al. (1996), Brown and Robertson (2007b), Keisler and Shadmehr (2010), Robertson (2009), Robertson et al. (2004a; 2004b), Spencer et al. (2006), Walker (2005), Walker et al. (2003).
[216] Brown and Robertson (2007a; 2007b), Fischer et al. (2006), Robertson et al. (2004a).

'hidden patterns' (Robertson, 2009: 15). This phenomenon, commonly known as "sleeping on a problem", describes how sleep facilitates re-approaching a problem by establishing 'high-order associations' and allowing the reconstruction of memories potentially 'disrupted' during wakefulness (Robertson, 2009: 16).[217] Such processing is reflected as an improved recall of declarative memory,[218] but also as more fluent motor performance.[219]

Clearly, interference plays an important role in forgetting.[220] However, forgetting is not 'a failure of retention' (Baddeley et al., 2020: 306):[221] the brain selectively forgets superfluous details, prompting abstraction and conceptual memory formation.[222] Also, forgetting knowledge by making it 'temporarily inaccessible' to other memory systems might enhance how these systems process other content (Robertson, 2009: 16-17).[223] Similarly, it also decreases potential interference, facilitating retrieval of newly acquired information.[224] Other benefits include optimising decision-making by reviewing obsolete information and stimulating generalisation,[225] providing an essential mechanism for regulating cognition.[226] Therefore, interference results from an essential interaction across memory systems for integrating information.[227]

However, during sleep, there is no interference since memory systems process information independently.[228] Still, sleep plays an essential role in forgetting by performing a *sleep-dependent*

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217 See also Drosopoulos et al. (2007), Fenn et al. (2003).
218 Albouy et al. (2013), Dumay and Gaskell (2007), Fenn et al. (2013), Fischer et al. (2006), van Hedger et al. (2015).
219 Cash (2009), Fischer et al. (2002), Kuriyama et al. (2004), Robertson et al. (2004a), Simmons and Duke (2006), Spencer et al. (2006), Walker et al. (2002).
220 e.g., Baddeley and Hitch (1977), Nairne (1990), Underwood (1957).
221 See also Nørby (2015).
222 Quian Quiroga (2012a; 2012b). When memorising new content, the main information is summarised and preserved, whereas most ornamental details, if not needed, are forgotten (Bartlett, [1932] 1995).
223 See also Crick and Mitchison (1983), Robertson (2009).
224 e.g., Hardt et al. (2013).
225 Richards and Frankland (2017).
226 e.g., Anderson (2003), Bjork (1988), Bjork et al. (2006).
227 Cohen and Robertson (2012), Robertson (2009).
228 Brown and Robertson (2007b), Robertson (2009), Diekelmann and Born (2010).

memory triage, in which content learned is selectively enhanced.[229] Accordingly, important information is further strengthened in memory, whereas less relevant content is forgotten.[230] Such selection depends on the content's emotional salience;[231] and its 'perceived importance' (Baddeley et al., 2020: 139), which could result from a set of given instructions, a promised reward, or other incentives.[232] Fischer and Born (2009) identified this effect when instructing their participants on what content was likely to be evaluated. Therefore, as Stickgold and Walker (2013) suggested, the sleep-dependent memory triage ensures that content perceived as more important is emphasised during consolidation and integrated with that knowledge stored in LTM. Thus, through forgetting, the most relevant content is selected and consolidated, promoting generalisation and abstraction, being particularly useful 'at high memory loads, when reactivation-based consolidation reaches capacity limits' (Feld and Born, 2017: 20). Consequently, forgetting is essential for off-line learning to be effective with memory formation.

This subsection conveyed sleep's role in consolidating knowledge.[233] Also, that memory enhancement does not solely result from practice, but from a combination with effortless off-line learning, which is a product of time for implicit skills and of sleep for explicit skills.[234] Accordingly, sleep deprivation negatively impacts the retention of new information,[235] since sleep-dependent consolidation is still noticeable 'long after' initial learning happened (Baddeley et al., 2020: 139).[236] Therefore, ensuring good quality sleep translates into increasing the chances that new learning is enhanced and efficiently transferred to LTM

[229] Stickgold and Walker (2013).
[230] Feld and Born (2017).
[231] Payne and Kensinger (2018), Payne et al. (2008).
[232] e.g., Fischer and Born (2009), van Hedger et al. (2015).
[233] Stickgold and Walker (2013).
[234] Robertson et al. (2004a: 208).
[235] Maquet et al. (2003a), Stickgold et al. (2000).
[236] See also Gais et al. (2007).

during consolidation.[237] This result is either achieved after a short nap or a night's sleep, and for both procedural and declarative memories.[238] The same benefits were also observed in the musical domain for overnight sleep.[239] The next section discusses the last process of memory formation.

2.2.2.3 Retrieval

Effective encoding and consolidation permit retrieving information previously stored. Such recovery is enhanced with memory cues, which can be adapted to any feature of a memory, making it *content-addressable*.[240] In music, these cues are studied with Performance Cue Theory,[241] which focuses on different *features* of a memory, including its basic perceptual and conceptual components.[242] These cues are related to specific locations in the piece, allowing musicians to access them from memory at any given point.[243] The more cues are associated with a certain memory, the more effective retrieval is.[244] Furthermore, cues' effectiveness depends on whether these are triggered in similar conditions as these cues were created. This is known as the *encoding specificity principle*, which addresses the influence that context has on memory encoding for retrieval.[245] The encoding specificity principle is related to the *context-dependent memory effect*, which describes the dependency between certain material and the context in which this is memorised: recall is stronger when attempted in the same

237 Baddeley et al. (2020: 141), Walker (2017).
238 e.g., Albouy et al. (2013), Diekelmann and Born (2010), Gais et al. (2007), King et al. (2017), Korman et al. (2007), Kuriyama et al. (2004), Lahl et al. (2008), Mazza et al. (2016), Mednick et al. (2002; 2003; 2008), Peigneux et al. (2001), Walker et al. (2003).
239 Allen (2007; 2013), Cash (2009), Duke and Davis (2006), Duke et al. (2009), Simmons (2007; 2011; 2012), Simmons and Duke (2006), van Hedger et al. (2015), Wilson (1983).
240 Baddeley et al. (2020: 241).
241 Performance Cue Theory is reviewed in the last section of this chapter and in Chapter 3. Some of the most relevant studies on performance cues are Chaffin and Lisboa (2008), Chaffin et al. (2002; 2009; 2010; 2021), Chen (2015), Chueke and Chaffin (2016), Ginsborg and Chaffin (2011a), Ginsborg et al. (2006a; 2006b), Lisboa et al. (2015).
242 Baddeley et al. (2020: 242).
243 Chaffin et al. (2002; 2010), Rubin (2006: 280).
244 Baddeley et al. (2020: 247).
245 Baddeley et al. (2020: 245).

environment as encoding.[246] Thus, recalling such material in a different context causes an 'apparent forgetting' (Mishra and Backlin, 2007: 455),[247] when context is varied in time, space, mood, cognition[248] or physiological state.[249] Therefore, any memory encoded according to the previous parameters can be easier retrieved when the corresponding parameters stay invariant but be temporarily forgotten when those parameters vary.[250] Concretely, Mishra and Backlin (2007: 463-469) showed that memorising a short piano piece on an instrument and subsequently retrieving it from memory on a different instrument in the same room reduces accuracy almost by half. Given that pianists often switch instruments and locations in their performance practice, these results might seem discouraging. Nonetheless, the context-dependent memory effect can be reduced by combining different contexts when learning and memorising.[251] Furthermore, processing information in an associative manner rather than using rote repetition also contributes to decreasing memory's dependency on the encoding context,[252] since meaningful and subjective organisation of new information positively impacts retrieval.[253]

Retrieval can be attempted in different ways: by *recognising* whether certain information was learned; by *relearning* content previously learned; or by *recalling* memories without assistance.[254] While recognising is easier than attempting recall,[255] memory is further secured in LTM when

[246] Hupbach et al. (2008), Mishra and Backlin (2007).
[247] See also Godden and Baddeley (1975). Smith and Vela (2001) provide a review on further studies verifying the context-dependent memory effect.
[248] Here, cognition includes any thoughts, ideas or concepts that were present in one's mind while encoding certain information (Baddeley et al., 2020: 258).
[249] Baddeley et al. (2020: 254).
[250] Baddeley et al. (2020: 254-258).
[251] Smith (1982). See also Smith and Vela (2001) for a review.
[252] Glenberg (1997), Smith and Vela (2001).
[253] Bower et al. (1969), Tulving (1962). Concretely, for music, evidence is provided by Chaffin (2007), Chaffin and Imreh (1997a; 2001), Chaffin and Logan (2006), Chaffin et al. (2003; 2010), Chueke and Chaffin (2016), Fonte (2020), Miklaszewski (1989), Nielsen (1999a), Noice et al. (2008), Ockelford (2011), Rubin-Rabson (1937), Soares (2015), Tsintzou and Theodorakis (2008), Williamon and Valentine (2002).
[254] Baddeley et al. (2020: 251-252), Mazza et al. (2016).
[255] Bahrick et al. (1975), Meeter et al. (2005).

recall is attempted.[256] Hence, retrieval is more effective for memory retention than relearning.[257] This might explain why memorising a musical work requires developing extensive knowledge of it: performing from the score can be thought of as a recognition task, whereas performing from memory involves recall. Secondly, retrieval can be *incidental*, resulting from a spontaneous reminder; or *intentional*, as a deliberate process.[258] Thus, a memory can be *available*, rightly stored in memory; and *accessible*, depending on whether the right cue is presented for recovering it.[259] Retrieval is also influenced by serial position effects such as the primacy effect, the recency effect and chaining. These effects illustrate how attention varies when a series of items are presented, and how attention shifts determine retention.[260] The *primacy effect* is the tendency of focusing on those items at the beginning of a sequence, whereas the *recency effect* is the tendency of focusing on those items placed last. Meanwhile, *chaining* is the association created between one item and the next. The consequences of these effects for musical memory are later discussed.

Finally, the most effective strategy for strengthening LTM and ensuring successful retrieval is attempting frequent recalls.[261] This is known as the *testing effect*, and it happens for two main reasons. First, intentional retrieval benefits from sleep-dependent replay and overnight consolidation, preventing potential forgetting and enhancing long-term retention.[262] Secondly, unlike other types of rehearsal, retrieval practice prompts the formation of an additional memory trace.[263] The effectiveness of these recalls is determined by the difficulty of retrieval: the more challenging the better, which is known as the *retrieval difficulty*

256 Bjork (1975), Rowland (2014).
257 Adesope et al. (2017), Bahrick et al. (1975), Gerbier and Koenig (2015), Karpicke and Roediger (2008), Linton (1975), Soderstrom et al. (2016).
258 Jacoby (1984), Pu and Tse (2014).
259 Baddeley et al. (2020: 282), Bjork and Bjork (1992).
260 Baddeley et al. (2020: 48-51; 183-185).
261 Adesope et al. (2017), Bahrick et al. (1975), Karpicke and Roediger (2008), Linton (1975), Soderstrom et al. (2016).
262 Antony et al. (2017), Rasch and Born (2013), Stickgold and Walker (2013), Walker and Stickgold (2006).
263 Cho et al. (2017), Karpicke and Roediger (2008), Karpicke et al. (2009), Rowland (2014).

hypothesis.[264] Furthermore, off-line learning improves LTM in the absence of practice.[265] In music, this is experiencing that performing a musical work feels easier after not practising it for a while.[266] Therefore, given that pre-existing knowledge enhances encoding and consolidation,[267] the next section focuses on the role of expertise in memorisation.

2.3 Expert Memory

The acquisition of expertise involves a long learning process.[268] According to Dehaene (2015: 5), *learning* is the ability 'to form an internal model of the external world', but is also the ability to adjust this model, to explore new possibilities, to minimise mistakes, to optimise, to restrict search space and to project a prior hypothesis. This is because 'the human brain breaks down the problem of learning by creating a hierarchical and multilevel model', and that principle is implemented by 'all sensory systems' (Dehaene, 2015: 11). Thus, acquiring new knowledge over time is 'the process of memory formation, expressed behaviourally as learning' (Walker, 2005: 52).[269]

Time invested in practising a skill determines the expertise attained, leading to the well-known "10,000 hours rule".[270] In music, this was extended to reject the idea of musical talent as an innate gift and focus instead on the student's capacity to learn.[271] Concretely, the Suzuki

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264 Bjork and Bjork (1992), Pyc and Rawson (2009), Rowland (2014). Additionally, learning can be further enhanced by re-studying the correct information after attempting to retrieve it. This is known as *test-enhanced learning* and consists of a retrieval test followed by the corresponding feedback of re-studying the information tested (Baddeley et al., 2020: 128-129; Butler and Roediger, 2008).
265 Brashers-Krug et al. (1996), Karni et al. (1998), Kuriyama et al. (2004), Walker and Stickgold (2004), Walker et al. (2002; 2003).
266 Allen (2013: 800).
267 e.g., Chase and Ericsson (1982), Gobet (2005; 2015), Gobet et al. (2001), Oura and Hatano (2004), Schulze and Koelsch (2012), Tse et al. (2007), Tsintzou and Theodorakis (2008), van Kesteren et al. (2012).
268 Ericsson et al. (1993).
269 See also Baddeley et al. (2020: 113).
270 Ericsson and Charness (1994), Ericsson et al. (1993), Sloboda et al. (1996).
271 Gardner ([1983] 2011), Haroutounian (2002), Mosing and Ullen (2016), Scripp et al. (2013), Suzuki ([1963] 1981; [1980] 1981).

method exploits the effects of practice in achieving high levels of musical performance, under the view that 'every child can be highly educated if given the proper training' (Suzuki, [1980] 1981: 233). The 10,000 hours rule also aligns with Ebbinghaus' ([1885] 1913) *total time hypothesis*: the volume of information learned correlates with the time spent learning it. However, simply spending more time practising does not suffice for the acquisition of expertise, especially when such practice is based on repetition.[272] Instead, *deliberate practice* is required, which Ericsson (2013: 534) defines as 'the engagement with full concentration in a training activity designed to improve a particular aspect of performance with immediate feedback, opportunities for gradual refinement by repetition and problem solving'. Ericsson's (2013) views were supported by studies on the detrimental effect of unattended or identical repetition,[273] also for musical content.[274]

As expertise increases in a certain domain (e.g., sports, music, theatre, dance, chess, mathematics, medicine),[275] retention is higher for new content. However, this capacity relies on the individual's ability to implement the relevant knowledge to make sense of such content. Furthermore, expert memory acquisition in a particular domain does not automatically transfer into another.[276] For example, an expert musician does not instantly become an expert mathematician, but instead, needs to acquire the relevant knowledge and skills. Therefore, expertise is a highly organised ensemble of knowledge that scaffolds the expert's future acquisition of further relevant knowledge. Moreover, the integration of new

[272] Ericsson (2013).
[273] Glenberg et al. (1977), Naveh-Benjamin and Brubaker (2019), Rubin and Kontis (1983), Young and Salmela (2010).
[274] Austin and Berg (2006), Barry and Hallam (2002), Carter and Grahn (2016), Ginsborg (2004: 129), Hallam (1997: 95-96), Renwick and McPherson (2000), Sloboda (1985: 96).
[275] e.g., Allard et al. (1980), Bartlett ([1932] 1995: 21; 26), Chaffin and Imreh (2002), Chaffin and Logan (2006), Chaffin et al. (2010), Chase and Simon (1973a; 1973b), Chassy and Gobet (2011), Coughlin and Patel (1987), Ericsson and Kintsch (1995), Gardner ([1983] 2011), Gobet (2015), Gobet and Simon (1996a; 1996b; 1996c; 1996d), Hatano and Osawa (1983a; 1983b), Krampe and Ericsson (1996), Noice and Noice (2002), Noice et al. (2008), Norman et al. (1989), Paige and Simon (1966), Schoenfeld and Herrmann (1982), Starkes et al. (1987; 1990), Tsintzou and Theodorakis (2008), Weiser and Sheertz (1983), Williamon and Valentine (2002).
[276] Chase and Ericsson (1982), Gobet (2015).

information into the expert's memory is so efficient because this is chunked and encoded according to pre-existing knowledge. Consequently, effortful remembering is substituted by effortless understanding: finding meaning translates into organising such information.[277] However, when new content (e.g., random patterns) does not match the expert's pre-existing knowledge, expertise becomes 'irrelevant' and the resulting memory 'perfectly ordinary' (Baddeley et al., 2020: 181).[278] Still, experts can be more proficient than novices in identifying smaller patterns than usual, which can be used for memorising.[279]

In musical performance, expertise is essential to sight-reading. However, "sight-reading" can refer to two different activities:[280] *sight-reading* as the process of reading through the score while imagining how it sounds;[281] and *sight-playing* as physically playing through a score with little practice or none beforehand.[282] Since the term "sight-reading" is widely established for referring to the act of "sight-playing", I keep this convention, unless a distinction needs to be made. Good sight-reading skills require a fast recognition of familiar patterns: like expert chunking leads to optimal encoding,[283] fluent sight-reading is possible through the swift identification on the score and the keyboard of known structures and patterns, instead of reading individual notes.[284] Such fluency in processing the information allows anticipating upcoming bars, while avoiding hesitations and interruptions during performance.[285] Therefore, an expert sight-reader manages WM's limited capacity by chunking information

277 Baddeley et al. (2020: 181-182), Bartlett ([1932] 1995).
278 See also Allard et al. (1980), Chase and Simon (1973a; 1973b), Norman et al. (1989), Starkes et al. (1987).
279 Gobet and Simon (1996a; 1996b), Sala and Gobet (2017), Starkes et al. (1990), Tsintzou and Theodorakis (2008: 7-9). See also Soares (2015: 210).
280 Mishra (2005), Richardson (2004).
281 Gordon (1997), Waters et al. (1998). In Mishra (2005), sight-reading is defined as 'notational overview', sight-playing as 'performance overview', and listening as 'aural overview'.
282 Lewandowska and Schmuckler (2020), Pike and Carter (2010), Wolf (1976).
283 Allard and Starkes (1980), Chase and Simon (1973a), De Groot (1978), Gobet et al. (2001), Underwood et al. (1994).
284 Fourie (2004), Gobet et al. (2001), Pike and Carter (2010), Rayner et al. (2006), Richardson (2004), Underwood et al. (1990), Waters et al. (1998).
285 Fan et al. (2022), McPherson (1994), Pike and Carter (2010), Sloboda (1985), Waters et al. (1998), Wolf (1976), Wristen (2005).

into established meaningful pitch and rhythmical patterns.[286] Nevertheless, to be effective, the corresponding 'visual cue must be linked to a motor skill that can be performed effortlessly so that the pianist can attend to other details of the score such as musical expression' (Pike and Carter, 2010: 232).[287]

Generally, there is consensus that extended deliberate practice is a central component for acquiring expert performance,[288] including for music,[289] suggesting that combining self-regulation and deliberate practice is an optimal approach for musical achievement.[290] However, some researchers questioned whether deliberate practice suffices for achieving expert performance, or whether this is only one requirement amongst others.[291] Many individuals do not achieve an expert level, although investing significant time practising,[292] and other parameters (e.g., physical traits, intelligence, personality) can also determine performance.[293] Similarly, genetics play a role in expertise achievement,[294] many traits of which have a hereditary origin,[295] even for music.[296] For example, good sight-reading skills relate to having a considerably larger WM capacity,[297] which is hugely hereditary, general and stable, and it 'may limit the ultimate level of performance that can be attained' (Meinz and Hambrick, 2010: 918). This could indicate that expert knowledge or deliberate practice might

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286 Drake and Palmer (2000), Gilman and Underwood (2003), Gobet et al. (2001), Goolsby (1994a; 1994b), Kopiez et al. (2006), Pike and Carter (2010), Wolf (1976).
287 See also Lehmann and McArthur (2002).
288 Ericsson (1997; 2002; 2013), Ericsson et al. (1993; 2004), Krampe and Ericsson (1996), Lehmann and Ericsson (1997), Wilding and Valentine (1994).
289 e.g., Ericsson et al. (1993), Platz et al. (2014).
290 e.g., Bonneville-Roussy and Bouffard (2015), Ericsson and Charness (1994), Ericsson et al. (1993), Nielsen (1999a; 1999b; 2001).
291 e.g., Campitelli and Gobet (2011), Hambrick et al. (2014), Meinz and Hambrick (2010), Mosing et al. (2014).
292 Corrigall et al. (2013), Hallam et al. (2012), Hambrick et al. (2014), Ruthsatz et al. (2008).
293 Corrigall et al. (2013), Ruthsatz et al. (2008), Tucker and Collins (2012).
294 For example, having a certain 'genetic predisposition to practice' (Mishra, 2019: 586; Mosing et al., 2014) prompted by one's motivation and personality (Burland and Davidson, 2002; Kemp and Mills, 2002).
295 e.g., Dubois et al. (2012), Jang et al. (1996), Posthuma et al. (2009), Vinkhuyzen et al. (2009).
296 Hambrick et al. (2018), Mosing et al. (2014).
297 Arthur (2017), Baddeley (1992), Lee (2003), Meinz and Hambrick (2010).

not suffice for becoming proficiently fluent in sight-reading,[298] but it can help.[299] Therefore, while engaging in deliberate practice for thousands of hours significantly improves a skill,[300] this might not always permit overcoming one's limitations. Furthermore, individual differences in WM capacity also condition the amount of overnight consolidation:[301] i.e., the actual learning and memorisation that materialises.[302] Thus, the traditional view that 'expert performance is solely a reflection of deliberate practice' is seriously questioned (Meinz and Hambrick, 2010: 914).[303]

Expert memory satisfies three main principles: meaningful encoding, retrieval structure and prolonged practice.[304] *Meaningful encoding* states that experts in a certain area can encode new information using familiar structures stored in memory. Therefore, content learned is associated with pre-existing knowledge and chunked into meaningful units, by relying on patterns previously acquired during extensive specific training.[305] For Western classically-trained musicians, these correspond to tonal structures and patterns (e.g., scales, chords, arpeggios, harmonic progressions), that are deeply rooted in memory, after many years of musical education and practice.[306] However, post-tonal music does not always evidently present such patterns. Therefore, performers can either try to impose a tonal framework and translate the music into standard tonal entities,[307] or devise a set of principles to chunk and

[298] Hambrick et al. (2014).

[299] Ericsson and Charness (1994), Ericsson et al. (1993), Kopiez and Lee (2008), Lee et al. (2007), Lehmann and Ericsson (1996), Mishra (2014a; 2014b).

[300] Ericsson and Charness (1994), Ericsson and Ward (2007), Ericsson et al. (1993), Howe et al. (1998), Krampe and Ericsson (1996), Platz et al. (2014), Roring et al. (2007).

[301] Fenn and Hambrick (2012).

[302] Lahl et al. (2008), Luft and Buitrago (2005), Mazza et al. (2016), Mednick et al. (2008), Robertson (2009), Robertson et al. (2004b), Walker (2005), Walker et al. (2002).

[303] See also Hambrick et al. (2014; 2018), Mosing et al. (2014).

[304] Ericsson (1988), Ericsson and Kintsch (1995), Lehmann and Gruber (2006).

[305] Brewer (1987), Ericsson and Charness (1994), Ericsson et al. (2017), Gobet (2015).

[306] Chaffin and Imreh (1997a: 316), Chaffin and Logan (2006), Chaffin et al. (2002), Hallam (1997), Halpern and Bower (1982), Mishra (2005), Oura and Hatano (1988), Sloboda et al. (1985).

[307] Chueke and Chaffin (2016), Fonte (2020), Gordon (2006: 84), Miklaszewski (1995), Nuki (1984), Ockelford (2011: 237), Oura and Hatano (1988), Sloboda et al. (1985), Soares (2015: 75; 194), Tsintzou and Theodorakis (2008: 8). Even further, the musical savant participant in Ockelford (2011: 237) reconstructed the pitch organisation of a post-tonal piece by Schoenberg into a more coherent 'quasi-tonal framework', when recalling

encode the music accordingly.[308] For example, using the piece's composition principles, if familiar enough, and the performer finds them useful for memorising.[309] Nevertheless, awareness of such patterns or composition principles (e.g., twelve-tone rows) is useless, if failing to identify and use them for memorising more effectively.[310]

Existing research has not clarified yet the amount of expertise required to be fluent at chunking music according to a composer's writing techniques. The remarkable memory achievements of pianist Ermis Theodorakis[311] reported by Fonte (2020) suggest that is possible.[312] However, Soares (2015: 148), another specialised pianist in this repertoire, but less experienced than Theodorakis,[313] acknowledged recognising serial rows in Pierre Boulez's *Douze notations* (1945), but only using these to inform his memorisation strategies. Consequently, a composer's principles can be helpful for memorising effectively when the required expertise and working methods for that purpose are satisfied.[314] Furthermore, the lack of memorisation training in musical education institutions[315] and the small presence of recent post-tonal music in the curriculum[316] might explain why Fonte's (2020: 201-202) recruited piano students missed the twelve-tone row pattern of the given composition and its potential as a memorisation strategy.[317] Finally, according to Bourdieu ([1984] 2010: 233),

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it from memory. A similar result was observed by Sloboda (1978), in which participants had to sight-read a score that had been manipulated by the researcher to contain some tonal incongruences. Without knowing that, participants unconsciously corrected those outlier notes to fit well within the corresponding tonality, as they sight-read through the piece.

[308] Chueke and Chaffin (2016), Fonte (2020: 298; 318-319; 439-450), Li (2007), Soares (2015), Tsintzou and Theodorakis (2008).

[309] Fonte (2020: 318-319; 439-450), Soares (2015: 148-149).

[310] Chueke and Chaffin (2016), Fonte (2020: 106-108; 134; 293; 440; 443; 452), Soares (2015: 148).

[311] Pianist Ermis Theodorakis was also interviewed in this thesis and further details of his background and memorisation strategies are provided in Chapter 4, Chapter 6 and Appendix C.

[312] Fonte (2020: 318-319; 439-450).

[313] Fonte (2020: 80), Soares (2015: 37).

[314] Fonte (2020: 108; 197-264; 293), Imberty (1993).

[315] Mishra (2005), Soares (2015: 11).

[316] Fonte (2020: 84), Jónasson and Lisboa (2016: 80).

[317] This was one of the findings of Fonte's (2020: 197-264) multiple-case study with six master's piano students, who had to memorise the solo piano piece *Leaf* (1990) by Luciano Berio. These participants had limited experience with post-tonal piano music, particularly in performing such repertoire from memory. See Fonte (2020: 201-202) for further details on their profiles.

understanding is conditioned by possessing 'the code in which [a work] has been codified'. Therefore, 'as a greater number of styles or their variants become better known, one feels less coerced or tempted to forcefully apply the available codes, and more and more oriented to assume or admit that the works can "speak" through codes that are ignored' (Bourdieu, [1984] 2010: 80-81).

Retrieval structure indicates that memory cues for both procedural and declarative knowledge are developed during learning and organised in a well-learned retrieval structure. Thus, experts can access chunks of information stored in LTM through this retrieval scheme.[318] Concretely, music's formal structure provides the information organised into a hierarchical scheme that can be used for that purpose,[319] even when not following standard formal models (e.g., rondo, sonata form), or these are not evident.[320]

Finally, *prolonged practice* decreases the time needed for encoding and retrieving information.[321] Particularly, this allows experts to rely on LTM, instead of WM, for fulfilling tasks cognitively complex. Hence, dependency on STM's limited capacity is avoided.[322] For music, this requires practising memory retrieval multiple times and in different conditions, until performance is not disrupted.[323] During such practice, musicians develop performance cues for highlighting those features that should be explicitly attended to when playing,[324] but without interfering with kinaesthetic memory's automatised movements.[325] This is important since explicitly monitoring on a step-by-step basis the technical execution of automatised

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318 Bower et al. (1969), Ericsson and Oliver (1989), Johnson (1970), Rosenbaum (1987).
319 Chaffin and Imreh (2002), Chaffin et al. (2010; 2013), Ginsborg and Chaffin (2011a; 2011b), Williamon and Egner (2004), Williamon and Valentine (2002).
320 Chaffin et al. (2013), Chueke and Chaffin (2016), Fonte (2020), Soares (2015: 48).
321 Chase and Ericsson (1982), Ericsson and Staszewski (1989).
322 Ericsson and Delaney (1999), Ericsson and Kintsch (1995), Roring et al. (2007: 169).
323 Chaffin and Imreh (1997b), Chaffin et al. (2002: 216-229).
324 Performance Cue Theory is further discussed in the next section of this chapter.
325 Chaffin et al. (2002).

implicit skills can fully disrupt performance under pressure.[326] In the sports domain, explicit monitoring theories defined this phenomenon as *choking*, which can be avoided with prolonged deliberate practice and by relying on implicit memory's automaticity.[327] This approach can remove potential choking and significantly enhance the resulting *clutch performance*: an improved performance under pressure.[328]

Previous studies also identified two general approaches to memorisation. The first one, commonly used by novices despite being inefficient, is based on repetition until automaticity is reached:[329] musicians rely on a type of memory known as *associative chaining*, which naturally develops when learning.[330] This memory is activated by serial cueing, meaning that the auditory and motor feedback generated by playing a certain passage activates the search in memory of what comes next. Therefore, when the performance is interrupted, the serial chain of cues breaks. Hence, if the performer exclusively relied on associative chaining, restarting from the beginning will be needed.[331] Consequently, experts use a hierarchical retrieval scheme with different landmarks that allow resuming the performance, without stopping or starting all over.[332] Such content-addressable memory functions as a safety net, should memory failures happen.[333] Therefore, musical expertise significantly conditions the usage of effective practice strategies,[334] although these may vary and are conditioned to the repertoire.[335]

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326 Beilock and Carr (2001), DeCaro et al. (2011), Otten (2009).
327 Beilock and Carr (2001: 715). See also Baddeley et al. (2020: 149), De Caro et al. (2011), Flegal and Anderson (2008), Mackenzie (1990), Schooler and Engstler-Schooler (1990).
328 Otten (2009: 584).
329 Austin and Berg (2006), Barry and Hallam (2002), Carter and Grahn (2016), Ginsborg (2004: 129), Hallam (1997: 95-96), Renwick and McPherson (2000), Sloboda (1985: 96).
330 Chaffin et al. (2008).
331 Sloboda (1985: 91).
332 Chaffin and Lisboa (2008), Chaffin et al. (2002; 2010).
333 Chaffin and Logan (2006), Chaffin et al. (2008: 352).
334 Barry and Hallam (2002), Hallam (1995a; 1997), Hallam et al. (2012), Mishra (2019).
335 e.g., Chueke and Chaffin (2016), Fonte (2020), Ginsborg and Chaffin (2011a; 2011b), Jónasson and Lisboa (2015), Mishra and Fast (2015), Soares (2015), Thomas (1999), Tsintzou and Theodorakis (2008).

Based on Ericsson's (1988) principles of expert memory, Ericsson and Kintsch (1995) developed the notion of *long-term working memory*, suggesting that experts rely on LTM's greater capacity, accessing the information stored there, whenever they need it, through WM and by using retrieval cues. This theory aimed to explain how mastering a complex cognitive skill such as playing chess or performing a piano work from memory is accomplished, despite this requiring greater resources than STM's limited storage.[336] Therefore, Long-Term Working Memory Theory posits that when experts engage in skilled and complex cognitive tasks of their domain, they access content stored in LTM (e.g., patterns, hierarchical retrieval structures). Nevertheless, Ericsson and Kintsch (1995) neither define these terms nor detail how these operate.[337] Such fast access to LTM's content and the ability to successfully memorise vast amounts of new information makes it seem as if the expert's WM capacity was greater than the rest.[338]

Originally, Ericsson and Kintsch (1995) proposed that experts can use these retrieval structures efficiently and swiftly, regardless of whether the content to memorise is ordered or not. However, this assumption received criticism: this was only the case when experts previously learned the relevant retrieval structures that permit identifying the underlying patterns presented. Otherwise, expertise is not so advantageous when information is presented in random order,[339] since 'distorting the natural structure of the material impairs recall performance' (Gobet, 2015: 50). Such results were also found for post-tonal music, in which expert practitioners might not be as efficient as they would be with tonal music.[340] However, the novelty of facing unfamiliar post-tonal music and the corresponding strategies needed to make sense of such material can contribute to enhancing the memorisation of

[336] Ericsson and Delaney (1999).
[337] Foroughi et al. (2016), Gobet (2015: 50).
[338] Ericsson et al. (2017), Guida et al. (2013).
[339] Coughlin and Patel (1987), Ericsson et al. (2017), Gobet (2015: 50-51), van Kesteren et al. (2012).
[340] e.g., Fonte (2020), Halpern and Bower (1982).

such repertoire.[341] While exploratory, this result aligns with general learning findings stating that incongruent or novel information can sometimes be 'better remembered' due to distinctiveness (van Kesteren et al., 2012: 211).[342] Nevertheless, the benefits associated to expert memory disappear when content surpasses the scope of the expertise domain.[343]

Existing memorisation strategies are now discussed, along with how expert memory interacts with these.

2.4 Musical Memorisation

This last section reviews models for learning periods and musical memorisation strategies.

2.4.1 Learning Periods

Practitioners structure practice into different learning periods to memorise a musical work. The resulting models were progressively refined with more exhaustive research designs, from interviews to longitudinal case studies. Generally, memorisation comprises an initial exploration, followed by sectional work, integration of sections, evaluation of flaws and specific preparation (e.g., run-throughs) for public performance.

Wicinski (1950) developed a three-stage model based on interviews with ten Russian pianists.[344] Amongst these, three did not distinguish different learning periods when preparing a new piece, whereas the remaining seven established three distinct stages. The first period involved becoming acquainted with the music and making initial performing

[341] Jónasson and Lisboa (2015; 2016).
[342] See also Chee and Goh (2018), Eysenck (1979b), Hunt (2013), Tulving and Kroll (1995), von Restorff (1933).
[343] Chase and Ericsson (1982), Gobet (2015).
[344] Cited in Miklaszewski (1989: 96). Wicinski's (1950) original article in Russian is available here: http://elib.gnpbu.ru/text/izvestiya-apn_vyp25_1950/go,171;fs,1

decisions. The second consisted of practising to master technical challenges. Finally, the third focused on building the ultimate version of the piece, by repeatedly playing through the music.

A second model is Chaffin et al.'s (2002: 93-138), in which six stages are identified from a longitudinal case study with pianist Gabriela Imreh.[345] In this, Imreh learned the three-and-a-half-minute third movement of Bach's Italian Concerto. The learning stages were:

> 1) Preliminary scouting of the piece.
>
> 2a) Work by sections.
>
> 2b) The grey stage, in which detailed monitoring is progressively substituted by automation of playing.[346]
>
> 3a) Putting it together.
>
> 3b) Polishing.
>
> 4) Maintenance of the piece, in preparation for the public performance.

Chaffin et al. (2002) divide Wicinski's (1950) second stage into sectional work and the grey stage; and the third stage into putting it together and polishing. Finally, an additional final phase reflects maintenance rehearsal and preparation for public performance. Similarly, Chaffin et al. (2010) provide a third model with a longitudinal case study with cellist Tânia Lisboa,[347] while learning the 5-minute Prelude from Bach's Suite No. 6. In this, sectional work and practice towards linking sections do not happen linearly, but alternate with each other, as Figure 2.2 shows.

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[345] Gabriela Imreh (2017) *Biography*. Available at: https://www.gabrielaimreh.com/biography [Accessed 23 December 2022].
[346] The length of this stage may vary conditioned by the technical challenges of the piece (Chaffin et al., 2002: 100-101).
[347] Royal College of Music (2022) *Dr Tania Lisboa*. Available at: https://www.rcm.ac.uk/research/people/details/?id=91142 [Accessed 23 December 2022].

Learning period	Stage (main goal)	Cycle	Session	Duration (hr/min)	Weeks	Breaks	Public performance
1. Initial learning	1. Explore	Putting-together	1	0:20			
		Section-by-section	1–10	5:38	3		
					6	Break 1	
		Section-by-section	11–14	2.03	2		
	2. Smooth out	Putting-together	15–16	0:48	1		
		Section-by-section	17–20	4:19	3		
	3. Listen	Putting-together	21–26	1:51	3		
					34	Break 2	
2. First re-learning		Putting-together	27	0:10			
		Section-by-section	28–30	1:50	1		
		Putting-together	31–32	0:43	1		
					16	Break 3	
	4. Rework technique	Section-by-section	33–35	2:24	1		
	5. Prepare performance	Putting-together	36–37	0:41	1		
		Section-by-section	38–44	1:38	3		
		Putting-together	45–47	0:29	1		1–2
					5	Break 4	
		Not recorded	48–53	3:02			
		Putting-together	54–67	8:04	1		3–8
					82	Break 5	
3. Second re-learning		Putting-together	68–69	0:49	2		
		Putting-together	70–72	2:12	1		
		Putting-together	73–75	1:16	1		9–10

Figure 2.2: Distribution of practice sessions from Chaffin et al. (2010: 10), along with the duration of learning periods, stages and cycles, and how these relate to the public performances.

Moreover, Chaffin et al. (2010: 11-12) suggest a different terminology, merging Polishing and Maintenance into a single phase.[348]

1) Explore

2) Smooth out

3) Listen

4) Rework technique

5) Prepare performance

The above model fits within Wicinski's (1950), since it identifies a first stage of exploring initial ideas, alternating specific technical work (Smooth out, Rework technique) with a stage of trial rehearsals (Listen, Prepare performance).

[348] The sixth learning period suggested by Chaffin et al. (2002) was added to describe an additional stage that the pianist needed to master the piece, in preparation for its public performance (Chaffin et al., 2002: 220).

Finally, two models are provided for post-tonal music through longitudinal case studies with practitioners-researchers. The first is Soares (2015: 44-47), who analysed his learning of the two-and-a-half-minute main solo piano cadenza in Olivier Messiaen's *Oiseaux Exotiques* (1955-56) throughout a five-step process:

1) Understanding: Listening and overview of the score.
2) Sectional: Work in short segments.
3) Re-approach: Integrated practice to connect the short segments together.
4) Evaluation: Further development of integrated practice, to build up the performance.
5) Preparation: Final work to prepare for the performance and solve memory pending issues.

The second is Fonte (2020: 130-137), who memorised a 10-minute commissioned piano work. Due to the obstacles that extended techniques posed on the initial preview and exploration of the piece, Fonte decided to move early to deliberate memorisation, obtaining the following model:

1) Reading/Exploring
2) Deliberate Memorisation
3) Interpretative/Big Picture
4) Preparing for Performance

These models for tonal and post-tonal music cannot be taken as absolute, since they are developed from a non-practitioning method,[349] or based on a single practitioner's experience.[350] Nevertheless, all indicate a tendency to broadly structure learning as a general-detail-general three-part basis. This aligns with Mishra's (2005: 77) theoretical model of

[349] Wicinski (1950), reported by Miklaszewski (1989: 96).
[350] Chaffin et al. (2002; 2010), Fonte (2020), Soares (2015).

memorisation based on a literature review, which identifies three general stages: preview, practice and over-learning. The preview stage comprises three different overviews: notational, aural and performance. The practice stage consists of notational practice, which involves incidental memorisation and associative chaining derived from score-based practice; and conscious memorisation, which corresponds to deliberate memorisation.[351] Finally, the over-learning stage is divided into re-learning, automatisation and maintenance rehearsal. All these stages are flexible, depending on individual learning styles, repertoire difficulty, goals, background, personal ability, and the performer's previous expertise or *enculturation*.[352] Mishra's (2005: 77) model also reinforces the importance of firstly developing an overview of the piece,[353] to then structure deliberate practice by segmenting the piece as needed,[354] until this is understood and mastered.[355]

The following section reviews the main memorisation strategies for music.

2.4.2 Musical Memorisation Strategies

Performers memorise using an idiosyncratic combination of visual, aural and kinaesthetic memories.[356] Nonetheless, an individual's learning style might convey certain preferences and can be classified accordingly.[357] *Visual learners* rely on the recognition of visual patterns (e.g., hand and keyboard shapes), and visualising the score. *Aural learners* benefit from auditory

351 Mishra (2005: 79-80). See also Chaffin et al. (2008), Fonte (2020: 44), Hallam (1997), Mishra (2010).
352 Mishra (2005: 76-78).
353 Chaffin et al. (2003: 465-466; 2013), Mishra (2004), Neuhaus ([1973] 2006: 17).
354 Chaffin and Imreh (1997a; 2001), Chaffin et al. (2002: 248-250), Ericsson (2013), Fonte (2020), Gerling and Dos Santos (2017), Ginsborg (2004), Lefkowitz and Taavola (2000), Miklaszewski (1989; 1995), Miklaszewski and Sawicki (1992), Mishra (2002; 2005; 2011), Soares (2015), Williamon and Valentine (2002).
355 Austin and Berg (2006), Barry and Hallam (2002), Carter and Grahn (2016), Chaffin (2011: 691), Chaffin and Logan (2006), Chaffin et al. (2004), Christensen et al. (2016), Ginsborg (2004: 129), Hallam (1997: 95-96), Lisboa et al. (2018), Renwick and McPherson (2000), Sloboda (1985: 96).
356 Chaffin et al. (2002), Jones (1990), Mishra (2007), Odendaal (2019), Svard and Maack (2002).
357 Mishra (2004: 233; 2005: 81-83), Svard and Mack (2002).

input for pattern recognition. For perfect-pitch possessors, this might involve memorising through listening,[358] whereas those experiencing synaesthesia develop additional associations between colour and sound.[359] Finally, *kinaesthetic learners* memorise through physical movement and sensation. Along with the Sensory Learning Styles, musicians can also follow an Analytical Learning Style by engaging conceptual memory to chunk according to familiar patterns and structures.[360] This procedure depends on the performer's ability to identify and engage relevant knowledge, which in post-tonal music might either involve trying to fit the information into a tonal framework,[361] or chunk according to other spotted patterns or known composition principles useful for that purpose.[362] Either way, engaging conceptual memory is important since, although 'music is performed serially, the musician's brain perceives it as a web of connections' (Mishra, 2010: 17). Hence, combining all these learning styles leads to a multimodal representation, which can also involve emotional input.[363]

Furthermore, memorisation can happen implicitly, as an outcome of practice; or explicitly, by engaging conceptual memory. These are known as *incidental memorisation* and *deliberate memorisation*, respectively.[364] Novices and advanced students mostly memorise incidentally,[365]

358 Brodsky et al. (2003; 2008), Ginsborg (2004: 130-131), Haueisen and Knösche (2001), Keller (2012), Kopiez and Lee (2006; 2008), Peretz and Zatorre (2005), Zatorre et al. (1994; 2007).
359 According to the American Psychological Association, *synaesthesia* is 'a condition in which stimulation of one sense generates a simultaneous sensation in another' (retrieved from https://dictionary.apa.org/synesthesia). In music, the most common is to repeatedly experience a certain colour for each tonality or note (Bernard, 1986; Itoh and Nakada, 2008; Peacock, 1985; Simner et al., 2006; Ward et al., 2006).
360 Chaffin and Imreh (1997a: 316), Chaffin and Logan (2006), Chaffin et al. (2002), Fonte (2020: 318-319; 439-450), Hallam (1997), Halpern and Bower (1982), Miller (1956), Mishra (2005), Oura and Hatano (1988), Sloboda et al. (1985), Soares (2015: 148), Tsintzou and Theodorakis (2008).
361 Chueke and Chaffin (2016), Fonte (2020), Gordon (2006: 84), Miklaszewski (1995), Nuki (1984), Ockelford (2011: 237), Oura and Hatano (1988), Sloboda et al. (1985), Soares (2015: 75; 194), Tsintzou and Theodorakis (2008: 8). Even further, the musical savant participant in Ockelford (2011: 237) reconstructed the pitch organisation of a post-tonal piece by Schoenberg into a more coherent 'quasi-tonal framework', when recalling it from memory. A similar result was observed by Sloboda (1978), in which his participants had to sight-read a score that had been manipulated by the researcher to contain some tonal incongruences. Without knowing that, participants unconsciously corrected those outlier notes to fit well within the corresponding tonality, as they sight-read through the piece.
362 Chueke and Chaffin (2016), Fonte (2020: 106-108; 134; 293; 298; 318-319; 439-450; 452), Li (2007), Soares (2015), Tsintzou and Theodorakis (2008).
363 Baddeley et al. (2020: 188), Gabrielsson (2009).
364 Fonte (2020: 44), Hallam (1997), Mishra (2010).
365 e.g., Hallam (1997: 94-95).

whereas experts tend to memorise deliberately using their knowledge, although this is not always the case for professional musicians.[366] There are four memory processing strategies, both for tonal and post-tonal music:[367] *segmented*, which involves practising sections separately and eventually linking them; *additive*, a similar process but by lengthening the segment itself; *holistic*, the repeated performance of the whole piece, regardless of whether any mistakes or lapses happen; and *serial*, which consists of a holistic strategy that when errors occur, the performance is restarted.[368] In Mishra's (2002; 2011) studies, those subjects memorising faster generally used additive and holistic strategies, whereas slower memorisers tended to use segmented and serial strategies. However, the excerpts used in both studies were brief and straightforward. Consequently, implementing an additive strategy in a longer and more challenging piece might require further steps and more time. A similar reasoning applies to the holistic approach. The studies were completed with different instrumentalists, hindering the comparison of the strategies' effectiveness across the same instrument. Furthermore, observational and longitudinal studies showed that longer and post-tonal pieces require a segmented approach for tackling unfamiliarity, and the corresponding technical and interpretative challenges.[369] Despite this, the main processing strategy for both novices and professionals is *rote memorisation*, which consists in the automaticity through repetition using kinaesthetic memory.[370] Experts tend to complement this method with strategies based on conceptual memory, using repetition as an *overlearning strategy*.[371] This is the continuation of practice beyond the point that the piece is memorised, since the performer is still not confident enough for public performance.[372]

366 e.g., Chen (2015: 94-138), Fonte (2020: 103-104), Hallam (1997: 90-91).
367 e.g., Chaffin et al. (2002), Fonte (2020), Mishra (2002; 2004), Soares (2015).
368 Mishra (2002; 2004: 232; 236).
369 Chueke and Chaffin (2016), Fonte (2020), Soares (2015), Tsintzou and Theodorakis (2008).
370 Baddeley et al. (2020: 148), Chaffin et al. (2002), Chen (2015: 147-148), Fonte (2020: 109; 156; 424-425), Hallam (1997).
371 Hallam (1997), Rubin-Rabson (1941c; 1941d).
372 Chaffin et al. (2002), Hallam (1997), Mishra (2004: 233), Rubin-Rabson (1941c; 1941d).

Another crucial aspect of memorisation is how practice sessions are allocated. These can be *distributed*, dividing practice into multiple short sessions over a certain period; or *massed*, involving longer and fewer sessions, concentrated in a shorter timeframe.[373] Massed practice might seem easier, further focused and immediately effective. However, it does not result in significant retention in LTM:[374] performance might improve during the session, but motivation and attention decrease with time due to fatigue, which limits or even reverses improvement.[375] Alternatively, distributed practice is superior for retention and time efficiency of both declarative and procedural memories,[376] even for music.[377] Moreover, such superiority increases when a non-practice gap is placed between sessions, preferably with a different activity.[378] Mazza et al. (2016) suggested that interspersing practice sessions with sleep was the best option for boosting this *spacing effect*.[379] This result was also found by Rubin-Rabson (1940a), despite not attributing such finding to sleep-dependent consolidation.[380] Nonetheless, this spacing effect declines when such periods without practice are too extensive.[381]

The advantages of distributed practice are not costless: memorisation becomes slower and harder,[382] since it is easier to recall content continuously practised through massed practice, than retrieving information learned in another practice session. Also, rest intervals placed

373 Baddeley et al. (2020: 120), Carter and Grahn (2016), Rubin-Rabson (1940a).
374 Cepeda et al. (2006; 2008), Dail and Christina (2004), Rubin-Rabson (1940a), Shea et al. (2000), Tsutsui et al. (1998).
375 Walker (2005: 54).
376 Cepeda et al. (2006; 2008), Dail and Christina (2004), Dunlosky et al. (2013), Gerbier and Toppino (2015), Kim et al. (2019), Shea et al. (2000), Soderstrom et al. (2016), Tsutsui et al. (1998).
377 Allen (2013), Carter and Grahn (2016), Cash (2009), Duke and Davis (2006), Duke et al. (2009), Rubin-Rabson (1940a), Simmons (2011), Soares (2015: 193-194; 205).
378 Baddeley et al. (2020: 120; 153), Mazza et al. (2016), Soderstrom et al. (2016).
379 Benson and Feinberg (1975), Castaldo et al. (1974), Cepeda et al. (2008), Dail and Christina (2004), Ebbinghaus ([1885] 1913), Kim et al. (2019), Shea et al. (2000), Soderstrom et al. (2016).
380 Sleep research was in a premature stage in the 1940s since the effect of sleep on memory was not rigorously studied until the 1990s (King et al., 2017). Concretely, the first to suggest how sleep should be combined with learning to prompt consolidation was Smith (1985).
381 Baddeley et al. (2020: 153).
382 e.g., Baddeley and Longman (1978).

between distributed sessions prompt forgetting, requiring a greater effort to recall such content. The *desirable difficulty hypothesis* states that this extra difficulty triggers deeper cognitive processes, eventually leading to longer term retention.[383] Therefore, the harder this process is, the stronger the resulting memory will be.[384] Furthermore, the distributed-practice effect relates to the testing effect,[385] which results from attempting frequent intentional recalls for prompting LTM and successful retrieval.[386] The testing effect is stronger when a significant effort is made to retrieve such content. Thus, learning information in distributed sessions boosts this effect, given the time elapsed between one session and the other. Likewise, the testing effect may strengthen the impact of distributed practice in a similar fashion.[387] Encoding the same content in different ways, also known as *encoding variability*, enriches further the memory trace and contributes to the distributed-practice effect, since it is more likely to take different approaches on different days than on a massed practice session.[388]

Finally, memory is strengthened simply by remembering, thus mental practice contributes further to the testing effect.[389] Moreover, mental practice can be a complement to physical practice,[390] involving kinaesthetic, visual, emotional or sensory imagery; and mental rehearsal, including analysis and mental run-throughs.[391] Concretely, both structural analysis and pitch imagery are amongst the most effective mental strategies to enhance physical performance.[392]

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383 Bjork (2014), Bjork and Bjork (2011), Schmidt and Bjork (1992).
384 Bjork (1975), Bjork and Bjork (1992).
385 Dunlosky et al. (2013), Soderstrom et al. (2016). The testing effect was further discussed earlier in this chapter.
386 Adesope et al. (2017), Bahrick et al. (1975), Bjork (1975), Karpicke and Roediger (2008), Linton (1975), Soderstrom et al. (2016).
387 Baddeley et al. (2020: 554), Dunlosky et al. (2013), Soderstrom et al. (2016).
388 Baddeley et al. (2020: 125), Craik and Lockhart (1972), Craik and Tulving (1975), Kerr and Booth (1978), Memmert (2006), Shoenfelt et al. (2002).
389 Baddeley et al. (2020: 127), Bjork (1975; 2014), Bjork and Bjork (2011), Schmidt and Bjork (1992).
390 Bernardi et al. (2013), Connolly and Williamon (2004), Driskell et al. (1994), Hinshaw (1991), Iorio et al. (2022), Keller (2012).
391 Bernardi et al. (2013), Brodsky et al. (2003; 2008), Clark et al. (2012), Ginsborg (2004), Hallam (1997), Rubin-Rabson (1937).
392 Bernardi et al. (2013), Brodsky et al. (2003), Highben and Palmer (2004).

However, mental practice needs to be combined with physical practice to be successful.[393] This suggests that a combination of mental and physical practice might be the most effective approach,[394] especially since by solely accessing conceptual knowledge, the corresponding motor areas associated with such content are activated.[395] Furthermore, combining mental and physical practice contributes to reducing 'physical overload', and preventing 'playing-related overuse injuries' (Iorio et al., 2022: 230).[396] How these types of practice are to be combined along with other strategies is decided using one's *metacognitive knowledge*: the ability to select the most effective ways to learn, identify potential obstacles, coordinate one's resources, and consciously monitor and assist one's learning progress.[397] Musicians' most common metacognitive strategies are planning, monitoring and evaluating, which are implemented to enhance performance.[398]

After reviewing the main cognitive, processing and metacognitive strategies for memorisation, mnemonics are discussed along with how these are implemented in music with Performance Cue Theory.

2.4.3 Mnemonics

Mnemonics are techniques[399] based on the principles of expert memory,[400] with which relevant pre-existing knowledge in LTM is activated 'to compensate for' STM's limited capacity and encode new content accordingly (Gobet, 2015: 40). However, mnemonics may

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393 Bernardi et al. (2013), Driskell et al. (1994), Highben and Palmer (2004), Lim and Lippman (1991).
394 Coffman (1990), Hinshaw (1991), Iorio et al. (2022), Keller (2012), Ross (1985), Rubin-Rabson (1941c).
395 e.g., Miller et al. (2018).
396 Keller (2012).
397 Berardi-Coletta et al. (1995), Colombo and Antonietti (2017), Fairbrother et al. (2021), Hallam (2001), Jabusch (2016), Karpicke et al. (2009), Ste-Marie et al. (2013), Veenman et al. (2006), Velzen (2017).
398 Antonietti et al. (2009), Colombo and Antonietti (2017), Hallam (2001).
399 Baddeley et al. (2020: 547; 558), Yates (2010).
400 Ericsson (1988), Ericsson and Kintsch (1995), Lehmann and Gruber (2006).

not be equally effective for music, due to their propensity to interference or distraction.[401] Instead, music's ready-made hierarchical structure makes it a better option for retrieval since mnemonics require recalling the whole sequence memorised, until the relevant information is found.[402] Consequently, musical memorisation is better explained with Performance Cue Theory.

Observational and longitudinal case studies were completed with singers,[403] cellists,[404] classical pianists,[405] jazz pianists,[406] guitarists[407] and ensemble,[408] to understand their thoughts and strategies when memorising and performing a selected repertoire. These studies focused on tonal music, with only some incursions to the post-tonal repertoire,[409] explaining which decisions the practitioner makes during practice: e.g., fingering, hand arrangements, dynamics, articulation, sound quality, phrasing. During rehearsal, most of these choices are automatised, but some become landmarks in the musician's mental map of the piece. These landmarks are referred to as *performance cues* and provide content-addressable access to the performer's memory:[410] the practitioner organises all these cues into a hierarchical retrieval structure,[411] even in the context of post-tonal music.[412] Therefore, highly rehearsed

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[401] Baddeley et al. (2020: 540-542), De Beni and Moè (2003). For example, in the case of the method of Loci, assigning the same place to difference pieces of information across different repertoire might prompt confusion. Also, imagining a visual image can clash with the visual appearance of the score or other elements internalised through visual memory: e.g., hand position.
[402] Chaffin and Imreh (2002), Chaffin et al. (2010; 2013), Ginsborg and Chaffin (2011a; 2011b), Williamon and Egner (2004), Williamon and Valentine (2002).
[403] Chaffin et al. (2021), Ginsborg (2002), Ginsborg and Chaffin (2009; 2011a; 2011b), Ginsborg and Sloboda (2007), Ginsborg et al. (2006a; 2006b; 2012; 2013).
[404] Chaffin and Lisboa (2008), Chaffin et al. (2010), Lisboa et al. (2004; 2007; 2009a; 2009b; 2011; 2013a; 2018).
[405] Chaffin (2007), Chaffin and Imreh (1994; 1997a; 2001), Chaffin and Logan (2006), Chaffin et al. (2002; 2003; 2013), Chueke and Chaffin (2016), Fonte (2020), Lisboa et al. (2013a; 2013b; 2015; 2018), Miklaszewski (1989), Soares (2015).
[406] Noice et al. (2008).
[407] Jónasson and Lisboa (2015; 2016). See also Aranguren (2009).
[408] Ginsborg et al. (2006a; 2006b; 2013), Lisboa et al. (2013a), Soares (2015: 92-104; 129-134).
[409] Chaffin (2007), Chaffin et al. (2021), Chueke and Chaffin (2016), Fonte (2020), Ginsborg and Chaffin (2009; 2011a; 2011b), Ginsborg et al. (2012), Jónasson and Lisboa (2015; 2016), Soares (2015).
[410] Chaffin and Lisboa (2008: 118), Chaffin et al. (2002; 2010), Chen (2015).
[411] Chaffin and Imreh (2002), Chaffin et al. (2010; 2013), Ginsborg and Chaffin (2011a; 2011b), Williamon and Egner (2004), Williamon and Valentine (2002).
[412] Chueke and Chaffin (2016), Fonte (2020), Soares (2015).

performance cues establish and function as a safety net, helping the expert musician to effortlessly monitor the performance, while preventing memory failure.[413] Performance Cue Theory proposes different retrieval cues: *structural*, for supervising the formal structure, including switches; *basic*, for technical aspects; *interpretative*, relating to parameters such as articulation, phrasing, dynamics or tempo; and *expressive*, that incur into the performance's emotional layer.[414] Outside solo repertoire (e.g., lied, chamber and ensemble music), performers may also develop *shared* cues in conjunction with the other musicians.[415]

All these cues were validated for post-tonal excerpts and full piano works.[416] However, given the huge variety of composition principles and challenges in this body of repertoire,[417] further cues were developed. For example, as a practitioner, Soares (2015: 75-88) used cues for interval relationships, hand shapes and fingering, keyboard shapes and patterns, voice leading, blocking, verbal association and rhythm. Some of these were presented by Nellons (1974), Li (2007) and Chen (2015: 76-82). Similarly, Fonte (2020: 322) discussed basic cues for extended techniques and body position; and Li (2007: 43-60) developed a method of six musical mnemonics, which operate as performance cues for mostly tonal music.[418] These are *inner speech*, involving different kinds of internal verbalisation (e.g., beat counting, solfège, word and verbal connotation);[419] *kinaesthetic*, as a result of memorising by repetition; *key note* and *imagery*, as a combination of aural and visual memories; *interval*, for finding enharmonic

413 Chaffin and Lisboa (2008: 118), Chaffin et al. (2010: 2-3), Chen (2015: 37).
414 Chaffin and Imreh (1997a), Chaffin and Lisboa (2008), Chaffin et al. (2002; 2009; 2010; 2021), Chen (2015), Chueke and Chaffin (2016), Ginsborg and Chaffin (2011a), Ginsborg et al. (2006a; 2006b), Lisboa et al. (2015).
415 Ginsborg et al. (2006a; 2006b; 2013), Lisboa et al. (2013a).
416 Chueke and Chaffin (2016), Fonte (2020), Soares (2015).
417 Auner (2017), Thomas (1999).
418 Concretely, Li (2007: 3) states that:

> The mnemonic may take any form: it may be a number, like a pin number, a name, a concise chunk of information, or something else. Whatever it is, this mnemonic comes to be associated in my mind with the correct execution of the passage in question. Indeed, the piece can be divided into a sequence of mnemonics, each referring to a segment which may be as short as a bar or two or as long as a page. But each one points the way forward to the next mnemonic, and thus provides (changing the metaphor) a series of signposts which guide me towards the successful completion of the work.

419 Li (2007: 46) associates verbal connotation with colour-coding.

equivalences or other interval relationships; and *relative*, for developing cues in less elucidating passages.[420] Despite these strategies summarising pianists' common memorisation practice,[421] including chunking according to tonal patterns,[422] these are idiosyncratic and tied to the specific examples Li uses for illustrating them, hence, a systematic method is not provided. Furthermore, her presentation is brief and limited, without explaining how these strategies could be generalised or implemented differently. Finally, Li's (2007) proposed mnemonics might function locally for a few notes, but it is not clear how these can be used in a broader level (e.g., whole section or piece, different repertoire). All these limitations in existing musical memorisation strategies are now discussed.

2.4.4 Existing Gaps in the Literature

Performance Cue Theory is the main approach for studying memorisation of tonal and post-tonal music.[423] This is more systematic and sophisticated than mnemonics to explain how musicians organise learning and memorisation according to their expertise and repertoire style.[424] Moreover, it explains well how chunking according to familiar patterns and structures strategically works for practitioners.[425] Nevertheless, while this theory elucidates the nature of a musician's mental representation and monitoring of performance, it does not provide any guidelines on how all these memory cues can be best combined: e.g., how switches should be encoded and practised, or how to identify patterns. Therefore, it is descriptive

[420] These strategies are also available in the author's commercial publication Li (2010).
[421] Cienniwa (2014), Mishra (2010).
[422] Chaffin and Imreh (1997a: 316), Chaffin and Logan (2006), Chaffin et al. (2002), Hallam (1997), Halpern and Bower (1982), Miller (1956), Mishra (2005), Oura and Hatano (1988), Sloboda et al. (1985).
[423] Chaffin (2007), Chaffin and Imreh (1994; 1997a; 2001; 2002), Chaffin and Lisboa (2008), Chaffin and Logan (2006), Chaffin et al. (2002; 2003; 2009; 2010; 2013; 2021), Chen (2015), Chueke and Chaffin (2016), Fonte (2020), Ginsborg (2002), Ginsborg and Chaffin (2009; 2011a; 2011b), Ginsborg and Sloboda (2007), Ginsborg et al. (2006a; 2006b; 2012; 2013), Lisboa et al. (2004; 2007; 2009a; 2009b; 2011; 2013a; 2013b; 2015; 2018), Noice et al. (2008), Soares (2015).
[424] e.g., Chaffin and Imreh (1997a), Chaffin et al. (2009; 2010), Chen (2015), Chueke and Chaffin (2016), Fonte (2020), Ginsborg et al. (2012), Lisboa et al. (2013a), Noice et al. (2008), Soares (2015).
[425] e.g., Chaffin et al. (2010), Chen (2015: 76-82), Soares (2015: 75-88).

instead of instructive. One could argue that providing a memorisation method is not the main goal of Performance Cue Theory, but to explain practitioners' memorisation strategies and individual learning differences.[426] However, this theory still ignores the influence of sleep and off-line learning for memory consolidation.[427]

Also, even if musicians effectively develop a hierarchical retrieval scheme to articulate all these performance cues, such memory hints do not allow the performer to reconstruct or deduce the content to which these provide access. Evidence of this problem is provided by the same studies using Performance Cue Theory, which report that memory is more reliable for section boundaries, which are likely to be attended with structural cues, than other locations.[428] Thus, as distance from these landmarks increases, associative chaining deteriorates, disrupting subsequent recall.[429] Similarly, landmarks established by basic cues are also *lacunae*: places that tend to be poorly recalled or are forgotten.[430] Hence, as with mnemonics, performance cues work, using Li's (2007: 3) own words, as 'a series of signposts', directing one's attention to the right track.

Consequently, although Performance Cue Theory effectively explains the expert performer's memorisation procedures, the theory itself is not "a memorisation method", but rather the structured explanation of that process, repeatedly used for articulating general suggestions or

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426 Mishra (2002; 2004; 2007), Odendaal (2019).

427 Albouy et al. (2013), Allen (2007; 2013), Cash (2009), Cash et al. (2014), Diekelmann and Born (2010), Duke and Davis (2006), Duke et al. (2009), Dumay and Gaskell (2007), Fenn et al. (2003; 2013), Fischer et al. (2002; 2006), Gais et al. (2000), Ji and Wilson (2007), Karni et al. (1994), King et al. (2017), Korman et al. (2003), Krakauer and Shadmehr (2006), Lahl et al. (2008), Lewis and Durrant (2011), Luft and Buitrago (2005), Maquet et al. (2000; 2003a), Mazza et al. (2016), Mednick et al. (2008), Peigneux et al. (2004), Rasch and Born (2013), Robertson (2009), Robertson et al. (2004b), Simmons (2007; 2011; 2012), Simmons and Duke (2006), Squire et al. (2015), Stickgold and Walker (2013), Stickgold et al. (2000; 2001), Timperman and Miksza (2019), Tse et al. (2007), van Hedger et al. (2015), van Kesteren et al. (2012), Wagner et al. (2004), Walker (2005), Walker and Stickgold (2004), Walker et al. (2002), Yordanova et al. (2008). See also section 2.2.2.2 for a review.

428 Begosh et al. (2010), Chaffin and Imreh (1997a; 1997b), Chaffin et al. (2002; 2010), Fonte (2020: 190), Ginsborg and Chaffin (2009; 2011a: 354; 2011b), Lisboa et al. (2009a; 2009b), Soares (2015: 23; 161).

429 Ginsborg and Chaffin (2011a: 354), Roediger and Crowder (1976).

430 Anokhina (2015), Ginsborg and Chaffin (2011a: 339).

guidelines for performers.[431] Like mnemonics, these can be regarded as a complimentary aid to memorisation, but not as the primary tool for that purpose. Similarly, Soares (2015) and Fonte (2020) do not provide memorisation methods but extend Performance Cue Theory to post-tonal music.

Accordingly, Conceptual Simplification addresses this gap of Performance Cue Theory and mnemonics.[432] A first prototype of this memorisation method was provided in Farré Rozada (2018), with which I proposed strategies for simplifying complex chords, identifying interval relationships, simplifying layers of complexity, conceptualising switches and devising structural dynamics maps. All these strategies are further discussed in Appendix A and emerged from a self-case study when memorising George Crumb's *Makrokosmos I* (1972): a 35-minute work comprised of 12 pieces involving extended techniques. While Conceptual Simplification's first prototype was effective for me as a practitioner, as demonstrated by a successful public performance with no memory issues,[433] it resulted from the experience of a single practitioner and musical work. Consequently, with this PhD, Conceptual Simplification was tested with a broader sample of repertoire and practitioners, leading to a further refined, extended and formalised three-stage version of the method, supported by a range of evidence of its effectivity. Moreover, Conceptual Simplification is also reframed as a method for scaffolding analysis and learning, beyond memorisation. Therefore, after reviewing relevant knowledge on memorisation for this thesis and identifying the literature's main gaps for musical memorisation, the next chapter discusses in detail this doctoral research's final version of Conceptual Simplification.

[431] For post-tonal piano music, see general guidelines provided by Fonte (2020: 326-328).
[432] See Chapter 3 for a thorough discussion of Conceptual Simplification.
[433] This performance happened within the George Crumb Festival on 16 February 2018, organised by the Royal College of Music.

Chapter 3: Conceptual Simplification

3.1 Introduction

This chapter explains the theoretical underpinning and implementation of Conceptual Simplification. First, an introductory section reviews how computer science and mathematics can enhance memory, and how the literature defines musical complexity. Then, Conceptual Simplification is thoroughly explained, focusing on the algorithms followed and how the method implements mathematical thinking. Finally, the method's strategies are discussed, according to its three main steps: Triage, Simplifying Layers of Complexity and Conceptual Encoding. Finally, a summary of how Conceptual Simplification fits into the literature is provided.[1]

3.1.1 Computer Science and Mathematics: Tools for Enhancing Memory?

It may be puzzling how human memory can relate to algorithms or mathematics: humans and computers think[2] differently and excel at different tasks.[3] For example, unlike humans, computers can process large amounts of data and complex calculations in record time.[4] However, humans and computers present two important similarities: a limited capacity and restricted timeframes to operate.[5] Furthermore, mathematics is amongst the best tools for problem-solving and identifying patterns,[6] also prompting computer science:[7] another means

[1] A summary of Conceptual Simplification is provided in Chapter 5.
[2] Here, I regard thinking in line with Dehaene's (2015: 3) definition of *intelligence*: a process that allows to convert 'unstructured information into useful and actionable knowledge'.
[3] Hassabis et al. (2017), Hawkins (2021), Jaarsveld and Lachmann (2017), Turing (1950).
[4] Should a mistake happen, that is attributable to whoever designed the algorithm, not the computer. However, artificial intelligence might change this (Hawkins, 2021).
[5] Cormen et al. (2009).
[6] Gardner ([1983] 2011: 152), Sáenz de Cabezón ([2016] 2020).
[7] Dodig-Crnkovic (2001), Turing (1950). Some of the mathematicians who established more notable milestones in this field are Gottfried Leibniz (1646-1716), Charles Babbage (1791-1871), Ada Lovelace (1815-1852) and Alan Turing (1912-1954). See Dodig-Crnkovic (2001) for a historical review, and Turing (1950) for a more technical discussion.

for solving problems.[8] Building on my training and experience in mathematics and computer science, Conceptual Simplification is my attempt at translating and adapting effective techniques from these fields to human learning in the musical domain. However, beyond the strategies proposed in this thesis, Conceptual Simplification advocates for a certain way of thinking and approaching analysis, learning and memorisation. Furthermore, the method's successful implementation does not require any previous scientific training.

In general terms, Conceptual Simplification operates following paradigms[9] used for optimising a computer's running time at completing a task, without surpassing its memory resources. In a closer view, Conceptual Simplification strategies are informed by mathematical thinking and its problem-solving techniques. As stated, strong reasons support this approach. First, computers have limited memory resources and need to complete tasks within a reasonable time.[10] Similarly, musicians have a limited WM capacity,[11] and finite time for practising conditioned by deadlines.[12] Therefore, musicians need tools to succeed despite these constraints. Given that computer science developed effective ways of overcoming these limitations, it is reasonable to consider what can musicians learn from these approaches. Secondly, mathematical problem-solving strategies can relate to musicians' attempts when approaching a new work: trying to identify familiar patterns,[13] while solving those challenges encountered.[14] Concretely, using mathematical strategies for enhancing understanding can be particularly helpful, since encoding post-tonal piano music according to standard tonal patterns is not always effective:[15] composers tend to develop their own

[8] Cormen et al. (2009), Levitin (2012).
[9] Here, the word "paradigm" refers to algorithm research designs in computer science (Levitin, 2012). Some of these are discussed in this chapter.
[10] Cormen et al. (2009).
[11] e.g., Cowan (2001; 2005).
[12] Berman (2010), Cienniwa (2014), Ginsborg (2004).
[13] Cook (1989), Sloboda (1985).
[14] Berman (2010), Chaffin et al. (2003), Thomas (1999).
[15] Aiello (2000), Nuki (1984), Oura and Hatano (1988), Sloboda et al. (1985).

composition principles, which can be unique and unprecedented.[16] Therefore, it is worth exploring how mathematics can enhance musicians' working procedures. But what does mathematical thinking exactly mean?

Given this problem below, there are different ways in which this could be approached:

$$1 + 2 + 3 + \cdots + 100 = ?$$

In a straightforward manner, this sum could be solved by adding one term after the other, until reaching the result. Despite this eventually leading to solving the problem, it is not the most efficient procedure. Alternatively, a pattern could be sought within this sum, noticing that by successively grouping in pairs the biggest and lowest terms, these always total 101:

$$\begin{gathered} 1 + 100 = 101 \\ 2 + 99 = 101 \\ 3 + 98 = 101 \\ 4 + 97 = 101 \\ \dots \end{gathered}$$

Hence, as 10-year-old Carl Friedrich Gauss figured out, the original problem simplifies into adding 50 times 101, which is the same as multiplying 50 by 101.[17] However, this is not only an effective strategy for solving the problem faster: the time initially spent analysing the problem permits developing a deeper understanding of it, leading to higher proficiency in solving similar problems in the future. Consequently, the original problem can be generalised[18] for all positive integers *n*:[19]

$$1 + 2 + 3 + \cdots + n = \frac{n}{2}(n + 1)$$

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[16] Aiello (2000), Auner (2017), Noyle (1987: 84), Thomas (1999).
[17] Meavilla (2021: 37).
[18] This process is also known as *inductive reasoning* (Sáenz de Cabezón, [2016] 2020).
[19] The set of integer numbers comprises natural numbers {1, 2, 3, 4, 5, …}, the number 0 and the inverse of natural numbers {…, -5, -4, -3, -2, -1} (Hardy and Wright, [1938] 1975). Hence, natural numbers can also be referred as positive integers.

Furthermore, by understanding the problem's underlying patterns and finding an effective problem-solving strategy, there is no need to memorise the formula as such. This can be forgotten and deduced when needed, by reconstructing the original steps. Accordingly, only one key idea must be remembered: how the terms of this sum are to be paired, which summarises with the symmetrical arrangement below:

$$\begin{array}{ccccccccc} 1 & + & 2 & + & 3 & + & \cdots & + & n \\ n & + & (n-1) & + & (n-2) & + & \cdots & + & 1 \end{array}$$

This example illustrates the main issue in how musicians approach a new piece: analysis, learning and memorisation are typically regarded as linear problems. On the one hand, less experienced musicians (i.e., novices) tend to memorise through mindless repetition,[20] exclusively relying on Sensory Learning Styles.[21] This non-declarative knowledge acquisition is generally slow,[22] since memorisation results from repeated practice.[23] On the other hand, expert musicians follow a more analytical approach that engages conceptual memory and implements problem-solving strategies for achieving certain goals.[24] Hence, in contrast with novices, experts effectively use their knowledge of tonal patterns to encode music, and memorise by triggering these familiar entities.[25] Additionally, declarative knowledge's swift acquisition strengthens the effectiveness of this approach.[26]

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[20] Austin and Berg (2006), Barry and Hallam (2002), Carter and Grahn (2016), Ginsborg (2004: 129), Hallam (1997: 95-96), Renwick and McPherson (2000), Sloboda (1985: 96).
[21] Mishra (2004: 233; 2005: 81-83).
[22] e.g., Luft and Buitrago (2005), Mishra (2019: 582).
[23] Ginsborg (2004: 129), Hallam (1997: 95-96), Sloboda (1985: 96).
[24] Hallam (1997), Mishra (2019), Tsintzou and Theodorakis (2008).
[25] Bower et al. (1969), Brewer (1987), Chaffin and Logan (2006), Chaffin et al. (2002), Ericsson (1988), Ericsson and Charness (1994), Ericsson and Kintsch (1995), Ericsson and Oliver (1989), Gobet (2015), Hallam (1997), Halpern and Bower (1982), Johnson (1970), Lehmann and Gruber (2006), Mishra (2005), Oura and Hatano (1988), Rosenbaum (1987), Sloboda et al. (1985).
[26] e.g., Walker (2005).

Nevertheless, when experts deal with post-tonal music's unfamiliar languages, this approach becomes more challenging and time-consuming,[27] since composition principles do not necessarily concur, making it harder to develop common codes.[28] Within this context, these practitioners can lose some of their advantage in respect to novices,[29] at being exposed to an unknown framework with less evident ways to proceed.[30] Thus, a frequent strategy used is fitting the music within a tonal framework, if possible, to restore some familiarity.[31] However, this process is slow and difficult: patterns are not explicit as in tonal music, but content is reinterpreted according to these,[32] significantly increasing the time investment that an equivalent tonal context would require.[33] Furthermore, the more challenging a musical work is, the higher the tendency in linearly segmenting it in smaller units than usual.[34] Therefore, practice becomes mostly ruled by a linear understanding of the music, according to the structure identified.[35]

Generally, approaching tonal music linearly is not an issue,[36] since this repertoire can be analysed and encoded with tonal theory.[37] However, post-tonal music may lack traces of tonality or standard theory,[38] although such unfamiliarity is still tackled with linear

[27] e.g., Fonte (2020: 89-91).
[28] Aiello (2000), Auner (2017), Noyle (1987: 84), Thomas (1999), Tsintzou and Theodorakis (2008: 9).
[29] Allard et al. (1980), Chase and Simon (1973a; 1973b), Norman et al. (1989), Starkes et al. (1987).
[30] Aiello (2000), Noyle (1987: 84), Thomas (1999), Williamon (1999b: 94). This was also found for musical savants with exceptional memories. The most famous case is that of pianist Derek Paravicini reported by Ockelford (e.g., 2007a; 2007b), who despite his extraordinary memory ability, was found to significantly struggle in the context of post-tonal music (Ockelford, 2011). See also a similar case with Sloboda et al. (1985).
[31] e.g., Chueke and Chaffin (2016), Fonte (2020), Gordon (2006: 84), Ockelford (2011), Soares (2015), Tsintzou and Theodorakis (2008).
[32] Gordon (2006: 84), Miklaszewski (1995), Nuki (1984), Oura and Hatano (1988), Sloboda et al. (1985), Tsintzou and Theodorakis (2008).
[33] e.g., Fonte (2020: 89-91).
[34] Chaffin and Imreh (1994), Miklaszewski (1989), Mishra (2002).
[35] e.g., Fonte (2020: 118-196), Ginsborg (2004), Soares (2015: 42).
[36] Aiello (2000), Chaffin (2007), Chaffin and Imreh (1997a: 333), Chaffin et al. (2002: 116-119; 2010: 6), Hallam (1997), Miklaszewski (1989; 1995), Nielsen (1999a), Tsintzou and Theodorakis (2008: 9), Williamon and Valentine (2002: 28).
[37] Aiello (2000), Chaffin and Imreh (1997a; 1997b), Gruson (1988), Hallam (1997), Miklaszewski (1989; 1995), Williamon and Valentine (2002).
[38] Chueke and Chaffin (2016), Fonte (2020), Jónasson and Lisboa (2015; 2016), Soares (2015), Thomas (1999), Tsintzou and Theodorakis (2008).

segmentation, to divide complexity into smaller units.[39] Nonetheless, these units could still be too complex to memorise: difficulty might not remain in the temporal dimension, but in how certain parameters are presented instead.[40] Also, excessive segmentation leads to a time-consuming process, since all parts are to be eventually unified:[41] the smaller these are, the more time needed.[42] This is why Conceptual Simplification reduces complexity differently, as later detailed, allowing to work with bigger chunks while identifying the main obstacles for understanding.

The next section reviews the literature's lack of definition for the term "complexity".

3.1.2 The So-Called "Complexity" of Post-Tonal Piano Music

Existing studies explored in what ways post-tonal music memorisation can differ or be more challenging than with tonal repertoire,[43] mostly focusing on pitch and structure. Generally, a musical work entails four main elements: pitch, harmony, rhythm and context. Pitch provides melody, direction and contour; while harmony settles tonality through chord progressions and texture. Similarly, rhythm involves meter, duration, accents and tempo; whereas context focuses on articulation, expressive markings, dynamics, form and musical structure.[44] Among these, melodic contour and tonality are fundamental in the perception of a musical work.[45] However, in atonal contexts, melodic contour achieves a more notable role,[46] for which

39 e.g., Fonte (2020: 118-196; 306; 314; 327), Ginsborg (2004), Soares (2015: 42; 45; 117; 210).
40 Fonte (2020: 118-196), Soares (2015: 34-185), Thomas (1999), Williamon (1999b: 94). For example, in her self-case longitudinal study, Fonte (2020: 134) reported not noticing a theme variation in the right hand since she was 'so focused on the complexity of the left hand', that she 'could not see what was musically important in that passage'.
41 Chaffin (2007), Chaffin and Imreh (1997a: 333), Chaffin et al. (2002: 116-119; 2010: 6), Nielsen (1999a), Tsintzou and Theodorakis (2008: 9), Williamon and Valentine (2002: 28).
42 Fonte (2020: 118-308), Miklaszewski (1995), Mishra (2002), Nuki (1984).
43 Chueke and Chaffin (2016), Fonte (2020), Ginsborg and Chaffin (2011a; 2011b), Jónasson and Lisboa (2015), Soares (2015), Tsintzou and Theodorakis (2008).
44 Fourie (2004), Wristen (2005).
45 Dowling (1971; 1972; 1978), Schmuckler (2009; 2016).
46 Morris (1987; 1993), Polansky and Bassein (1992).

different theoretical models were developed.[47] The main conclusion of such models is that atonal melodic contours tend to differ from tonal ones in terms of structure and function. Some examples could be a lack of hierarchy in harmony and texture, namely tonal cadences and leading voices.[48] Likewise, the metamorphosis of rhythm over the twentieth century, and particularly within atonality, was also a focus of study.[49] The resulting theories demonstrate that in atonal music, rhythm and time become two different entities, since compositions are not necessarily built on a beat-based principle with a steady metrical structure, as commonly happens in tonal music. Instead, 'innovational pitch structures go hand in hand with innovational rhythmic structures' (Forte, 1983: 240).

Therefore, in post-tonal music, each of the above-mentioned elements (i.e., pitch, harmony, rhythm, context) can be taken to an extreme of detail and even prominence, diverging from established traditional practices.[50] Along with these transformations, the conventional sound world of musical instruments is also expanded with *extended techniques*.[51] For the piano, this implies new ways of manipulating the keys (e.g., clusters, silent depressing, key-lip plucking, under-pressure playing), the pedals, the strings (e.g., pizzicato, harmonics, strum, scraping, rubbing, muting), the metal frames and the soundboard.[52] Despite practitioners progressively becoming more acquainted with extended techniques,[53] pianists need to devise efficient systems for preparing the piano,[54] and include new routines and gestures in their performance.[55] Hence, extended techniques provide an additional layer to piano playing, non-existent in traditional repertoire.[56]

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[47] e.g., Friedmann (1985; 1987), Marvin and Laprade (1987), Quinn (1999), Schmuckler (1999).
[48] Lewandowska and Schmuckler (2020).
[49] e.g., Forte (1980; 1983), Hasty (1981), Hyde (1984), Kramer (1985; 1988; 1996), Lewin (2007), Marvin (1991).
[50] Aiba and Sakaguchi (2018), Forte (1983), Lewandowska and Schmuckler (2020), Reina (2015).
[51] Auner (2017).
[52] Shockley (2018).
[53] Borkowski (2016), Shockley (2018).
[54] e.g., Bunger (1973), Crumb (1972), Thorvaldsdóttir (2011).
[55] Farré Rozada (2018), Fonte (2020).
[56] Chiantore ([2001] 2007), Gerig ([1974] 2007).

All these features might increase post-tonal music's difficulty, which was summarised by the literature with the term "complexity".[57] Nonetheless, a definition of this concept was not provided, only reporting specific examples related to practice-based experience.

As an exception, Jónasson et al. (2022: 193) designed a visual task in which three different criteria of musical complexity were established: the amount of visual information; how diverse this information was; and the variability of each musical parameter. The first criterion considered the density of the information: i.e., how many elements were presented. The second criterion measured the different features involved: e.g., the typology of durations, accidentals, rests, etc. Finally, the last criterion focused on what ways parameters could diverge from their standard canonical forms in a traditional context: e.g., melodic contour, pitch range, tonality, associated expectation to a composition principle, regularity of rhythmical patterns. While this description of complexity is detailed and precise, this model reflects the visual impact of notation and does not fully capture the "complexity" associated with learning, and more importantly, memorisation.[58] Alternatively, Soares (2015: 129) details the 'extremes of musical complexity' faced with Tristan Murail's *Treize couleurs du soleil couchant* (1978) from a practitioner's point of view. However, these are addressed for a single piece, and within the context of ensemble music, whose implications are beyond the scope of this thesis.[59] Similarly, Soares (2015) also explores Messiaen's solo piano music, but repertoire-based complexity is discussed locally, without providing a general model.

[57] Chueke and Chaffin (2016), Fonte (2020), Fonte et al. (2022), Ginsborg and Chaffin (2011a; 2011b), Jónasson and Lisboa (2015), Li (2007), Mishra and Fast (2015), Soares (2015), Thomas (1999).
[58] Jónasson et al. (2022), Thomas (1999).
[59] See Soares (2015: 129-134).

This thesis defines "complexity" for post-tonal piano music, after testing and refining Conceptual Simplification: a method purposely developed for tackling it. The definition proposed consists of three main types of complexity:

> A) Highly detailed and multi-layered scores, with contrasting sections and lacking repetition.
>
> B) Self-referencing scores with a significant presence of switches.
>
> C) Scores combining different degrees of complexity types A and B.

These are further discussed in Chapter 8. The next section reviews those areas of computer science and mathematics from which Conceptual Simplification was developed.

3.2 What is Conceptual Simplification?

Conceptual Simplification is a novel method for musical analysis, learning and memorisation. Although this was developed for post-tonal piano music, it is also suitable for tonal music and could be adapted to other instrumentalists, singers and conductors.[60]

During its implementation, the method's main principle is:

What essential information do I need to memorise to remember this music?

Accordingly, the method identifies and encodes the least amount of information needed to learn and memorise effectively. It also seeks ways of triggering, deducing or reconstructing the content of a passage, through a series of conceptual clues or instructions. That is

[60] Given the purpose of this thesis, I focus on implementing the method for memorisation. Nevertheless, the reader is welcome to use it for other purposes, including outside the musical domain.

translating into music the same procedure used for solving the mathematical problem in section 3.1.1.

Conceptual Simplification proceeds by slicing into layers of complexity a musical score, to scaffold learning and memorisation. Consequently, the practitioner is always comfortable with the amount of difficulty involved, without tackling more information than can be successfully managed or internalised. This procedure is justified since the difficulty of a musical work is not often perceived objectively, but rather conditioned by how and what strategies are used to address its challenges.[61] Hence, confronting complexity by layers intends to provide a more versatile approach than the traditional of linearly segmenting the score.[62] This prevents time-consuming practice and ineffective complexity simplification.[63] Accordingly, Conceptual Simplification's implementation comprises three steps:

1) **Triage**, which develops an overview of the musical work, encompassing identification of main challenges and how these can be conquered. This is achieved by implementing a series of mental and physical strategies.

2) **Simplifying Layers of Complexity**, which consists in temporarily and recursively removing parameters or features in the musical work that are an obstacle for learning or memorisation. The set of information removed with this process is a *layer of complexity*.[64] These layers are generally identified during the Triage but can vary and evolve as learning and memorisation progress, remaining flexible to the practitioner's

[61] e.g., Pike and Carter (2010).
[62] e.g., Fonte (2020), Soares (2015).
[63] e.g., Fonte (2020: 118-196) self-case study. See also Chaffin (2007), Chaffin and Imreh (1997a: 333), Chaffin et al. (2002: 116-119; 2010: 6), Fonte (2020: 118-308), Miklaszewski (1995), Mishra (2002), Nielsen (1999a), Nuki (1984), Tsintzou and Theodorakis (2008: 9), Williamon and Valentine (2002: 28).
[64] A *layer of complexity* can be the range of octaves in which a single melody is displayed, the extended techniques involved in a piece, a repetitive pattern or figuration that cyphers a chord or progression, or any other secondary information that contributes to the complexity of the music, without being the primary source.

needs. This second step comprises simplifying strategies for pitch, harmony, rhythm and context.

3) **Conceptual Encoding**, which consists in encoding and practising the patterns identified after removing one or more layers of complexity. This third step is frequently used in conjunction with the previous one, because once the relevant information is successfully chunked, encoded and memorised for that modified version of the musical work, the method restores a previously removed layer, restarting the process. This procedure is recursively repeated until the original passage is obtained.[65] During Conceptual Encoding, pre-existing knowledge is used to chunk according to a tonal framework or established composition principles. The practitioner can also use any conceptual or sensorial structures found useful for boosting meaning, especially when these contribute to engaging conceptual memory further.[66] This third step provides conceptualisation strategies for pitch, harmony, rhythm and context.

Implementing Conceptual Simplification to a musical work produces versions of reduced complexity by removing layers of information to enhance understanding. Once that amount of difficulty is assimilated, it can be slightly increased by restoring removed layers. The removal and restoration of layers are carried out mentally without modifying the score, while the piano is used throughout the process to internalise all these modified versions of the musical work. This is to facilitate that the practice done by layers is faster internalised and

[65] It can also happen that layers of complexity are not removed and added back linearly but following a different order in combination with Conceptual Encoding. The method also contemplates this possibility and allows some flexibility on this matter. This is because Conceptual Simplification aims to provide a model that is systematic enough to guide practice, but that can still be adjusted to the challenges presented and the individual learning styles.

[66] For instance, Soares (2015: 65) uses the verbal reference 'Washington D.C.' for encoding the starting notes of two similar sections (D and C, respectively), and so avoiding being confused by these switches during performance.

memorised, due to the additional effort associated with performing these transformations mentally.[67] However, should it be helpful, these transformations can be mapped on the score, or written down separately. Since the musical work is progressively simplified, the underlying patterns are identified, permitting to comprehend better the principles behind the composition. Therefore, making Conceptual Simplification a powerful tool for analysing music, in which existing theory falls short. For example, Schenkerian analysis and Set Theory provide valuable insight into harmony or pitch organisation, but miss other information.[68] Furthermore, the proposed strategies can be used individually or combined, including with those added by other practitioners. All this can be done without requiring expertise on a specific composer, genre or style, since the method always implements the same three steps: Triage, Simplifying Layers of Complexity and Conceptual Encoding. A detailed explanation of how these interact follows.

3.2.1 Algorithms: Conceptual Simplification's Paradigm

Conceptual Simplification operates as an algorithm. Thinking of algorithms leads to thinking of computers. But algorithms predate computers.[69] One of the oldest is Euclid's method for calculating the greatest common divisor (gcd) of two integers a and b.[70] According to Euclid's algorithm, computing gcd(a, b) is equivalent to calculating the gcd of the smallest of the two integers, here it is assumed that is b, and the remainder of dividing a by b (i.e., a mod b).[71] In short, gcd(a, b) = gcd(b, a mod b). This process is repeated until the remainder becomes zero,

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[67] Bjork (1975), Bjork and Bjork (2011).
[68] e.g., Chaffin et al. (2013), Forte (1973; 1980; 1983), Friedmann (1985; 1987), Hasty (1981), Morris (1987; 1993), Temperley (2011).
[69] Biggs ([2002] 2008: 157; 159), Dasgupta et al. (2008).
[70] Knuth ([1969] 1997: 334-335). The *greatest common divisor* (gcd) of a set of integers is the greatest positive integer that divides each of them (Cormen et al., 2009: 929). For example, the complete list of divisors of 27 is <u>1</u>, <u>3</u>, 9, 27 and the complete list of divisors of 12 is <u>1</u>, 2, <u>3</u>, 4, 6, 12. Therefore, the divisors that 27 and 12 have in common are 1 and 3. The greatest of these two is 3, and so 3 is the greatest common divisor of 27 and 12. In short, gcd(27, 12) = 3.
[71] Here "mod" stands for "modulo" and shall be used later in this chapter.

or equivalently, until the pair (d, 0) is reached, in which d is the greatest common divisor.[72] For example, gcd(20, 12) according to Euclid's algorithm is calculated as:

$$\gcd(20, 12) = \gcd(12, 8) = \gcd(8, 4) = \gcd(4, 0) = 4$$

This example illustrates that an algorithm is a set of ordered instructions designed to achieve a certain goal, which usually involves solving a problem. Regardless of whether the algorithm is implemented by a human being or a computer, it is a procedure that is given an input as an initial set of values and produces an output as a result.[73] Euclid's example also shows in which way algorithms can be mechanical, unambiguous, precise and efficient,[74] ensuring that the algorithm's running time in the worst-case scenario does not exceed the computer's resources, including memory.[75]

A common technique for ensuring algorithm efficiency is using *recursion*. This means solving the main problem by making the algorithm call itself repeatedly, as many times as needed, to deal 'with closely related sub-problems' (Cormen et al., 2009: 30). Again, this is exemplified with Euclid's algorithm, in which the same procedure is repeated, each time with a simpler version of the problem, until the final solution is achieved. Hence, recursive algorithms solve

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72 Euclid presented this algorithm in *Elements'* Book VII, Proposition 2 (see Euclid, [c.300 BC] 2013: 158-159). However, please note that Euclid develops it in geometrical terms, based on a series of axioms that he previously defines on page 157. The complete set of axioms defined by Euclid in the *Elements* is known as *Euclidean Geometry*. The modern terminology and notation used in this thesis can be found in Cormen et al. (2009: 934-935), along with its *pseudocode* implementation. In computer science, *pseudocode* is the preliminary form in which an algorithm is outlined before it is written in code (Biggs, [2002] 2008: 164; Cormen et al., 2009).

73 Biggs ([2002] 2008: 159), Cormen et al. (2009). For instance, given a sequence of numbers to be reordered in a particular way, different methods could be used. Each of these methods would imply a different set of instructions or steps to follow, hence, a different algorithm. In this case, the input of the algorithm would be the original sequence, and the output the sorted sequence. Clearly, ordering a sequence of numbers can be done manually by a human being or following lines of code by a computer. This is the implementation of the algorithm (Biggs, [2002] 2008: 165-167). Nevertheless, depending on the length of the sequence to be ordered, using a computer might be a faster and more efficient option. Also, algorithms are not limited to science but can also be used in basic daily routines, such as tying one's shoes. In this case, the input would consist of the shoes' lacings untied, and the output would be the shoes tied. This task can be completed without thinking, but it consists of an ordered and detailed sequence of steps that humans master, but that would be much harder for a computer (e.g., a robot) to attempt.

74 Dasgupta et al. (2008).

75 Biggs ([2002] 2008: 168-173), Cormen et al. (2009).

a problem by using solutions of simpler versions of the same problem. These simplified versions are easier to solve and imply simpler operations. Additionally, recursive algorithms are also frequently implemented to obtain certain values recursively.[76] Well-known examples include the Fibonacci sequence and fractals,[77] which respectively represent a numerical and geometrical outcome of this practice.[78] On the one hand, each term in the Fibonacci sequence (f_n) is recursively defined as the sum of the two previous ones:[79]

$$f_1 = 1, \qquad f_2 = 1, \qquad f_{n+1} = f_n + f_{n-1} \ (n \geq 2)$$

Hence, the resulting recursion can be represented as a binary tree, in which solutions are progressively obtained from previously calculated values, as Figure 3.1 shows.[80]

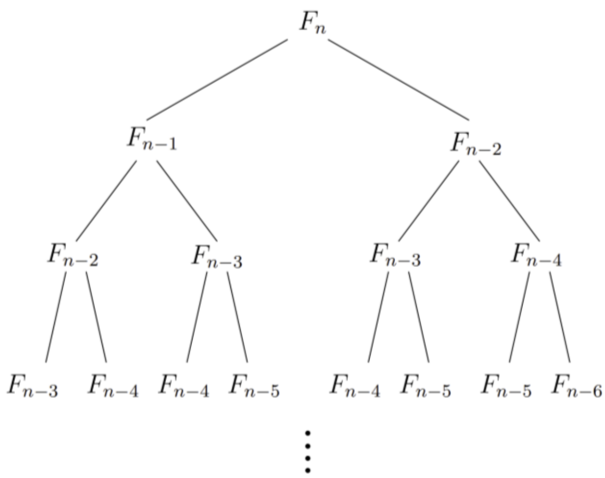


Figure 3.1: The binary tree with which the recursive definition of the Fibonacci sequence can be best illustrated.

[76] Biggs ([2002] 2008: 240-244).
[77] A *fractal* is a geometric pattern that repeats itself identically and infinitely on smaller scales, and it is generated with a recursion procedure (Mandelbrot, 1977).
[78] The Fibonacci sequence can also be represented geometrically through the golden ratio (Madden, 2005: 14-16; Newman and Boles, 1992: 216-218), although here it is used as a numerical example.
[79] Biggs ([2002] 2008: 32). It is easier to see from Fibonacci's recursive definition, that this produces an infinite sequence starting with 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610… The classical mathematical notation for defining the Fibonacci sequence is f_n. However, in computer science is more frequently used F_n or *fib* (Biggs, [2002] 2008: 32; Dasgupta et al., 2008: 12-14).
[80] Dasgupta et al. (2008: 5).

On the other hand, fractals benefit from recursion in that each iteration produces a more detailed picture of the fractal: e.g., the Sierpiński triangle illustrated in Figure 3.2.[81]

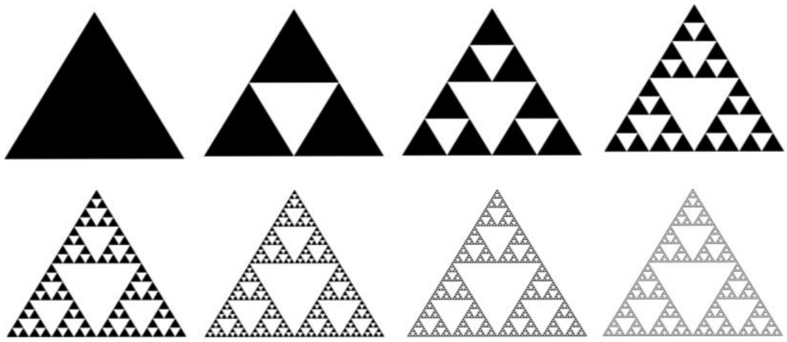


Figure 3.2: The construction of the fractal known as the *Sierpiński triangle* is based on recursion. Starting with an equilateral triangle, this is subdivided into four smaller equilateral triangles. Then, the central triangle of these is removed, which leaves an inversed white triangle. For each of the remaining black triangles, the same two previous steps are repeated: subdivision into four triangles and removal of the central one. Each repetition of this process conforms an iteration of this recursive algorithm, which can be infinitely repeated. The picture above illustrates the first seven iterations of this recursion, each time providing a more detailed representation of this fractal (Sierpiński, 1915).

Therefore, both the Fibonacci sequence and the Sierpiński triangle exemplify that recursion can also be used for computing a highly detailed representation of a defined problem, both numerically and geometrically. Thus, implementing recursion is not limited to simplifying complexity, but can also be used to increase it: this is how Conceptual Encoding progressively restores layers of complexity until the original version is obtained. However, how Conceptual Simplification simplifies complexity still needs to be defined. Hence, this section focuses now on the relevant paradigm associated with recursion that underpins this procedure: *divide-and-conquer*.

[81] Sierpiński (1915).

Divide-and-conquer algorithms involve three main steps at each level of the recursion. According to Cormen et al. (2009: 30), these are:

1) **Divide** the problem into a number of subproblems that are smaller instances of the same problem.

2) **Conquer** the subproblems by solving them recursively. If the subproblem sizes are small enough, however, just solve the subproblems in a straightforward manner.

3) **Combine** the solutions to the subproblems into the solution for the original problem.

Subproblems that are big enough to be solved recursively are denoted as the *recursive case*. Thus, when subproblems become straightforward to solve, it means that the *base case* and the lowest point of the recursion have been reached. Furthermore, using divide-and-conquer might imply having to solve subproblems that differ from the original problem. When that happens, this becomes part of the third step of combining the solutions.[82] Nevertheless, divide-and-conquer algorithms should only refer to those cases in which the original problem is partitioned into two or more subproblems. When only a single subproblem is obtained, then it is denoted as a *decrease-and-conquer* algorithm or *simplification*. In this case, the three stages of the algorithm become: *decrease* to a simpler problem, *conquer* the problem by solving that simpler version, and *extend* the solution of the simpler subproblem to the original one.[83] Again, Euclid's algorithm is an example of decrease-and-conquer, since it consists of a recursive simplification of the problem, which essentially works as a loop, that eventually leads to the main solution. Hence, to explain how divide-and-conquer works in practice, this is now illustrated with the *merge sort* algorithm.

Invented at the end of World War II, merge sort is a *sorting* algorithm that, given an initial sequence, the algorithm splits it into smaller units that are sorted and then merged back

[82] Cormen et al. (2009: 65).
[83] Brassard and Bratley (1995: 226-228), Levitin (2012: 131-168).

together into a sorted sequence.[84] For example, Figure 3.3 presents the step-by-step merge sort procedure for arranging in ascending order a given numerical sequence.

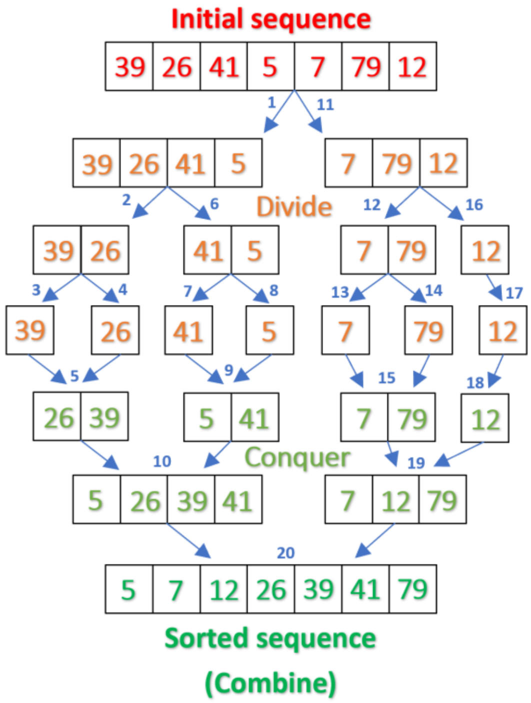


Figure 3.3: Step-by-step implementation of the *divide-and-conquer* paradigm, exemplified with the *merge sort* algorithm on a numerical sequence. The example highlights in different colours the main steps. In red, the original given sequence to sort. In orange, the transformations involved during the *divide* step, in which the sequence is recursively divided into two halves, until reaching individual units that are trivially sorted: i.e., the *base case*. In light green, the needed permutations for recursively sorting the two sub-sequences using merge sort during the *conquer* step. Finally, in dark green, the *combine* step, in which the final sorted sequence is obtained by merging the two sorted halves of the sequence.[85] Additionally, blue arrows and numbers break down the order in which the algorithm operates.

However, the divide-and-conquer paradigm is not limited to mathematics or computer science. This principle, or its Latin equivalent *divide et impera*, is widely used in politics and sociology, and its war applications are quite established.[86] In this thesis, it underpins Conceptual Simplification's implementation to music. Concretely, the steps "Divide" and "Conquer" are respectively translated into "Simplifying Layers of Complexity" and

[84] Knuth (1998: 158-162).
[85] Every time the algorithm needs to merge and sort two sorted sub-sequences, it uses the premise that these are sorted. Hence, for each position of the sequences, the algorithm compares which one has the smaller number, and fits them in the bigger sequence accordingly. For example, if the ordered sequences are x[1…k] and y[1…k], and these are to be merged and sorted into the final sequence z, the algorithm assumes that the first element in z shall be the smallest of x[1] and y[1]. Similarly, the rest of z[.] is built recursively (Dasgupta et al., 2008: 50-51).
[86] For example, see Sun Tzu's book *The Art of War* (c. 5th century BC).

"Conceptual Encoding", while the "Combine" step enacts completing the full internalisation of the music. Essentially, Conceptual Simplification's divide-and-conquer design directs how the musical texture is modified to enhance analysis, learning and memorisation. Notwithstanding, the results are not perceptible on the printed score, but on the internal cognitive processes that develop while the method is implemented: the output materialises with the practitioner's understanding and ability to perform the music, presumably from memory. However, Conceptual Simplification's main goal is not necessarily a memorised performance. This method simply provides a systematic approach for excelling at the desired performing context.

Additionally, while the algorithms here discussed are typically used on numerical or verbal data, a musical score is a much richer input of information, involving potential challenges for pitch, harmony, rhythm, and context.[87] Consequently, an additional set of computer science techniques is needed to ensure the method's flexibility for the idiosyncratic possibilities of post-tonal music. These are known as *transform-and-conquer*.[88]

Like divide-and-conquer and its simpler version decrease-and-conquer, the *transform-and-conquer* paradigm embraces a series of problem-solving strategies. However, this focuses on transforming the problem through two main steps:

1) **Transform** the problem into a version that is more manageable to solve.
2) **Conquer** the problem by solving its transformed version.

[87] Fourie (2004), Wristen (2005).
[88] Levitin (2012: 201-250).

The implementation of transform-and-conquer has three main variants, depending on how the original problem is transformed:[89]

a) **Instance simplification:** an instance of the problem, which is generally the input, is transformed into a version with a certain property that is more convenient or simpler. Thus, such transformation makes the problem easier to solve. For example, pre-sorting a list before attempting to solve its associated problem may elucidate a faster-solving approach. This is what was done in section 3.1.1, by re-ordering the sum $1 + 2 + 3 + \cdots + 100 = ?$ as:

$$(1 + 100) + (2 + 99) + (3 + 98) + \cdots + (50 + 51)$$

b) **Representation change:** a more efficient structure of the problem's instance is sought through transformation: i.e., changing the representation of the data. For example, when calculating a series of arithmetic operations (e.g., sums, multiplications) whose numbers are expressed in Roman numerals (I, V, X, L…) instead of Arabic numerals (0, 1, 2, 3…),[90] a representation change to make the calculations more fluent and efficient would be translating Roman numerals into Arabic.

c) **Problem reduction:** the problem is transformed into another that is known how to solve with an established algorithm or set of strategies. Once this latter problem is solved, its solution is transformed into a solution for the original problem. For example, suppose the problem is calculating the lowest common multiple (lcm) of *a*,

[89] Levitin (2012: 201-250).
[90] This is also known as the *decimal numeral system*.

b integers,[91] for which an efficient algorithm is not available. However, lcm(a, b) is relatable to the greatest common divisor (gcd) through the following formula:

$$\mathrm{lcm}(a,b) = \frac{a \cdot b}{\mathrm{gcd}(a,b)}$$

Since Euclid's algorithm is an efficient procedure for computing gcd(a, b),[92] implementing problem reduction consists in calculating gcd's value first, and then transforming its solution using the above formula to obtain lcm's.[93]

Using transform-and-conquer strategies takes additional time. However, its potential benefits reside in reducing the overall time needed for solving a problem.[94] Furthermore, these can also be implemented in music. Instance simplification could involve reordering a melody according to the chromatic scale, to comprehend how the pitches fit within a tonal chord or scale. A representation change happens when chords in different inversions are switched back to root position, for enhancing comprehension of the harmonic progression. Finally, problem reduction is used whenever attempting to fit atonal music into a tonal framework. Further details of how Conceptual Simplification uses these transform-and-conquer strategies is provided in the next section. Nonetheless, Example 3.1 summarises it with David Lang's *Cage*.

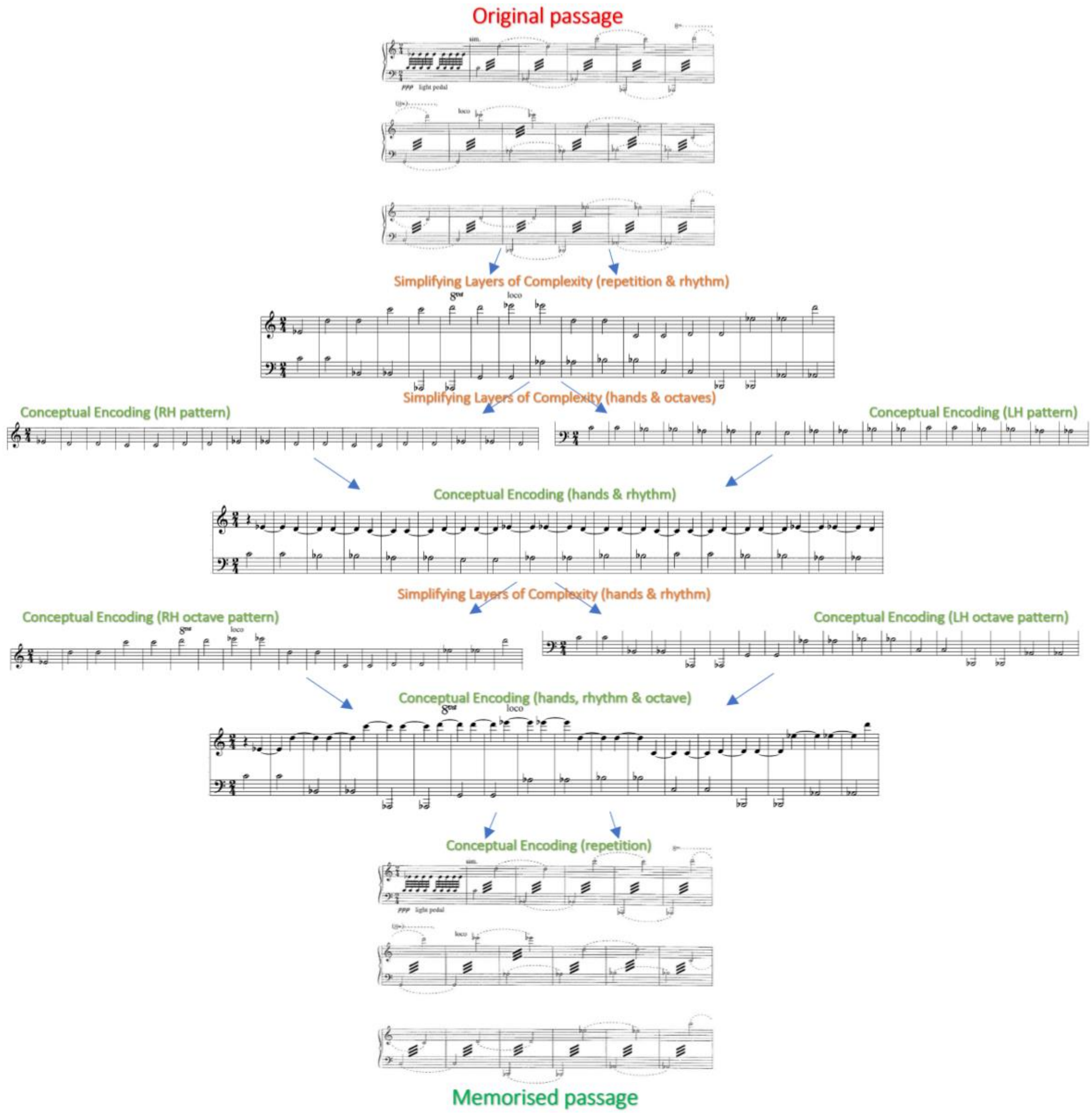
---

[91] The *least* or *lowest common multiple* (lcm) of a set of integers is the smallest positive integer that can be divided by all of them (Cormen et al., 2009: 939). For example, the multiples of 5 are 5, 10, 15, 20, 25, 30, <u>35</u>, 40, 45…; and the multiples of 7 are 7, 14, 21, 28, <u>35</u>, 42, 49... Since the first common multiple for these two numbers is 35, the lowest common multiple of 5 and 7 is 35. In short, lcm(5, 7) = 35.

[92] This is detailed in section 3.2.1 of this chapter.

[93] Levitin (2012: 241-242). For example, calculating lcm(24, 36) by implementing problem reduction is equivalent to computing $\frac{24 \cdot 36}{\mathrm{gcd}(24,\ 36)} = \frac{864}{12} = 72$. Hence, lcm(24, 36) = 72.

[94] Levitin (2012: 202).



Example 3.1: David Lang, *Memory Pieces* (1992), 'Cage', bars 1-18, step-by-step implementation of Conceptual Simplification. This example highlights in different colours the main steps of divide-and-conquer that translate here to Simplifying Layers of Complexity (Divide) and Conceptual Encoding (Conquer, Combine). In red, the original passage to memorise. In orange, the identification and simplification of repetition, rhythm, hands and octaves as layers of complexity: i.e., the *divide* step. The *base case* is reached after simplifying these four layers, leaving two straightforward patterns, one in each hand. In light green, the different patterns that are chunked, encoded and memorised, as layers of complexity are being progressively restored: i.e., the *conquer* step. Finally, in dark green, the *combine* step in which the original passage is fully memorised by restoring the repetition layer. Additionally, blue arrows clarify further the order in which the method is implemented.[95]

Example 3.1 shows divide-and-conquer's implementation to music through Conceptual Simplification. The first step divides the original passage into four subproblems: uniformity, hand coordination, independent melodies and changes of register. These are identified as

[95] Appendix B provides a higher-resolution version of Example 3.1.

layers of complexity, and labelled as repetition, rhythm, hands and octaves, respectively. Then, these layers are removed and restored as illustrated above. Once all four layers of complexity have been simplified, two independent pitch sequences are obtained: one for each hand. These are straightforward to solve (i.e., conquered) with Conceptual Encoding, by being synthesised into the following tonal patterns, in which each note is repeated twice:

RH: (E♭-D-C-D) x2 + (E♭-D) = Turn on D.

LH: C-B♭-A♭-G-A♭-B♭-C-B♭-A♭ = Oscillation on Cm, in the range of G-C (Perfect Fourth).

Hence, the base case reached by the algorithm indicates what is the essential information that needs to be memorised for a certain passage. In Example 3.1, the base case consists of the two independent patterns described above. From there, the conquer step implements Conceptual Encoding on different combinations of layers of complexity, by chunking, encoding and memorising its corresponding patterns. Finally, the combine step restores all layers simplified, adding back all complexity. In the above example, this merely consists in internalising the passage once the removed repetition is re-established.

The same example also shows how transform-and-conquer strategies can be used in Conceptual Simplification. For instance, the first step of removing repetition from the original passage is an implementation of the *problem reduction* strategy, since the musical texture is transformed into a melody with accompaniment:[96] a more common memorising problem. Likewise, simplifying octave transpositions is an example of a *representation change* strategy since the interaction between both melodies becomes clearer. Finally, removing rhythm or separating hands are different kinds of *instance simplification*. These facilitate recognising the sequences detailed above once their corresponding note repetitions have been removed, which is another example of instance simplification.

[96] See the penultimate version of the passage presented in Example 3.1, in which hands, rhythm and octave layers of complexity have been restored.

Until now, I detailed how Conceptual Simplification operates like an algorithm, by discussing three computer science paradigms that underpin the method: divide-and-conquer, decrease-and-conquer and transform-and-conquer. These were also used to illustrate Simplifying Layers of Complexity and Conceptual Encoding. After exposing Conceptual Simplification's general framework, the following section focuses on the role of mathematics in the method.

3.2.2 How Can Mathematical Thinking Be Translated into Music?

Conceptual Simplification strategies translate mathematical thinking and related techniques to music. Hence, this section explains how certain concepts and structures from number theory, geometry and group theory can be adapted for Conceptual Encoding and the abstraction of general rules. Concretely, to accomplish the musical equivalent of extending the problem…

$$1 + 2 + 3 + \cdots + 100 = 50 \times 101$$

…into a broader version that includes all possible problems of its kind:

$$1 + 2 + 3 + \cdots + n = \frac{n}{2}(n + 1)$$

Consequently, Conceptual Simplification also provides a systematic method for certain challenges or features.[97]

The benefits of implementing modular arithmetic from number theory, along with the conceptualisation of symmetry are now reviewed, which permits identifying or devising patterns to chunk and encode accordingly. However, given that post-tonal music sometimes omits tonal theory, patterns identified with Conceptual Simplification do not always fit that

[97] In other words, it can be used as a structured form of *deductive reasoning* (Sáenz de Cabezón, [2016] 2020).

framework. Instead, the method reveals the essential components of a musical work, to understand how these interact by layers. Since the method is flexible and does not impose an order on how strategies should be implemented, different perspectives could be taken for the same piece: practitioners should combine the strategies according to their needs.

As suggested, simplifying octave transpositions (i.e., the representation change strategy) can lessen an important obstacle in piano playing: the scattering of musical material throughout the keyboard and register of the instrument.[98] This feature increases during the nineteenth century, becoming particularly present in post-tonal music.[99] When this happens, Conceptual Simplification identifies octave transposition as a layer of complexity and simplifies it using *octave equivalence*,[100] which establishes that 'notes differing by a whole number of octaves' are equivalent (Benson, 2011: 146). In modular arithmetic, when two notes satisfy this property, these belong to the same *pitch class*.[101]

The reason why there are no computers with infinite memory, calendars of countless months and traditional clocks that do not reset every 12 hours, is modular arithmetic. This is a compendium of number theory methods frequently used to simplify problems that involve integers.[102] In modular arithmetic, integers a and b are equivalent if these are *congruent modulo* n, therefore, if these differ by a multiple of n, which is also an integer:[103]

$$a \equiv b \pmod{n} \leftrightarrow a - b \text{ is a multiple of } n$$

[98] The latter also includes using extended techniques, although this is not the main point I am making at this stage. The implications of extended techniques are more thoroughly discussed in the next section.
[99] Auner (2017), Chiantore ([2001] 2007), Thomas (1999).
[100] This approach can be effective for pianists, but might not work for other instrumentalists (e.g., violinists) or singers. This is because the technique required for playing at an octave higher or lower does not significantly vary for the piano, but it does for string instruments and singers. A similar argument could be used for wind instruments.
[101] Benson (2011: 333-335), Dasgupta et al. (2008: 25-27).
[102] Dasgupta et al. (2008: 25-33).
[103] Benson (2011: 334).

Thus, if *a* and *b* satisfy the above, *a* and *b* belong to the same *equivalence class*.[104] For example, 190 minutes is equivalent to 3 hours and 10 minutes, because 190 – 10 is a multiple of 60 (i.e., an hour). Hence, $190 \equiv 10 \pmod{60}$. However, this equivalence also works with negative integers. Given $57 \equiv -3 \pmod{60}$, this congruence indicates that it is the same to think 57 minutes past the hour than 3 minutes short of the next one. The musical translation of this approach models the keyboard's 12-note pattern (i.e., the chromatic scale), sequentially repeated either in lower or higher frequencies, depending on whether displacement happens to the left or right. Thus, if all notes in the piano keyboard are orderly numbered with integers, the resulting octave equivalence of $a \equiv b \pmod{12}$ condenses all these into the set {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11}, in which a pitch class is established for each note of the chromatic scale (see Figure 3.4).[105] Hence, the implementation of modular arithmetic through simplifying octaves as a layer of complexity circumscribes all pitches to a predefined range of an octave. These are reordered if necessary for facilitating its encoding and are transposed down an octave each time this range is surpassed: i.e., substituting the original pitch for its equivalent in that same pitch class.[106]

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[104] Biggs ([2002] 2008: 58-59).

[105] Benson (2011: 334-335). The standard nomenclature for defining a set of an equivalence class is $\{0, 1, \ldots, n-1\}$ instead of $\{1, 2, \ldots, n\}$. This is because within the congruence $a \equiv b \pmod{n}$, b is the remainder (i.e., the modulo or mod) when dividing a by n. Hence, by definition, $b \geq 0$ and $b < n$ (Dasgupta et al., 2008: 26-27). This can be illustrated with the example used before for time: $190 \equiv 10 \pmod{60}$. Here, 190 minutes are converted to 3 hours and 10 minutes by dividing 190 by 60, and 10 being the remainder of such division. Therefore, is not by chance that traditional clocks reset at 0 ~ 12 instead of 1.

[106] Cormen et al. (2009: 54; 928; 1164), Dasgupta et al. (2008: 26-27).

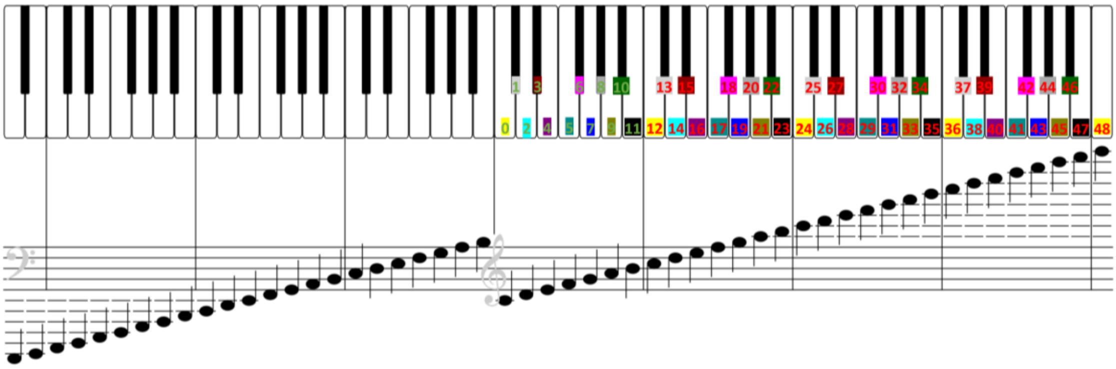

Figure 3.4: Implementation of modular arithmetic on the piano keyboard: octaves are simplified as a layer of complexity with Conceptual Simplification. The predefined range of an octave is numbered in light green, whereas those pitches that should be simplified to that octave are numbered in red. The 12 resulting *pitch classes* are highlighted in different colours, one for each note. These are C, C#, D, D#, E, F, F#, G, G#, A, A# and B. The same procedure is implemented to the pitches in the left side of the keyboard.

In summary, divide-and-conquer, decrease-and-conquer and transform-and-conquer ensure Conceptual Simplification's effectiveness at optimising practice and preventing cognitive overload. Accordingly, breaking down problems too complex to solve in their original form, as suggested by these paradigms, can be regarded as a sophisticated version of chunking,[107] while effectively tackling WM's limitations.[108] Similarly, Conceptual Simplification uses modular arithmetic on a smaller scale to systematise the identification and temporary removal of common information. For instance, given the sequence 4-6-8-10, all terms have in common being multiples of 2. Hence, modular arithmetic removes this common feature, revealing the underlying pattern 2-3-4-5. Likewise, Simplifying Layers of Complexity uses equivalence classes for all musical parameters:[109] since this approach is well-defined for pitch with pitch classes,[110] it can be simply adapted to the rest (e.g., rhythm, dynamics). Thus, simplification enhances the abstraction of the music's underlying patterns, which is a typical technique in mathematics and chess.[111] Consequently, less time and capacity are needed for

[107] Christensen et al. (2016), Gobet (2005), Gobet et al. (2001), Miller (1956).
[108] e.g., Cowan (2001), Miller (1956).
[109] This is illustrated with a musical work in Example 3.1.
[110] Benson (2011: 333-335). See also Figure 3.4.
[111] García (2013), Gardner ([1983] 2011: 152), Sáenz de Cabezón ([2016] 2020).

processing the remaining information, and general rules for encoding the music become clearer.

However, another important component of Conceptual Simplification is how these patterns are chunked and encoded. As reviewed, musicians use their training for recognising and forming patterns to chunk effectively.[112] With post-tonal music, familiarity is sought either using a tonal framework or established composition principles (e.g., Dodecaphonism, Set Theory)[113] that are familiar enough or useful for that purpose.[114] Nevertheless, research on musical memory ignored a frequent composition principle: symmetry.[115]

Several composers used symmetry in their works.[116] Since a full review is beyond the scope of this thesis,[117] this section concludes with some symmetrical structures from geometry and group theory that can be used in music.[118] The positive impact of using musical patterns to enhance mathematical thinking and abstraction was shown successful.[119] Therefore, Conceptual Encoding through symmetrical structures could be a first systematic exploration in the opposite direction. Concretely, the types discussed are translations, reflectional symmetries, glide reflections, rotational symmetries and permutations.[120]

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112 Bower et al. (1969), Brewer (1987), Chaffin and Logan (2006), Chaffin et al. (2002), Ericsson (1988), Ericsson and Charness (1994), Ericsson and Kintsch (1995), Ericsson and Oliver (1989), Gobet (2015), Hallam (1997), Halpern and Bower (1982), Johnson (1970), Koelsch et al. (1999; 2002), Krumhansl (1979), Krumhansl and Shepard (1979), Lehmann and Gruber (2006), Mishra (2005), Oura and Hatano (1988), Rosenbaum (1987), Schulze and Koelsch (2012), Sloboda et al. (1985).
113 Forte (1973), Hanson (1960), Schoenberg (1911).
114 e.g., Fonte (2020), Ockelford (2011), Soares (2015), Tsintzou and Theodorakis (2008).
115 Soares (2015) uses a *palindromic rhythmic cue* to chunk and encode according to symmetry when memorising a piano work by Messiaen. This strategy runs smoothly with the composer's compositional language (see *non-retrogradable rhythms* in Messiaen ([1944], 1993)), but it is wrongly implemented. Soares confuses a palindrome (e.g., 1-2-1); with a translation, which is a simple repetition (e.g., 1-2, 1-2). See Soares (2015: 88, Figure 3.21).
116 Benson (2011: 312-360), Haack (1998), Hodges ([2003] 2010), Hofstadter ([1979] 2010), Messiaen ([1944] 1993), Papadopoulos (2014).
117 For example, see Benson (2011), Cross ([2003] 2010), Hart (2009), Hodges ([2003] 2010), Jedrzejewski (2006), Keith (1991), Madden (2007), Papadopoulos (2014).
118 A similar approach can be applied to other mathematical-based composition principles: e.g., probability, chaos theory, Fibonacci sequence, prime numbers.
119 e.g., Azaryahu and Adi-Japha (2020).
120 Soares (2015: 78-79) refers to this possibility, but mostly focuses on identifying symmetrical hand shapes in relation to the keyboard. When referring to symmetry-related composition principles (e.g., a palindrome), his

A *translation* is the displacement of a musical pattern in a specific direction and distance.[121] Some examples are a canon or sheer repetition, as in Messiaen's *Catalogue d'oiseaux*.

Example 3.2: Olivier Messiaen, *Catalogue d'oiseaux* (1956-58), 'Le courlis cendré', bars 24-31, an example of implementing a translation within a *frieze pattern*. This is an ongoing unidimensional repetition of a motif (Hodges, [2003] 2010: 108-109).

Alternatively, *reflectional symmetries* result from applying a mirror on a musical score, either vertically, which results in a reversal of time (i.e., a palindrome); or horizontally, which is a reversal of pitch (i.e., contrary motion), as in Bartók's *Subject and Reflection*. The direction in which the mirror is applied establishes the *axis of symmetry*.[122]

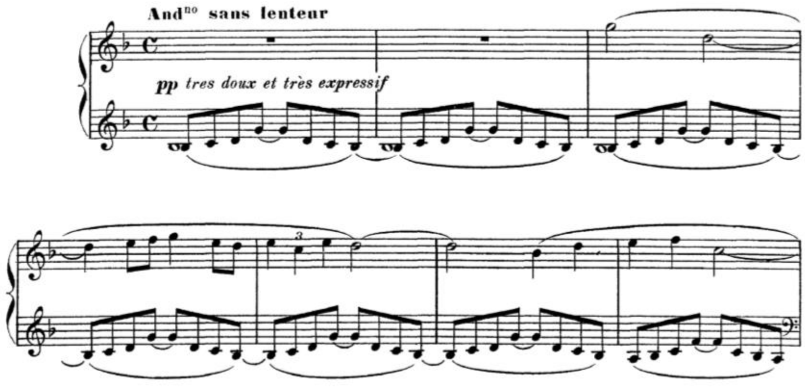
Example 3.3: Béla Bartók, *Mikrokosmos* (1926-39), 'Subject and Reflection', bars 1-7, an example of a horizontal reflectional symmetry, hence a reversal of pitch. The axis of symmetry has been placed horizontally, separating both hands. Thus, each becoming the projection of the other (Hodges, [2003] 2010: 100-101). Also, note that Bartók's year of birth (i.e., 1881) is a palindrome, and so a vertical reflectional symmetry.

interpretation and implementation are wrong: see my previous footnote on this or directly check Soares (2015: 88, Figure 3.21). Finally, Soares (2015: 155-158) mentions permutations, but basically sticks to its common implementation as dodecaphonic rows. In this thesis, I include these within the category of familiar composition principles, since these are widely known for writing music. Notwithstanding, Soares (2015: 127-128) provides an interesting example for tackling self-referencing with permutations in a composition by Aaron Copland. This is further discussed in the next section.

121 Hodges ([2003] 2010: 96-97).

122 Benson (2011: 313).

When a reflectional symmetry of either kind is combined with a translation along the same axis of symmetry, a *glide reflection* is obtained.[123] This is the case of the left-hand pattern of Debussy's *Rêverie*.



Example 3.4: Claude Debussy, *Rêverie* (1890), bars 1-7, an example of a glide reflection. The pattern in the left hand consists of a glide reflection, as a combination of a vertical reflectional symmetry, with its axis of symmetry partitioning the tied G, and a translation, which repeats this bar-pattern in time (Benson, 2011: 320).

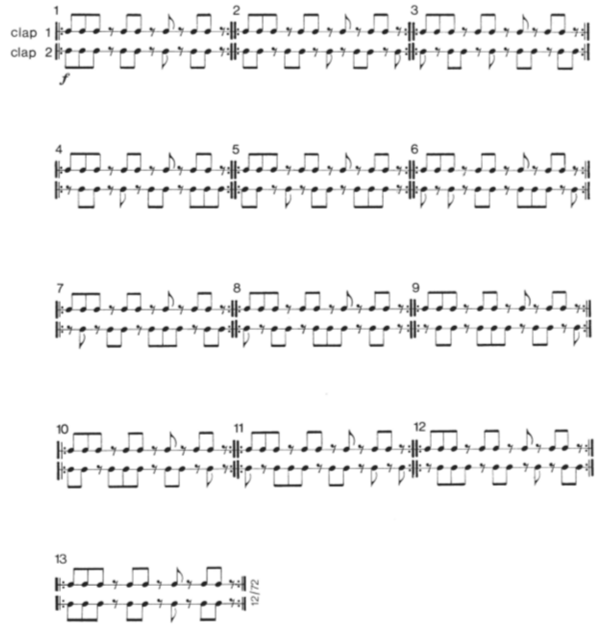
Conversely, a *rotation* transforms a musical pattern by turning it around a fixed point and an angle between 0º and 360º. The only musical symmetries obtained through this procedure are the identity;[124] and the rotation of order 2, (i.e., rotational symmetry R_2 of 180º), which is a rotation of a semicircle. Rotational symmetries are rarely encountered in tonal music since harmony is not flexible enough, but post-tonal music provides a more suitable context, as shows Hindemith's *Ludus tonalis*.[125]

123 Hodges ([2003] 2010: 97-98).
124 This is the trivial one, since no transformation is applied, and everything stays the same.
125 Hodges ([2003] 2010: 97-98; 103-104). An example to visualise this is by using letters. If a letter is taken as a set of points of the plane, the letters N, S, Z only cover the exact same set of points when either the identity or the rotational symmetry is applied. Therefore, R_2 is a symmetry of the letter S because the letter covers the exact same set of points of the plane when this is rotated for 180° (Hodges, [2003] 2010: 99).

Example 3.5: Paul Hindemith, *Ludus tonalis* (1942), 'Praeludium', bars 1-2, 'Postludium', bars 46-47, an example of a rotational symmetry. The first piano stave corresponds to the first movement 'Praeludium' of *Ludus tonalis*, whereas the second is from the last movement 'Postludium'. As can be appreciated in both excerpts, the last movement is the result of applying a rotational symmetry to the first. This is verifiable by starting with any of the two piano staves and tracing back its content to the other in reversal order (Hodges, [2003] 2010: 103-104).

Finally, the last symmetry discussed is *permutations*. A permutation group defines all possible ways in which a set of elements can be ordered.[126] In group theory, all possible permutations for a given set form the *symmetric group* for that set.[127] This resource is mostly used on pitch and rhythm.[128] For instance, Steve Reich frequently introduces small rhythmical variations, which eventually lead into a noticeable change in the resulting texture. This effect is either achieved by adding new information or by re-ordering it.[129] For the latter, a possible procedure is using *cyclic permutations*: the original order of the set is recovered after repeating a fixed re-arrangement a certain number of times.[130] In Reich's *Clapping Music*, every time the main rhythmical pattern is repeated, the second performer displaces the first beat of that pattern to the end. Since this is a 12-beat pattern, following this procedure 12 times produces the original version again.[131]

126 Biggs ([2002] 2008: 100-103).
127 Benson (2011: 328).
128 e.g., Cross ([2003] 2010), Haack (1998), Papadopoulos (2014). Dodecaphonism and Serialism are two examples of this practice.
129 Auner (2017), Haack (1998).
130 Benson (2011: 326-328), Biggs ([2002] 2008: 100-104).
131 Haack (1998).



Example 3.6: Steve Reich, *Clapping Music* (1971), bars 1-13, an example of a cyclic permutation. The first performer keeps repeating throughout the piece the same 12-beat pattern presented in bar 1. Meanwhile, the second performer implements each time the fixed permutation of displacing the first beat of the pattern to the end. For bars 2-12, the second stave details the metamorphosis that the original pattern undertakes with this repeated re-arrangement. Finally, this cyclic permutation ends in bar 13, where both performers meet again by clapping at unison.

This section detailed Conceptual Simplification's theoretical framework, discussing the main paradigms from computer science that articulate the steps of Triage, Simplifying Layers of Complexity and Conceptual Encoding. Furthermore, several resources were specified from number theory, geometry and group theory for scaffolding analysis, learning and memorisation. The next section reviews Conceptual Simplification's strategies.

3.3 Conceptual Simplification: A New Method for Analysis, Learning and Memorisation

Conceptual Simplification consists of three main steps. The first, defined as Triage, permits acquiring an overview of the musical work, identifying the main challenges and anticipating how these can be tackled. This is achieved with the following mental and physical strategies, along with any additional techniques one might find useful:

- Score overview.
- Listening to recordings.
- Sight-reading, sight-playing.[132]
- Decision-making on fingerings and hand arrangements.
- Formal analysis.
- Assessment of challenges.
- Decision-making on potential effective strategies.

Developing an overall understanding of the piece before deliberate practice begins is repeatedly suggested in research, identifying the above strategies as effective for conceiving such holistic understanding.[133] Similarly, the approach proposed in section 3.1.1 for solving $1 + 2 + 3 + \cdots + 100 = ?$ demonstrates that becoming acquainted with a new challenge (e.g., learning a musical work), is essential for efficient problem-solving.[134] Hence, Triage enables and facilitates that thinking to happen.

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[132] A deeper review of the implications of this dichotomy is provided in Chapter 2 and Chapter 8.
[133] e.g., Chaffin et al. (2003; 2013), Fan et al. (2022), Mishra (2005), Rubin-Rabson (1937).
[134] See section 3.1.1 of this chapter.

The second step is Simplifying Layers of Complexity, which temporarily removes layers of complexity to produce simplified versions of a musical passage. These *simplifying strategies* are classified into four categories, depending on whether layers correspond to pitch, harmony, rhythm or context:

a) Pitch: pitch, octaves.[135]

b) Harmony: voicing, chords, hands.[136]

c) Rhythm: rhythm, repetition, tempo.

d) Context: extended techniques, structure, preceding structure.[137]

Finally, the third step is Conceptual Encoding, in which encoding is combined with restoring removed layers of complexity until the original passage is obtained. Following a similar categorisation as in the previous step, these *conceptualisation strategies* are classified as follows:

a) Pitch: interval.

b) Harmony: chord.

c) Rhythm: *solkattu*, rhythm.

d) Context: pattern, switches, dynamics.

Real-world examples are now used to illustrate the potential of these strategies and contrast these with the literature.[138]

---

[135] For the categories of pitch and rhythm, the words "pitch" and "rhythm" refer both to the category itself and to the specific parameter within such category. For example, "pitch" agglutinates all pitch-related strategies, but also, the simplifying strategy for removing pitches.
[136] As shall be later explained, the simplifying strategy for hands refers to temporarily removing either hand.
[137] In a future version of Conceptual Simplification for conductors, a simplifying strategy for "timbre" should be added.
[138] Conceptual Simplification's effectiveness in all these examples provided is based on my own performance practice and experience as a practitioner.

3.3.1 Triage

Proficient performers use a holistic strategy for gaining an overview of the piece, identifying challenging passages and deciding on a suitable tempo.[139] Mishra (2005) defines three possible overviews: notational (sight-reading), performance (sight-playing)[140] and aural (listening). These can be combined 'to concurrently form an aural, physical, and cognitive map' for the piece (Mishra, 2004: 231). Developing this overall image is also required in problem-solving to gain understanding before approaching a problem in detail.[141] In music, this means developing an artistic view before deciding on fingering and hand arrangements.[142] Otherwise, these might have to be replaced, leading to potential memory interference.[143] This initial preview requires time, especially when patterns are not explicit (e.g., post-tonal music):[144] an expert approach that contrasts with that of novices, who tend to focus on superficial details of the music.[145]

Likewise, listening to a recording before learning of tonal material starts[146] prompts memory accuracy for pitch, rhythm and dynamics;[147] activation through sound of those brain areas responsible for the relevant movements;[148] and accelerates learning through sleep-dependent consolidation.[149] Furthermore, Mishra and Fast (2015: 72) found this strategy effective as an aural model and for identifying performing issues.[150] Listening to a recording to become

139 Hallam (1997), Miklaszewski (1995), Nuki (1984).
140 According to Mishra (2004: 231), the performance overview would involve further performances than sight-playing, 'to form a holistic impression of the music'.
141 Chaffin et al. (2003: 467; 2013), Fonte (2020: 99; 120), Gardner ([1983] 2011: 152), Sáenz de Cabezón ([2016] 2020).
142 Chaffin et al. (2003: 465-466; 2013), Mishra (2004), Mishra and Fast (2015: 71), Neuhaus ([1973] 2006: 17).
143 Allen (2013: 801), Chaffin and Imreh (1997a: 322), Chaffin et al. (2002: 146; 183-184).
144 e.g., Chaffin et al. (2013).
145 Chi et al. (1981), Glaser and Chi (1988), Paige and Simon (1966), Schoenfeld and Herrmann (1982), Tsintzou and Theodorakis (2008), Weiser and Shertz (1983).
146 e.g., Bangert et al. (2006), Buckner (1970), Cash et al. (2014), Haueisen and Knösche (2001), Lahav et al. (2013), Lotze et al. (2003), Meister et al. (2004), Rubin-Rabson (1937), Schlabach (1975).
147 e.g., Lahav et al. (2013).
148 e.g., Bangert et al. (2006), Haueisen and Knösche (2001), Lotze et al. (2003), Meister et al. (2004).
149 Cash et al. (2014).
150 This study focused on the performance practice of a professional orchestral woodwind player, when preparing for the premiere of a commissioned post-tonal work.

acquainted with a post-tonal piece was also noted by several pianists in Soares (2015) and Fonte (2020). Nonetheless, the latter reported that lacking an aural model for a commissioned work translated into difficulty in imagining the sound (e.g., extended techniques), and understanding 'the large-scale structure'.[151]

Similarly, Rubin-Rabson (1937: 13) suggested that analytical pre-study improves accuracy and quickness in memorisation since analysis stimulates the 'formation of concepts and the deduction of relationships'. This result was replicated by later studies, proposing that memorisation is closely associated with the ability to create a detailed mental representation using conceptual memory, based on the musician's semantic knowledge.[152] While analysis is rarely applied by novices,[153] this is implicitly implemented with segmentation.[154] Moreover, experts use structural analysis to hierarchically organise their mental representation,[155] and equivalent analytical strategies for chunking familiar patterns into meaningful units.[156] However, any effort to engage conceptual memory prompts sleep-dependent consolidation of that information.[157]

151 Fonte (2020: 132).
152 Aiello (2000), Chaffin and Imreh (1997a: 317), Chaffin et al. (2002), Ginsborg (2004: 14), Hallam (1997), Mishra (2002; 2004; 2005), Ross (1964).
153 Hallam (1997).
154 Lefkowitz and Taavola (2000: 171).
155 e.g., Aiello (2000), Chaffin and Imreh (1997a), Chueke and Chaffin (2016), Hallam (1997), Soares (2015), Williamon and Valentine (2002).
156 Chaffin and Imreh (1997a: 316), Chaffin and Logan (2006), Chaffin et al. (2002), Hallam (1997), Halpern and Bower (1982), Miller (1956), Mishra (2005), Oura and Hatano (1988), Sloboda et al. (1985).
157 Timperman and Miksza (2019).

3.3.2 Simplifying Layers of Complexity

This section discusses the eleven simplifying strategies corresponding to the second step of Conceptual Simplification. These are simplifying pitch, octaves, voicing, chords, hands, rhythm, repetition, tempo, extended techniques, structure and preceding structure.

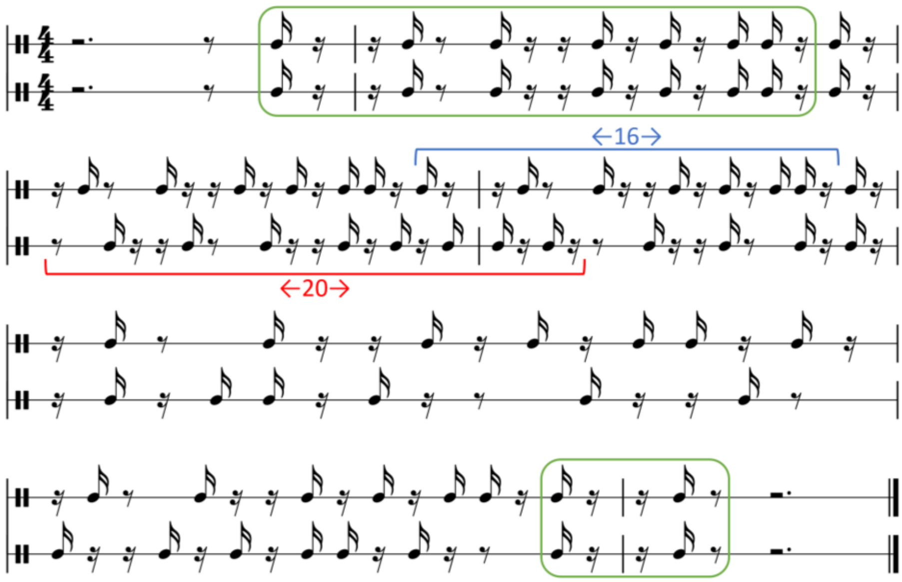
Simplifying Pitch

This strategy removes pitch when this is not the leading parameter of a passage but satisfies an ornamental role. Example 3.7 from Fujikura's *Frozen Heat* can be simplified by removing the right-hand's repeated F, to focus on the rhythmic patterns of the chords.

Example 3.7: Dai Fujikura, *Frozen Heat* (1998), bars 50-53, to exemplify Simplifying Pitch.

This passage apparently presents a cyclic permutation in the left hand.[158] However, after implementing Simplifying Pitch, two rhythmical sequences emerge: a 16-semiquaver pattern (right hand) and a 20-semiquaver pattern (left hand). These are illustrated in Example 3.8.

[158] Cyclic permutations are thoroughly discussed for rhythm with Steve Reich's *Clapping Music* (1971) in section 3.2.2 of this chapter, and for pitch with Pattern Conceptualisation in section 3.3.3.



Example 3.8: Dai Fujikura, *Frozen Heat* (1998), bars 50-53, resulting rhythmical structure after implementing Simplifying Pitch. The blue bracket highlights the right hand's 16-semiquaver pattern, whereas the red bracket indicates the left hand's 20-semiquaver pattern. Finally, the green circle emphasises the places where both hands' chords rhythmically synchronise, which corresponds to bars 50 and 54-55 in the original score.

Given the length difference in both sequences, and despite starting at rhythmical unison, these rapidly run out of synchrony, until matching again after some repetition.[159] The procedure for memorising similar sequences is discussed with Rhythm Conceptualisation.[160] The next strategy concerns the removal of octave transposition.

Simplifying Octaves

This strategy is implemented when understanding and encoding a passage or pattern benefits from transposing it all within the same octave, range or register. This includes passages written in the lower or higher registers of the piano, where it is more difficult to discern different harmonies or pitches.[161] Similarly, this strategy is also useful for transposing all notes

[159] The greatest common divisor (gcd) of 16 and 20 is gcd(16, 20) = 4, since $16 = 2^4 = 2^2 \cdot 4$ and $20 = 2^2 \cdot 5$. Therefore, this means that for both hands to synchronise, the right hand's 16-semiquaver pattern needs to be repeated 5 times, whereas the left hand's 20-semiquaver pattern only needs to be repeated 4 times.
[160] See section 3.3.3.
[161] Burns (1999), Lockhead and Byrd (1981), Pressnitzer et al. (2001), Semal and Demany (1990), Takeuchi and Hulse (1993).

from a disjointed and spread motif into the same octave to clarify the resulting melody, or how the pitches fall into a chromaticism, reordering them if necessary (see Example 3.10).

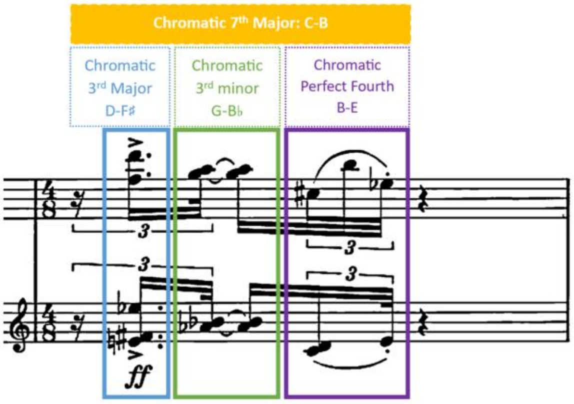
Example 3.9: Roger Redgate, *Trace* (1996), bars 1-2, to exemplify Simplifying Octaves.[162]

Example 3.9 from Redgate's *Trace* presents two atonal independent cells. Hence, Simplifying Octaves transposes and reorders all pitches within the same octave. This clarifies pitch organisation for each bar with the following chromatic patterns, which are illustrated in Example 3.10:

[162] Retrieved from Myers (2001: 51-53).

1) Bar 1 can be fitted within the chromatic 6th minor F-C#, in which G is excluded.

2) Bar 2 can be subdivided into three groups, each corresponding to a different chromatic structure. Altogether, these can be collated as the 7th Major C-B:



If pitches for the three groups in bar 2 are reorganised, these chromatic structures become clearer:

Example 3.10: Roger Redgate, *Trace* (1996), bars 1-2, chromatic patterns resulting from implementing Simplifying Octaves.

Therefore, implementing Simplifying Octaves for this excerpt requires segmenting it according to the identified cells. Additionally, bar 2 is further segmented into three groups. Then, all pitches are transposed to the same octave and reordered when necessary, making clearer how these fit into the chromatic scale. These transformations provide an encoding system for memorising the pitches, since chunking is based on tonal theory: a musical scale and three consecutive intervals. Then, both the original register and rhythm are restored. Using backward motion is also recommended for strengthening memory, including the transition between both bars, since the two cells are thematically unrelated. In Conceptual Simplification, backward motion is known as Simplifying Preceding Structure.[163]

Simplifying Octaves was implicitly suggested as a useful strategy for discerning patterns of pointillistic musical textures and disconnected cells. Concretely, pianist Ermis Theodorakis reported condensing all pitches within an octave to facilitate the harmonic analysis for the beginning of Xenakis' *Herma* (1961).[164] However, Theodorakis memorised the pitches in their original octaves, since these 'sound really different acoustically' (Fonte, 2020: 442, line 2640). Additionally, Tsintzou and Theodorakis (2008: 4) transposed their atonal excerpt an octave higher to facilitate the memorisation task.[165] Nonetheless, the authors do not acknowledge this transformation as a strategy. Finally, Soares (2015: 127) used the 4-note motif in Aaron Copland's self-referencing Piano Variations (1930) to enhance memorisation. However, he does not report this octave simplification as a strategy.[166] Different ways of memorising polyphony are now discussed.

Simplifying Voicing

This strategy is used for simplifying and memorising textures in which pitches are organised by different layers. For standard polyphony, voices are practised in all possible combinations. Thus, a four-voice polyphony requires memorising all voices individually first, to then proceed with 1+2, 1+3, 1+4, 2+3, 2+4, 3+4, 1+2+3, 1+2+4, 1+3+4, 2+3+4 and 1+2+3+4. This would be the approach for Xenakis' *Mists* (Example 3.11):

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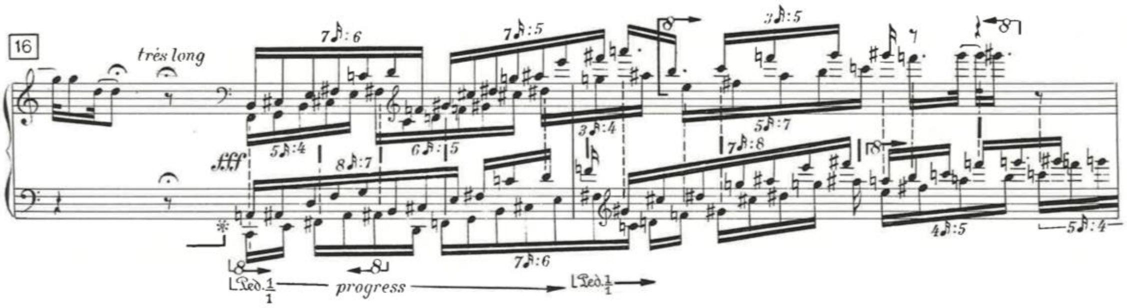
163 See section 3.3.2.
164 See Fonte (2020: 442, lines 2625-2646).
165 Tsintzou and Theodorakis (2008: 4) justify this phenomenon with the *Annotated equal loudness curves*. See http://physics.gmu.edu/~dmaria/phys260summer03/sound/EQLOUD.HTML
166 See Figure 4.17 in Soares (2015: 127).



Example 3.11: Iannis Xenakis, *Mists* (1980), bars 16-17, to exemplify Simplifying Voicing.

However, Simplifying Voicing is also helpful when pitch organisation does not solely consist of independent horizontal layers, as in Chin's Etude No.1, illustrated in Example 3.12:

Example 3.12: Unsuk Chin, *Etude No. 1 "In C"* (1999, revision 2003), bars 18-21, after implementing Simplifying Voicing. The three different *sforzando* layers are highlighted with green, blue and red frames, and are linked with the corresponding-coloured arrows.

The texture above presents three main voices: upper line, middle line and bass. However, in each of these, an extra layer is identified: a set of pitches emphasised with a *sforzando*, creating an additional line. Therefore, following a similar approach as in Example 3.11, implementing Simplifying Voicing requires practising each of the *sforzando* layers individually and combined, and doing the same for the main voices, which are only the upper and middle lines: the bass corresponds to its *sforzando* layer. Accordingly, the combinations to be memorised are 1, 2, 3, 1+2, 1+3, 2+3, 1+2+3, 4, 5, 4+5, 1+4, 1+5 and 1+4+5. These numbers correspond to:

1) (*Sforzando*) Bass

2) *Sforzando* middle line

3) *Sforzando* upper line

4) Middle line (i.e., left hand including the *sforzando* middle line)

5) Upper line (i.e., right hand including the *sforzando* upper line)

Finally, layers can also be placed vertically, as in Djambazov's *33:8* (Example 3.13), in which two vertical layers are observed. First, the chords on each bar's first beat. Secondly, the progression of thirds (right hand) with the ostinato (left hand). Therefore, Simplifying Voicing for this passage implies practising according to these two layers. Furthermore, both hands are worked first separately and then together, and the thirds can also be simplified into the upper line and the lower line.

Example 3.13: Vladimir Djambazov, *33:8* (1981, revision 2016), bars 172-180, to exemplify Simplifying Voicing.

As illustrated, Simplifying Voicing breaks down the music into different layers or blocks, depending on their corresponding role. This provokes mindful memorisation by leading attention to those elements less aurally distinguishable. Repeatedly practising these layers separately and combined allows to progressively build and understand how everything fits together. This is a common approach in piano pedagogy for solving technical problems, although not emphasised enough for the purpose of memorisation. However, the literature suggested that implementing such a problem-solving strategy with deliberate practice enhances memorisation.[167] The next strategy illustrates this same approach for chords.

[167] Ginsborg (2004), Mishra (2002: 74-75; 2010: 12).

Simplifying Chords

This strategy simplifies chord sequences, including when these are combined by layers across several piano staves. It can also be used for implementing certain transformations (e.g., switching chords into root positions), to prompt understanding of the harmonic progression or adding an arpeggiated articulation to a chord for internalising each note further. The latter aims at removing the difficulty of playing all notes at once while providing more time for thinking in analytical terms. This is illustrated with Dutilleux's Piano Sonata (Example 3.14), which presents three layers of chords. Following a similar approach as Simplifying Voicing, and numbering these layers from bottom to top, these can be practised using the combinations: 1, 2, 3, 1+2, 1+3, 2+3 and 1+2+3. Furthermore, when needed, each of these layers can be simplified into sublayers (i.e., voices), and practised again with similar combinations, following a fractal approach. Finally, chords can be further memorised by arpeggiating them instead.

Example 3.14: Henri Dutilleux, *Sonate pour piano* (1946-48), 'Choral et variations', bars 23-26, to exemplify Simplifying Chords.

Again, this strategy aligns with existing literature on how to tackle these cases.[168] The next strategy presents another variant of this approach.

[168] Ginsborg (2004), Mishra (2002; 2010).

Simplifying Hands

This strategy is implemented when understanding and encoding a passage or pattern benefits from removing either hand or simplifying some of its layering. Nevertheless, beyond the traditional strategy of practising hands separately,[169] Simplifying Hands also aims at isolating, unifying and memorising a leading thread that switches hands, by removing the rest of the ornamental layering. Such transformation permits understanding how this component is built in terms of fingering and hand coordination, facilitating its monitoring during performance. Once memorised, the remaining layers are progressively restored and integrated. This is the case with Ravel's *Ondine* (Example 3.15), in which a leading melody is divided between both hands. Therefore, Simplifying Hands first removes both hands' arpeggios, focusing on fingering, phrasing and coordination to memorise the melody. Then, hands are practised and memorised separately with Simplifying Rhythm and Blocking, explained below, and by combining both hands.

Example 3.15: Maurice Ravel, *Gaspard de la nuit* (1908), 'Ondine', bars 51-54, after implementing Simplifying Hands. The leading melody that should be isolated from the rest with Simplifying Hands has been framed in red, while green arrows highlight further how this switches hands.

[169] This aims at focusing all attention on one of the hands and becoming more aware of its patterns, instead of being cognitively divided into two independent hand sequences (Mishra, 2004: 233). e.g., Brown (1933), Chiantore ([2001] 2007), Fonte (2020: 153; 222; 229; 235; 256; 394; 396), Gruson (1988), Mishra (2010), Rubin-Rabson (1939), Soares (2015: 128; 193; 212).

The next block of strategies exemplifies how different rhythmical patterns can be simplified.

<u>Simplifying Rhythm</u>

This strategy removes, either completely or by steps, any difficulty that rhythm might add to a passage, including when this parameter presents an ornamental role: e.g., an arpeggio instead of a chord. Taking the same excerpt from Fujikura's *Frozen Heat* previously used for illustrating Simplifying Pitch:

Example 3.16: Dai Fujikura, *Frozen Heat* (1998), bars 50-53, to exemplify Simplifying Rhythm.

Two steps permit simplifying the rhythmical component:

1) Remove the right-hand's repeated F, which has an ornamental role.

2) Remove the semiquaver patterns for each hand.

Once both layers are removed, the following 7-chord and 8-chord sequences are obtained (see Example 3.17):

Example 3.17: Dai Fujikura, *Frozen Heat* (1998), bars 50-53, resulting chord sequences after implementing Simplifying Rhythm.

Example 3.17 should be practised hands separately and together. It also provides a reduction in which both hands are rhythmically synchronised. However, all rhythmical combinations are to be practised for mastering Example 3.16, although this work is completed with another strategy.[170] For further clarity, Simplifying Octaves is also implemented to transpose each chord sequence to a central register, obtaining Example 3.18:

Example 3.18: Dai Fujikura, *Frozen Heat* (1998), bars 50-53, resulting chord sequences after implementing Simplifying Rhythm and Simplifying Octaves.

After Simplifying Octaves, each chord sequence is memorised with Simplifying Chords.

Temporarily removing or ignoring rhythm to focus on other parameters is reported in the literature and is emphasised for post-tonal piano music, in which pitches require more attention at not following conventional harmony.[171] For tonal music, Pike and Carter (2010) tested different cognitive chunking techniques for improving piano sight-reading. Their evidence suggested that temporarily ignoring rhythm to focus on pitch chunking, that is isolating the resulting chunks and practising them in several keys, can significantly improve

[170] Further details of this were given when discussing Simplifying Pitch earlier in this section.
[171] e.g., Fonte (2020: 222; 248), Soares (2015: 64), Tsintzou and Theodorakis (2008: 6).

'pitch, rhythm and continuity accuracy' (Pike and Carter, 2010: 231). However, simplifying pitch to focus on rhythm instead only positively impacts continuity accuracy and rhythm.[172] Similarly, participant *Sophia* in Fonte (2020: 248) reported practising chords in different inversions and tonalities while ignoring rhythm, when memorising a post-tonal piano work. However, Fonte's study did not further test how this chunking technique influences memorisation. Similarly, in Tsintzou and Theodorakis (2008: 6), *student 2* focused first on the harmonical sequence when memorising an atonal piece.[173]

Memorising without rhythm also facilitates identifying hand shapes, since pitches are played simultaneously by blocks. This strategy of grouping pitches is known as Blocking,[174] and here is included within Simplifying Rhythm. Nellons (1974) summarised its possibilities:

1) Scale patterns should be identified as clusters.

2) Intervals, arpeggios and chord fragments should be regarded as solid chords.

3) Blocking also enhances the identification of those patterns resulting from the composers' language and techniques.

According to Nellons (1974), Blocking promotes a combination of Sensory and Analytical Learning Styles,[175] since the strategy can be used in physical and mental practice. Nellons (1974: 28-29) also suggests following the three-step rule of Analyse-Block-Play. Blocking's implementation focuses on tonal music (e.g., harmonic blocking),[176] but also involves a *pattern of abstract blocking* approach, for identifying black-and-white-key patterns and encoding

[172] Pike and Carter (2010: 240-241).
[173] The excerpt comprised bars 34-40 of this piece, which was slightly modified by the authors: the chords in the right hand were simplified and the whole excerpt was transposed one octave higher to enhance aural feedback (Tsintzou and Theodorakis, 2008: 4).
[174] Nellons (1974: 27-46).
[175] Both the Sensory and Analytical Learning Styles are explained in Chapter 2, section 2.2.2.1. For further reference, also see Mishra (2004: 233; 2005: 81-83).
[176] Aiello (2000), Nellons (1974: 30-44).

directional, interval and chord patterns, not necessarily tonal.[177] This trait is also noted by Chadwick (2013: 33-49) in Messiaen's *La fauvette des jardins* (1970-72). Furthermore, Soares (2015) and Fonte (2020) provide evidence of the effectiveness of identifying black-and-white patterns.[178] Here, is illustrated with Ravel's *Scarbo* (Example 3.19):

Example 3.19: Maurice Ravel, *Gaspard de la nuit* (1908), 'Scarbo', bars 448-449, before and after implementing Blocking. For this strategy to be effective, the original fingering should be maintained once Blocking has been applied. In this case, this is particularly important for the clusters in the right hand.

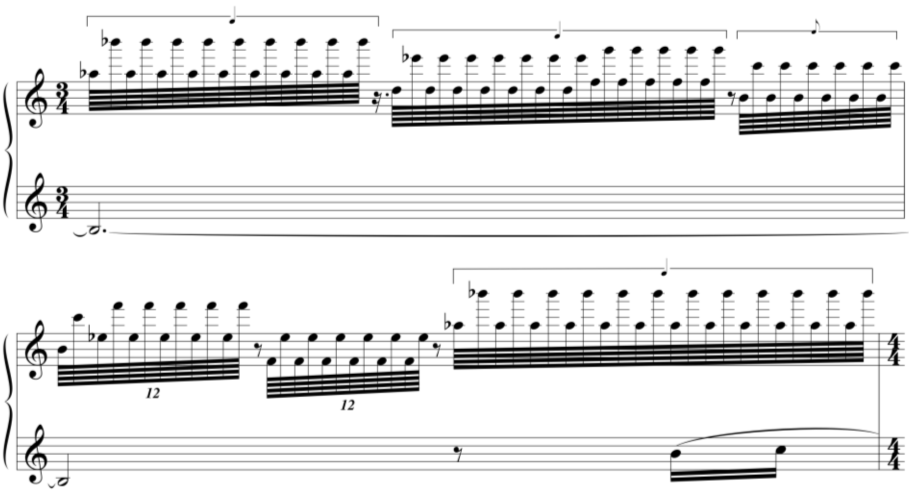
The next strategy simplifies repetition, which was implicitly implemented in Simplifying Rhythm.

<u>Simplifying Repetition</u>

The temporary removal of redundant repetition can contribute to clarifying further the patterns of a piece or passage. This is illustrated in Ben-Amots' *Akëda* (Example 3.20):

[177] Nellons (1974: 45-46).

[178] Concretely, see Fonte (2020: 106; 115; 159; 318) and Soares (2015: 84-85; 93; 108; 150; 197; 205).



Example 3.20: Ofer Ben-Amots, *Akëda* (2000), bars 13-14, to exemplify Simplifying Repetition.

The underlying sequence of these ornamental figures is clarified by suppressing repetitions, obtaining the intervals below (see Example 3.21). Hence, the rhythm is simplified, and the left hand is ignored at implementing Simplifying Rhythm and Simplifying Hands. Furthermore, when necessary, pitches are transposed into a central register for enhancing clarity with Simplifying Octaves.

Example 3.21: Ofer Ben-Amots, *Akëda* (2000), bars 13-14, after implementing Simplifying Repetition.

Using the simplified version above, repetition and rhythmical precision is restored by using the numerical sequence 9-(7-5)-6-(1-5)-6-12, which summarises the repetitions of each melodic interval. The next strategy focuses on tempo simplification.

Simplifying Tempo

This strategy regards speed of performance as a layer of complexity, since a fast tempo can increase the difficulty of a passage, while changes in tempo might provide an additional element to practise. Therefore, simplifying or restoring tempo involves playing at a slower tempo or at the original speed, respectively. Alternatively, when the original tempo is slow and playing faster helps, implementing Simplifying Tempo results in increasing the speed to facilitate, for instance, an easier connection of the elements to be memorised.[179] As with practising hands separately, tackling technical and cognitive difficulty of a piece by reducing its tempo is a standard approach for musicians.[180] However, here Simplifying Tempo is used for strengthening conceptual memory, allowing additional time to think analytically, or even test memory,[181] which was also reported for post-tonal music.[182] Similarly, pianist and composer Sergei Rachmaninov practised radically slow, supposedly to test and strengthen conceptual memory.[183]

Simplifying Extended Techniques

This strategy temporarily removes extended techniques, either partially or completely. Removing these fully would generally be the first step to simplify a musical texture, since these are a layer of complexity, frequently used as a sophistication of sound and expression.

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179 This strategy can be supported with the practice-based experience of professional pianists. For example, pianist Andrew Zolinsky interviewed in Fonte (2020: 395, lines 634-641) states:

> slow pieces are notoriously difficult to play from memory because we don't create a physical memory with them, because we just sit down, and sight read. So, I very often play a Chopin Nocturne, for instance, twice the speed, so I create a physical memory which then I can slow down… And the opposite works too, because when we are playing fast music, we actually need to slow down to load the information more slowly into the brain. So, you do the opposite, you play slow pieces very fast to create a sense of physical memory and fast pieces quite slowly.

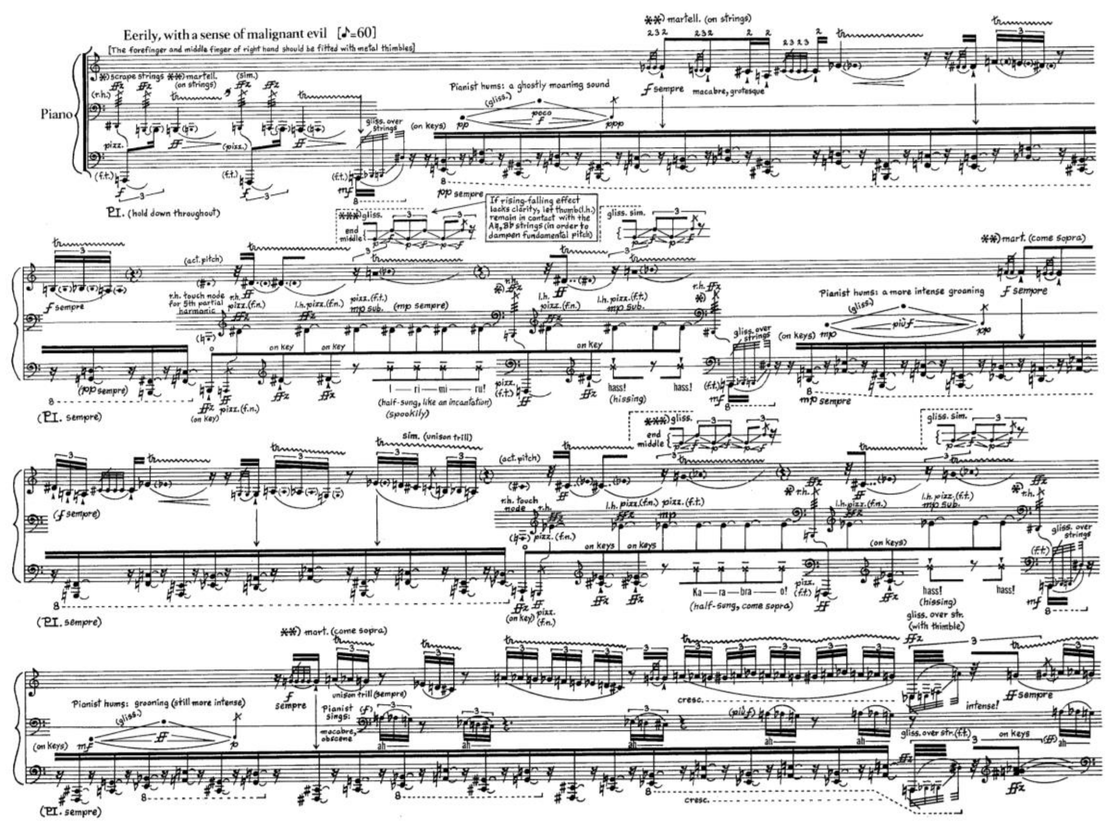
180 e.g., Chaffin and Imreh (2001), Chaffin and Lisboa (2008), Chaffin and Logan (2006), Chiantore ([2001] 2007), Fonte (2020: 153-154; 222; 235; 275), Mishra (2010), Soares (2015: 43; 65; 89-90; 186). See also professional pianist Philip Thomas interviewed in Fonte (2020: 461, lines 3468-3470), who states that 'If I can't play in time, I just start slower and build up'.

181 Lehmann and Ericsson (1998), Mishra (2005).

182 Soares (2015: 42).

183 Chasins (1982: 44).

However, if extended techniques are a main element of the piece or these do not present a distraction, these can be partially removed instead. This means ignoring the exact effect that a certain technique is expected to produce inside the piano and transferring it to a distinct sound world. For instance, adapting and playing it on the keyboard instead, if pitch-related; clapping it, if not pitch-related; or imitating it with the voice if none of the previous options are suitable, and verbalisation could enhance interiorising this action. Partially or fully removing extended techniques aims at neutralising potential distractions or delays caused by the logistics or technicalities that these might require. Once the essential information is properly learned and memorised, extended techniques are progressively restored and integrated with the rest. Therefore, the partial removal of extended techniques is part of this scaffolding process. Additionally, Simplifying Extended Techniques also develops a map or written scheme, which summarises all required preparations inside the piano. For instance, given Example 3.22 from Crumb's *The Phantom Gondolier*:



Example 3.22: George Crumb, *Makrokosmos I* (1972), 'The Phantom Gondolier', first page, to exemplify Simplifying Extended Techniques.

Crumb's *The Phantom Gondolier* is challenging for coordination and extended techniques. The performer hits the strings in different ways with two metal thimbles in one hand, while playing with the other hand on keys without looking. Further techniques are also performed with voice and fingers. Hence, Simplifying Extended Techniques' first step for encoding the main theme consists in identifying the three main layers: (1) melody, (2) accompaniment, and (3) voice line. Furthermore, the first layer can be divided into two sublayers: (1.1) plain melody, and (1.2) extended techniques performed with thimbles. After simplifying the ornamental layers, only two elements remain: the plain melody and the accompaniment, which consists of a sequence of six fifths repeated three times. Within this pattern, there is a sub-pattern that is also repeated three times: fifths number 2, 4 and 6 of this sequence are respectively built from the 1, 3 and 5, by taking the upper note and transposing it a semitone. The resulting patterns are summarised in Figure 3.5:

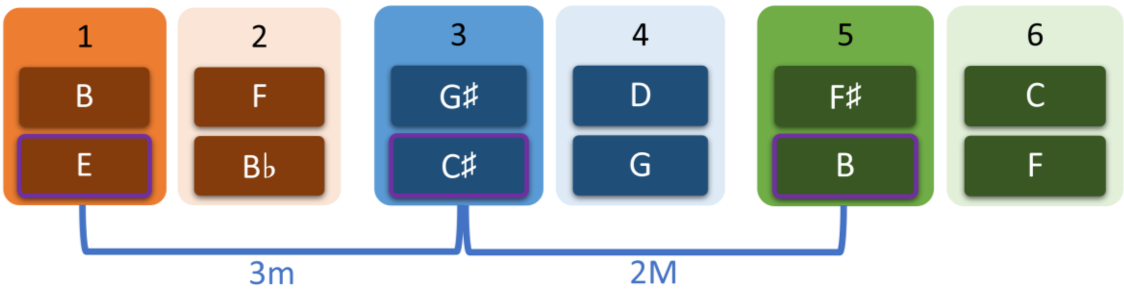


Figure 3.5: The resulting scheme of the left-hand accompaniment on keys of George Crumb's 'The Phantom Gondolier', after implementing Simplifying Extended Techniques.

Hence, Simplifying Extended Techniques facilitates identifying the main underlying pattern: fifths located in the sequence's even positions are deduced from those in the odd positions. Furthermore, the bottom note of the penultimate fifth coincides with the top note of the first fifth of the sequence. Accordingly, the left-hand accompaniment is remembered by solely memorising the three bottom notes of the odd fifths, from which the rest is deduced. Moreover, these notes form a melody consisting of a third minor and a second major.

Therefore, each time the left-hand's sequence of fifths reappears across the piece, these ideas are triggered and readjusted to the corresponding transposition. Once memorised, other layers are progressively integrated.

Simplifying Extended Techniques contributes to performance accuracy, since all elements are progressively internalised, developing an efficient choreography that eventually becomes part of the performance. Moreover, internalising extended techniques accordingly require less practice for two main reasons. First, extended techniques are not incorporated until the rest is learned, hence, restoring these simply consist in adding an additional layer of activity on top of previous confident work. This is important since muti-layered extended techniques can cause unnoticed internalisation of mistakes, along with potential hesitations. Secondly, a grand piano's internal structure varies according to its brand and model, affecting how metal beams and strings are distributed. Therefore, practising extended techniques early on, especially when switching pianos regularly, implies constantly altering visual and kinaesthetic memories, disrupting learning. Furthermore, extended techniques usually require preparing the piano, for which extra time needs to be allocated to the detriment of actual practice.

In a longitudinal case study, Fonte (2020: 118-196) reported several problems concerning extended techniques that involved glissando, harmonics and pizzicato. First, these were an obstacle for sight-reading since certain effects required previous preparation and rehearsal. Therefore, hindering the ability to develop a general picture of the music.[184] Secondly, performing those extended techniques implied multiple movements and uncomfortable positions that made the learning process slower, spending more time than expected.[185] Finally, lacking access to grand pianos prevented practising extended techniques for some

[184] Fonte (2020: 120-121; 164; 324). e.g., Chaffin and Logan (2006), Chaffin et al. (2003), Mishra (2005).
[185] Fonte (2020: 122; 165; 137).

sessions, although these were remembered due to distinctiveness.[186] Consequently, considering that the reported approach was inefficient in these conditions,[187] it would not be unreasonable to think that it could get worse with more challenging extended techniques. All these obstacles could have been avoided by Simplifying Extended Techniques, either partially or fully. Concretely, the extended techniques involved were straightforward, and not present throughout the piece, but placed in specific locations.[188] Thus, their removal would only involve segmenting accordingly.

The next couple of strategies discuss other context simplifications related to structure.

Simplifying Structure

This strategy segments the music to work on feasible sections, passages or cells. Therefore, it removes temporal layers of complexity, being the equivalent of segmentation.[189] Musicians organise practice according to the piece's formal structure or alternative divisions of interest (e.g., score layout, technical challenges), as a problem-solving strategy towards deliberate practice.[190] Thus, musicians segment the music into meaningful parts and practise to reconnect them, building up a performance.[191] In this process, they might 'shift focus'

[186] Fonte (2020: 171; 182-183; 191; 196).
[187] Fonte (2020: 137).
[188] The score of the piece from Fonte's (2020: 364-374) longitudinal case study can be retrieved from her thesis in the pages indicated.
[189] Chaffin and Imreh (1997a; 2001), Chaffin et al. (2002: 248-250), Fonte (2020), Gerling and Dos Santos (2017), Ginsborg (2004), Lefkowitz and Taavola (2000), Miklaszewski (1989; 1995), Miklaszewski and Sawicki (1992), Mishra (2002; 2005; 2011), Soares (2015), Williamon and Valentine (2002). In the literature, this is also known as the part approach versus the whole approach. The latter meaning the whole piece. See Mishra (2005; 2010; 2011), O'Brien (1943), Rubin-Rabson (1940b).
[190] e.g., Aiello (2000), Chaffin et al. (2002), Fonte (2020: 118-196), Gruson (1988), Hallam (1997), Soares (2015: 34-104), Miklaszewski (1989; 1995), Miklaszewski and Sawicki (1992), Tsintzou and Theodorakis (2008), Williamon and Egner (2004), Williamon and Valentine (2002). This approach is defined by Mishra (2004: 233) as the Segmented Processing Strategy.
[191] Aiello (2000), Chaffin (2007), Chaffin and Imreh (1997a: 333), Chaffin et al. (2002: 116-119; 2010: 6), Hallam (1997), Miklaszewski (1989; 1995), Nielsen (1999a), Tsintzou and Theodorakis (2008: 9), Williamon and Valentine (2002: 28).

between the different hierarchical levels of their conceptual understanding of the music, combining short segments with larger ones: a process defined as the *zoom mechanism* (Williamon, 1999a: 97).[192] Furthermore, Gruson (1988) suggested that expert pianists tend to segment the music into bigger sections than novices, although in post-tonal music, that might not always be possible due to unfamiliarity with the language.[193] Finally, beyond practice, segmentation is useful for experts at organising their memory at encoding and retrieval.[194]

Simplifying Preceding Structure

The last simplifying strategy is a particular case of segmentation but working in backward motion (i.e., playing from end to beginning). Accordingly, preceding content is removed: practice focuses first on the end of a given segment, and further content (e.g., a beat, cell, bar or section) is progressively added towards the beginning. However, the purposes of segmentation and working in backward motion are different. The main goal of segmentation is enhancing detailed work towards a sectional approach, whereas working in backward motion aims at removing hesitation from performance practice, prompting always running into a higher confident section, passage or cell of the piece. Thus, although both strategies contribute to boosting fluency and confidence, their corresponding approaches to reaching this goal are different. Simplifying Preceding Structure should be implemented when a certain segment, no matter its length, is too difficult to attempt from beginning to end. Hence, implementing this strategy means starting practising with the latest biggest cell that can be played without hesitation, completing all necessary actions for that segment, and then repeating this work pattern by recursively adding the previous cell that satisfies the same

192 See also Miklaszewski (1995).
193 Williamon (1999b: 94).
194 Chaffin and Imreh (2002), Chaffin and Logan (2006), Chaffin et al. (2002; 2010), Chueke and Chaffin (2016), Fonte (2020), Hughes (1915: 601), Jordan-Anders (1990: 35), Soares (2015), Tsintzou and Theodorakis (2008), Williamon and Valentine (2002).

principle. This is repeated as many times as needed, until the initial goal (i.e., the beginning) is reached and the full segment is integrated. Simplifying Preceding Structure fulfils the decrease-and-conquer paradigm in which, as happens with Simplifying Structure, those temporal layers of complexity that complicate the music are recursively removed and restored as a loop. Working backward was reported as a problem-solving strategy,[195] to challenge practice or memory,[196] or to compensate for extra practice usually invested on the beginning of a piece as opposed to the final sections.[197]

The next section introduces Conceptual Simplification's encoding strategies.

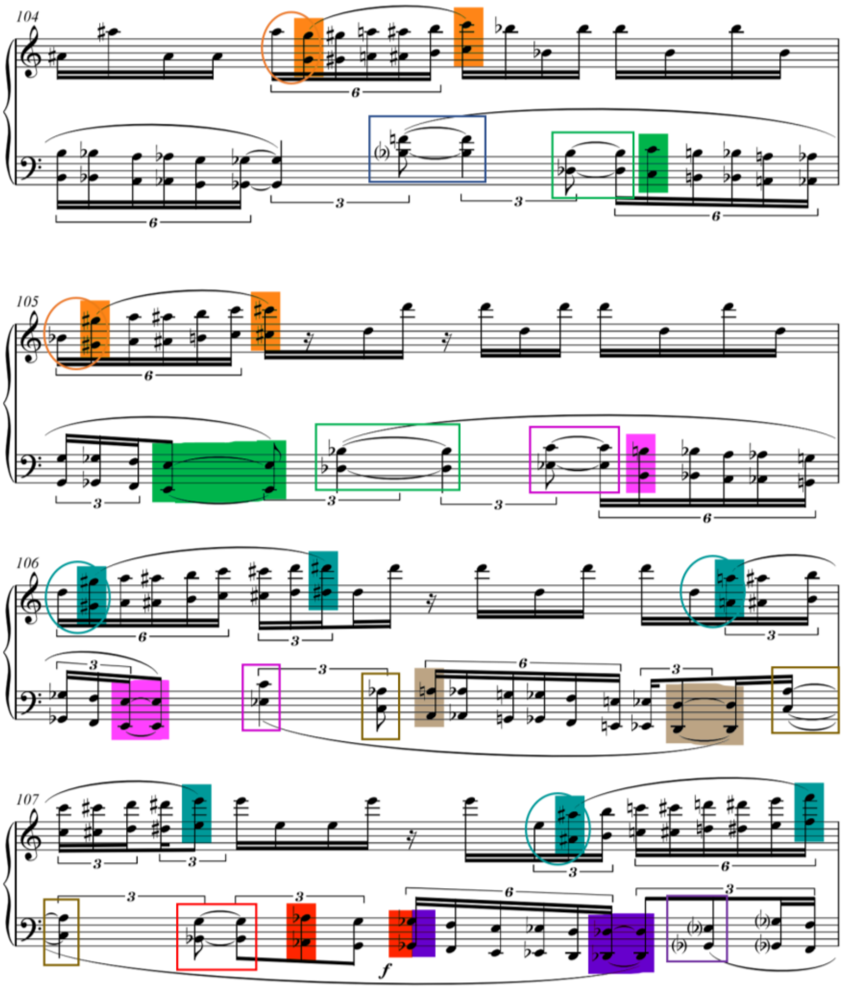
3.3.3 Conceptual Encoding

This section discusses the seven strategies corresponding to Conceptual Encoding: Interval Conceptualisation, Chord Conceptualisation, *Solkattu* Verbalisation and Clapping, Rhythm Conceptualisation, Pattern Conceptualisation, Switches Conceptualisation and Dynamics Conceptualisation.

Interval Conceptualisation

This strategy permits identifying the relationships amongst a series of consecutive or non-consecutive intervals within a passage. Although traditional harmony permits chunking and encoding this information, Interval Conceptualisation develops multi-layered guidelines used to deduce the rest of the content and monitor performance. This is illustrated with Fujikura's *Frozen Heat* (Example 3.23):

195 e.g., Fonte (2020: 222), Miklaszewski (1989), Mishra (2010), Soares (2015: 137).
196 e.g., Ginsborg and Chaffin (2011a: 346), Mishra (2004; 2010), Soares (2015: 42; 61; 193).
197 e.g., Jordan-Anders (1990: 34), Mishra (2004: 233).



Example 3.23: Dai Fujikura, *Frozen Heat* (1998), bars 104-107, after implementing the first step of Interval Conceptualisation. A four-layered scheme has been highlighted with colours, as a first step for implementing Interval Conceptualisation. For the right hand, two distinct components are marked. First, circles in orange and turquoise are used to indicate pivot points, depending on whether these correspond to melodic intervals of an augmented second or a diminished fifth, respectively. Secondly, the boundaries of the octaviated chromatic filling between these pivot points are highlighted accordingly. For the left hand, two other components are marked. First, frames in blue, green, pink, brown, red and purple are used to indicate the essential pivot points and how these are connected. Secondly, the boundaries of the octaviated chromatic filling between these landmarks are highlighted with the corresponding colours.

As a first step for implementing Interval Conceptualisation, the above multi-layered scheme is devised. For each hand, two distinct layers are identified, satisfying equivalent functions in both hands. First, a central component in the form of pivot points: for the right hand, these are circled and correspond to melodic intervals; whereas for the left hand, these are framed, indicating landmarks of the leading two-voice bass. Secondly, an ornamental component in the form of octaviated chromatic filling in both hands, summarised by its boundaries: i.e., the first and last octave of each chromatic sequence, which corresponds to the sequence's lowest and highest note, or vice versa. Consequently, a meaningful hierarchical structure for encoding the information is obtained, which is an effective strategy to memorise.[198] For Example 3.23, this hierarchy comprises three levels. Ordered by decreasing importance, these are: (1) pivot points, (2) octave boundaries and (3) chromatic filling. These levels are progressively assimilated from top to bottom using Simplifying Hands and Simplifying Octaves, both for register and for reducing the octaves to single-note chromatic sequences; and Simplifying Rhythm. Hence, the above passage is summarised in Figure 3.6:

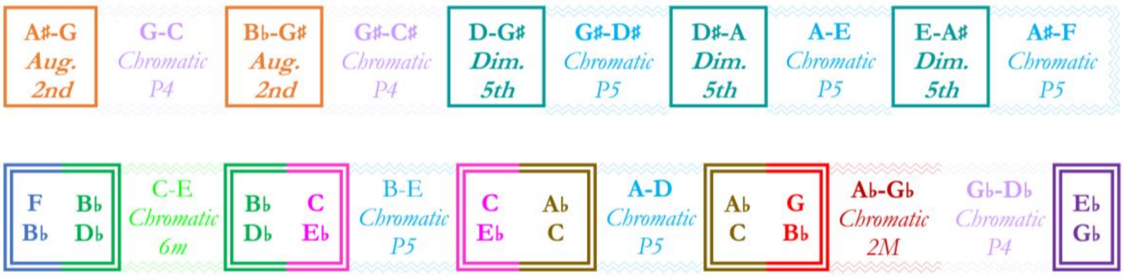


Figure 3.6: A concise version of the four-layered scheme for bars 104-107 of Dai Fujikura's *Frozen Heat*, as part of the process of implementing Interval Conceptualisation. The first row displays the corresponding hierarchical structure for the right hand, whereas the second row displays the one for the left hand. Both are structured according to the previously defined hierarchical levels: i.e., pivot points, octave boundaries and chromatic filling. In the first row, the right hand's hierarchical structure indicates the pivot points with orange and turquoise frames, depending on whether these correspond to melodic intervals of an augmented second or a diminished fifth, respectively. Then, chromatic sequences are defined first by their corresponding boundaries in **bold**, and then, by the range of its chromatic filling in *italics*. These are either marked in light purple or light blue, depending on whether their range extends to a perfect fourth or a perfect fifth. In the second row, the left hand's hierarchical structure indicates the pivot points of the leading two-voice bass with blue, green, pink, brown, red and purple double-edged frames. Then, following the same system as before, chromatic sequences are specified in colours light green, light blue, dark red and light purple, depending on whether their ranges are of a minor sixth, perfect fifth, major second or perfect fourth, respectively.

[198] e.g., Bower et al. (1969), Chaffin (2007), Chaffin and Imreh (1997a; 2001), Chaffin and Logan (2006), Chaffin et al. (2003; 2010), Chueke and Chaffin (2016), Deutsch (1980), Fonte (2020), Halpern and Bower (1982), Miklaszewski (1989), Nielsen (1999a), Noice et al. (2008), Ockelford (2011), Rubin-Rabson (1937), Soares (2015), Tsintzou and Theodorakis (2008), Williamon and Valentine (2002).

Taking Figure 3.6 as a basis, Interval Conceptualisation consists in:

1) Memorising the pivot points, first hands separately, and then together.

2) Memorising the pivot points in combination with the chromatic boundaries, which should be learned first without the octaviated interval, and then in their original form. This process is first completed hands separately, and then together.

3) Memorising hands separately, using the corresponding hierarchical structure for monitoring all components. The chromatic sequences should be approached first simplifying one of the voices: i.e., both the lower and the upper voices should be memorised separately. For the latter, this is particularly important for internalising the fingering. Then, the sequence is approached in its original octaviated form.

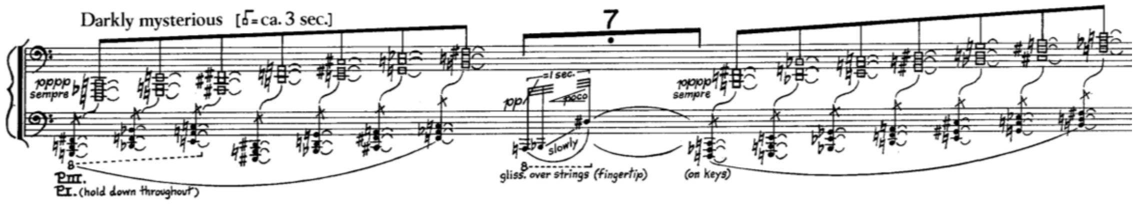
4) Memorising hands together.

5) The above steps can be combined with the simplifying strategies for tempo, structure and preceding structure.

After discussing conceptualisation for a sequence of intervals, the next strategy illustrates how to adapt it to chords.

<u>Chord Conceptualisation</u>

This strategy conceptualises chord sequences. Different examples are provided with Crumb's *Makrokosmos* (Example 3.24).



Example 3.24: George Crumb, *Makrokosmos I* (1972), 'Primeval Sounds', initial 49 seconds, to exemplify Chord Conceptualisation.

Example 3.24 consists of two chord sequences separated by a glissando. The first sequence consists of a chromatic progression of minor chords from F minor to B minor (right hand) and in the opposite direction (left hand). Thus, providing Figure 3.7:

Fm Em D♯m Dm C♯m Cm **Bm**

Bm B♭m Am G♯m Gm F♯m **Fm**

Figure 3.7: Chromatic progression of the first sequence of chords from Example 3.24.

In the second sequence, both hands exchange roles, providing the patterns in Figure 3.8:

Bm B♭m Am G♯m Gm F♯m **Fm**

Fm Em D♯m Dm C♯m Cm **Bm**

Figure 3.8: Chromatic progression of the second sequence of chords from Example 3.24.

Hence, Example 3.24 is conceptually encoded as two chromatic sequences from F minor to B minor, explored in both directions by each hand. Furthermore, these satisfy the chord inversion pattern in Figure 3.9:

(Root position + 1st inversion + 2nd inversion) x2 + Root position

Figure 3.9: Chord inversion pattern of both sequences of chords from Example 3.24.

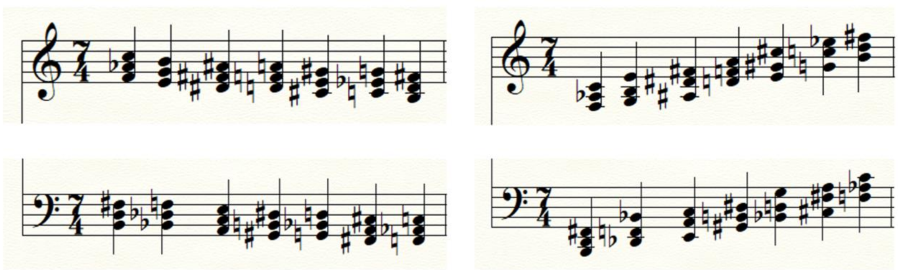
Therefore, three layers of complexity are used to conceptualise these sequences: octaves, hands and chord inversion. Accordingly, memorisation of Example 3.24 is structured into three main steps:[199]

1) All chords are transposed into the middle register by implementing Simplifying Octaves. Consequently, these can be more clearly visualised on the keyboard and the corresponding distinct harmonies can be heard more accurately. Additionally, the same strategy is used for switching all chords back to root position, and the rhythm is temporarily removed. Both sequences are first approached hands separately. After simplifying the music in this manner, for each chord sequence, two modalities are memorised for each hand: the corresponding chromatic chord progression in root position, and then, in its original inversions. For the first sequence, this step consists in the following:

Root position Original inversions

RH

LH



2) This process is repeated, but this time combining both hands. For the first sequence, the following two arrangements are to be memorised:

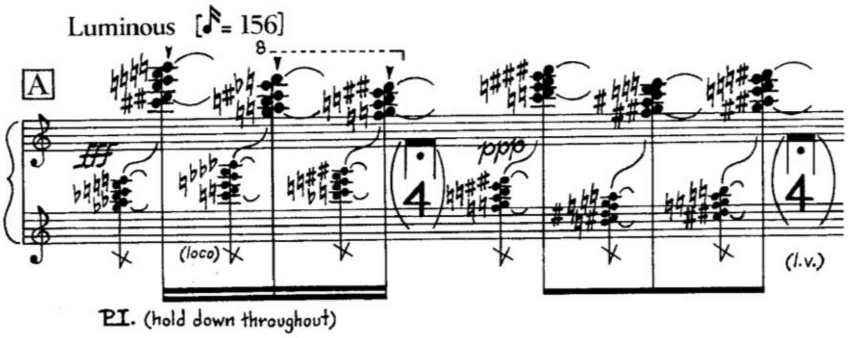
Root position Original inversions

3) The layers of rhythm and octaves are restored, and the excerpt is finally memorised in its original form.

Example 3.25: George Crumb, *Makrokosmos I* (1972), 'Primeval Sounds', initial 49 seconds, instructions on how to memorise Example 3.24 with Chord Conceptualisation in combination with several simplifying strategies.

[199] The benefits associated with effectively memorising these two chromatic sequences transcend this piece, since both sequences are also the main theme of two other pieces from *Makrokosmos I*: 'Crucifixus' and 'The Abyss of Time'.

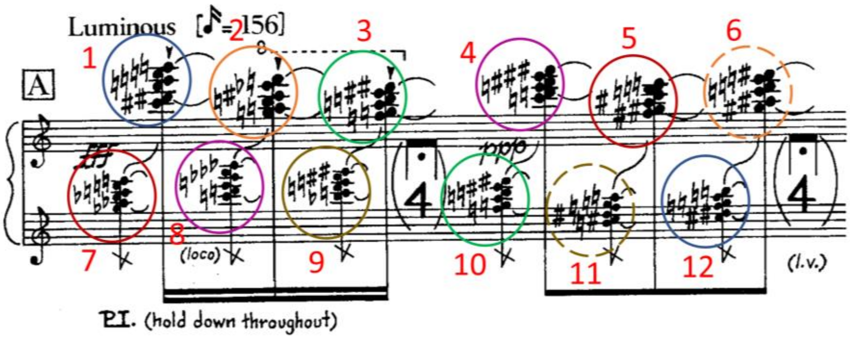
Thus, Chord Conceptualisation revealed Example 3.24's underlying tonal patterns and encoded these with tonal theory. This procedure is common in the literature,[200] and aligns with Raaijmakers and Shiffrin's (1981: 121) model for associative memory, which argues that 'a memory object will form most easily when the input to short-term storage consists of already unitised memory entities'. However, when no tonal references are available, a similar approach can be taken toward conceptualisation, although the resulting patterns might be unfamiliar to the practitioner's expertise.[201] For instance, given Crumb's *The Magic Circle of Infinity*:



Example 3.26: George Crumb, *Makrokosmos I* (1972), 'The Magic Circle of Infinity', Section A, to exemplify Chord Conceptualisation.

Example 3.26 consists of a 12-chord sequence divided into two halves. Harmonic analysis reveals that all chords are based on the whole-tone scale, requiring a certain familiarity with its pitch organisation and its two transpositions.[202] Furthermore, the first three chords in the right hand are followed by their corresponding transpositions to the alternative whole-tone scale. This is also observed in the left hand. Additionally, each chord is repeated twice, although chords 6 and 11 are the equivalent transposition of chords 2 and 9 (Example 3.27):

[200] Fonte (2020), Nielsen (1999a), Ockelford (2011), Rostron and Bottrill (2000), Sloboda (1985; 2005), Soares (2015), Tsintzou and Theodorakis (2008).
[201] Chase and Ericsson (1982), Fonte (2020), Gobet (2015), Soares (2015), Tsintzou and Theodorakis (2008).
[202] The whole-tone scale admits only two possibilities. First, starting on C, the first transposition of the scale defined as C-D-E-F♯-G♯-A♯-C is obtained. Secondly, starting on C♯, the second transposition of the scale is determined as C♯-D♯-F-G-A-B-C♯.



Example 3.27: George Crumb, *Makrokosmos I* (1972), 'The Magic Circle of Infinity', Section A, after implementing Chord Conceptualisation. Different colours are used to highlight how the numbered chords of the above sequence relate to each other. Chords are numbered by rows because these are to be practised hands separately first. As a result, the passage can be conceptualised using two main associations. First, chords 1-2-3 are repeated in 4-5-6, but this time in a different transposition of the whole-tone scale. Similarly, the same relationship can be established between chords 7-8-9 and 10-11-12. Secondly, using modular arithmetic, six different equivalence classes (~) in the form of *chord classes* can be established for encoding the whole sequence of chords. These are 1~12, 2~6, 3~10, 4~8, 5~7 and 9~11. This means that each pair describes a different chord class, hence indicating the locations in which that chord is repeated: i.e., its designated number in the sequence. Only two exceptions are given, in which the chord is not literally repeated, but transposed instead (≈): 2≈6 and 9≈11.

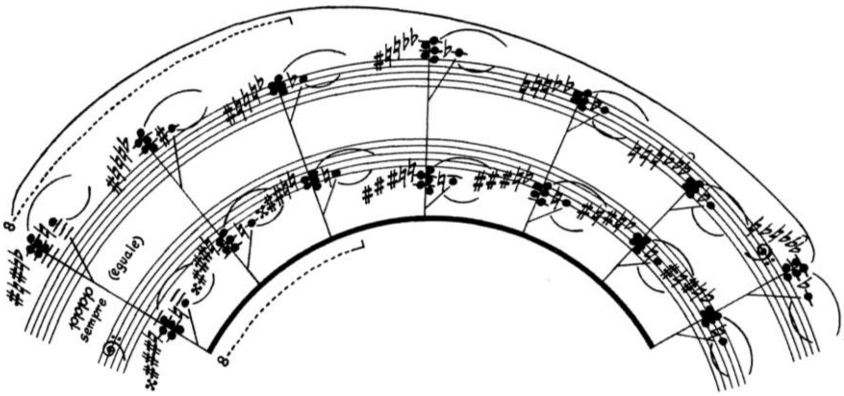
Therefore, for Example 3.26, Chord Conceptualisation provided three key ideas:

1) All pitches can be chunked and encoded according to the whole-tone scale.

2) Each hand is deduced from a three-chord cell. The second half of the sequence is obtained by transposing the first three chords of each hand to the alternative whole-tone scale.

3) Each chord is repeated twice, defining six *chord classes*: 1~12, 2≈6, 3~10, 4~8, 5~7 and 9≈11. Nonetheless, chords 6 and 11 are equivalently transposed.

During practice, hands and rhythm are simplified and progressively restored. A variation of this procedure is also implemented to the clusters of Crumb's *Spiral Galaxy* (Example 3.28):

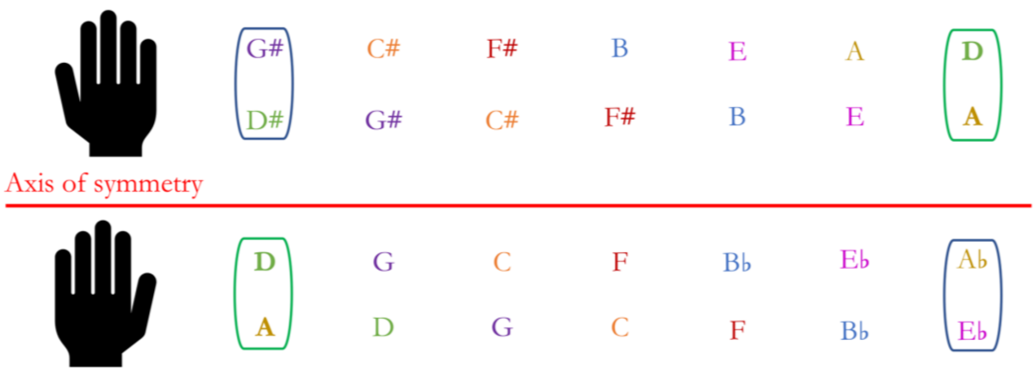


Example 3.28: George Crumb, *Makrokosmos I* (1972), 'Spiral Galaxy', third section, to exemplify Chord Conceptualisation.

Chord Conceptualisation provides the following key ideas for enhancing memorisation of Example 3.28:

1) Both hands start at the corresponding boundaries of the piano keyboard and get progressively closer until meeting at the middle register.

2) Pitches are organised in the form of chromatic clusters, for which it suffices to retain the upper and lower note of each chord. Therefore, a possible schematic version of the above excerpt would be:



3) The above simplification highlights that this sequence of chords is a chromatic symmetry between both hands, each playing a range of a fourth and moving according to the circle of fourths. As happened in the chromatic sequences of Crumb's *Primeval Sounds*, the above progression stops once both hands have reached the initial cluster of the other hand, but in the corresponding octave.

Figure 3.10: Instructions on how to memorise Example 3.28 with Chord Conceptualisation.

Chord Conceptualisation was here illustrated for three different pitch organisations, within tonal and post-tonal contexts. The next two strategies focus on rhythm.

Solkattu Verbalisation and Clapping

This strategy provides a systematic approach to challenging rhythms, based on techniques from South Indian Karnatic music. Given the scope of this thesis, I solely focus on *solkattu*:[203] a set of syllables that are freely assigned to a rhythmical pattern or phrase to 'sing' it (Reina, 2015: 22).[204] These syllables are combined according to their suitability with the phrasing, the needed rhythmic articulation and the resulting sound: e.g., strong sounds for accents and soft sounds for non-accented material.[205] This technique is included in Conceptual Simplification to substitute traditional counting for an intuitive approach, in which rhythm is translated into syllables that are vocalised and clapped along. Unlike Western systems that also use syllables to count and rationalise rhythm,[206] with *solkattu*, rhythmical patterns are internalised as a sequence of words, one for each rhythmic unit, involving an intonation component.[207] This strategy builds on pre-established knowledge, since the syllables typically assigned to a standard rhythmic unit do not vary. Therefore, becoming a standard chunking strategy for rhythm, if familiar with such method. For example, the *solkattu* syllables that I use are detailed in Example 3.29:

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[203] However, I encourage exploring further techniques discussed by Reina (2015).
[204] *Solkattu* is also known as *konnakkol*.
[205] Reina (2015: 22).
[206] e.g., Gordon (1997; 2000), Pike and Carter (2010: 234).
[207] An example of the practical implementation of *solkattu-konnakkol* is available here: https://youtu.be/K1Q9QgFyJjw

Example 3.29: ***Solkattu*** **syllables for the triplet, duplet, quintuplet, sextuplet and septuplet.** This is a standard combination of *solkattu* syllables widely used, in which the syllable "TA" is always assigned to the first beat. Furthermore, *solkattu* subdivides long rhythms into smaller familiar units. For example, the syllables for a septuplet are the sum of the syllables for a duplet and a triplet.

Thus, counting is substituted by a word previously assigned depending on the rhymical value. This is exemplified in the left hand of Chin's Toccata (Example 3.30):

Example 3.30: Unsuk Chin, ***Etude No. 5 "Toccata"*** **(2003), bars 57-60, after implementing** ***solkattu.*** The *solkattu* syllables for septuplets 'ta-ke-di-mi, ta-ki-da' were correspondingly assigned to the left hand. The resulting syllables are highlighted in colours, so the locations of the main accents are clearer, while the softer variations of the septuplet are further emphasised in green, yellow, blue, brown and purple.

The procedure for memorising the highlighted rhythm in Example 3.30 is to establish a steady groove by repeating the basic septuplet syllables 'ta-ke-di-mi, ta-ki-da' and emphasise those present in the rhythmical phrase. This is illustrated with the verbal summary below (see Figure 3.11), in which each row represents a bar: coloured syllables are the ones that should be emphasised, while those in black are not present in the left-hand pattern:

TA-KE-DI-MI, TA-KI-DA

TA-KE-DI-MI, TA-KI-DA

TA-KE-DI-MI, TA-KI-DA

TA-KE-DI-MI, TA-KI-DA

Figure 3.11: Summary of the *solkattu* syllables implemented in Example 3.30.

All syllables can be repeated either verbally or mentally, whereas those syllables to be emphasised can either be accented with voice or clapped. Additional practice using other resources is encouraged, to internalise further the rhythm. Since patterns are translated into a combination of pre-established syllables stored in memory, rhythm is chunked and encoded using verbal memory, instead of rote repetition and counting. Hence, facilitating chunking for rhythmical patterns. Moreover, syllables' intonation contributes to internalising rhythm further, emphasising temporal proportion and phrasing. Finally, by not overwhelming WM with counting, focus can switch to the right hand or other parameters (e.g., phrasing, pedalling, expressiveness), potentially overlooked when strictly monitoring rhythm.

While rhythm can significantly increase the complexity of a musical work,[208] this receives little attention in Western musical education and training.[209] Concretely, Pierre Boulez observed that 'the lack of [rhythmical] accuracy… is the biggest obstacle for communication between composers and [the] public'.[210] Furthermore, rhythmical complexity is an important obstacle to memorisation and the performance of post-tonal piano music, for which research

208 Duffy and Pearce (2018), Fonte (2020: 114-115; 118-138), Gregory (1972), Jónasson and Lisboa (2015), Li (2007: 45), McPherson (1994), Soares (2015: 37), Thomas (1999: 47-65). See also the post-tonal piano case study of *Emma* reported by Fonte (2020: 223), in which this participant admits struggling with rhythm, this being the reason why she kept delaying memorisation of the given piece. Participants *Harry* and *Emma* also struggled with rhythm in terms of learning and confidence in performance (Fonte, 2020: 275-276; 291).
209 Gordon (1997; 2000), Pike and Carter (2010), Reina (2015: 443-449).
210 Cited in Reina (2015: 443).

only suggested counting strategies or performance cues.[211] However, these are inefficient for challenging rhythms (e.g., polyrhythms, irregular rhythms).[212] Therefore, *Solkattu* Verbalisation and Clapping is a first step towards absorbing Karnatic rhythmical techniques into Conceptual Simplification. These Karnatic strategies were adapted to Western musical notation,[213] and their implementation aligns well with Conceptual Simplification's framework. Finally, beyond *solkattu*, the strategy described here relies on verbalisation and clapping, which are common in Karnatic rhythmical techniques for internalising rhythm. Concretely, verbalisation benefits from the *production effect*, with which memory for a series of items is more strengthened when verbalised aloud (e.g., rhythmical patterns with *solkattu* syllables), than when repeated internally.[214] This effect appears for both recognition and recall, prompted by verbalisation's distinctive processing.[215]

Rhythm Conceptualisation

This strategy is used for encoding challenging rhythmical structures. The resulting framework provides a tool for practising motor action but also a conceptual scheme for monitoring performance. For instance, given Example 3.31:

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211 e.g., Fonte (2020: 157-159), Li (2007: 90; 94), Soares (2015: 64; 86-88; 102-104; 117-121; 151-152), Thomas (1999: 47-65).

212 e.g., Fonte (2020: 160). Exceptionally, percussionist and conductor Steven Schick provides three main rhythmic strategies, that emerged when memorising Brian Ferneyhough's *Bone Alphabet* (1991):

(1) Solving polyrhythms by means of calculating the least common multiple of their constituent components.
(2) Translating rhythmic notations into indications of tempo.
(3) Casting one line of a polyrhythm as strongly foreground in nature against which other rhythmic lines act ornamentally in varying degrees of rhythmic dissonance to the original.

See Schick (1994) for further details.

213 Reina (2015) structures existing Karnatic rhythmical techniques to be used by performers and pedagogues into two main blocks. First, irregular groupings that he defines as *superimpositions*, and that involve techniques such as *nadai bhedam* (Reina, 2015: 183-211) and *anuloma-pratiloma* (Reina, 2015: 81-90; 213-244). Secondly, techniques for tackling *crossing accents phrasing*, and that involve techniques such as *gati bhedam* (Reina, 2015: 45-59) and *jathi bhedam* (Reina, 2015: 69-79).

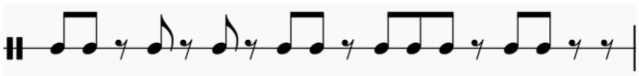
214 Forrin and MacLeod (2018), MacLeod et al. (2010).

215 Conway and Gathercole (1987), Craik and Lockhart (1972), Hunt (2013), MacLeod et al. (2010).

Example 3.31: György Ligeti, *Etude No. 8 "Fém"* (1989), bars 1-6, to exemplify Rhythm Conceptualisation.

Despite its simple appearance, Ligeti's *Fém* exemplifies rhythmical switches in a self-referencing context. Therefore, Rhythm Conceptualisation's first step is to identify the essential rhythmical cells. From this analysis, three basic ideas emerged:

1) The right hand's rhythmical phrasing consists of the following 18-beat pattern:

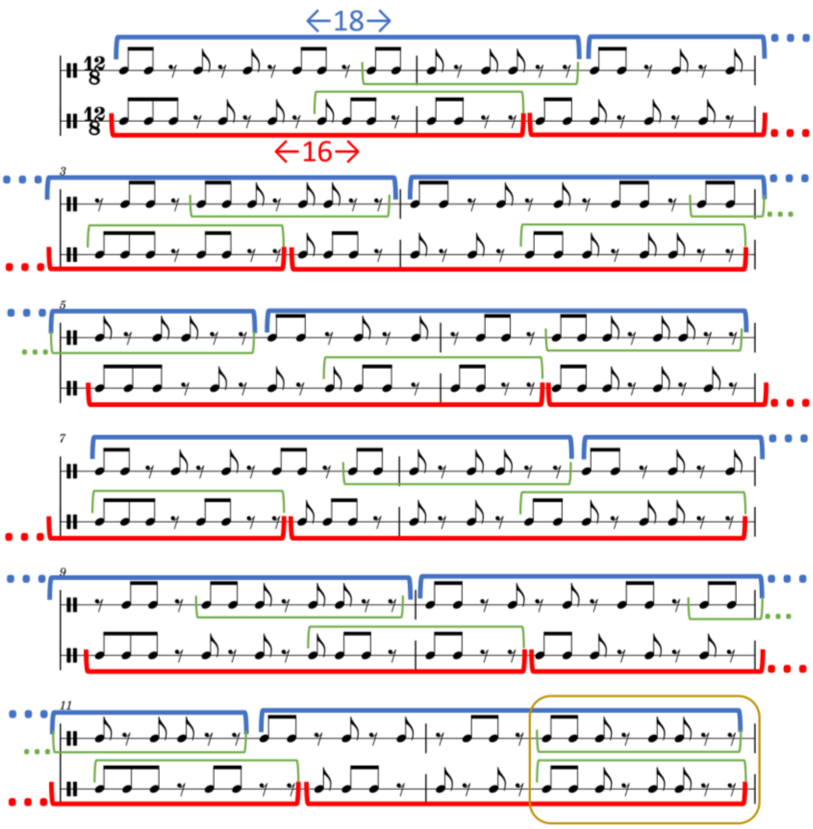


2) The left hand's rhythmical phrasing consists of the following 16-beat pattern:

3) Both patterns end with the following 5-beat pattern:

Example 3.32: György Ligeti, *Etude No. 8 "Fém"* (1989), bars 1-6, analysis of all rhythmical patterns to implement Rhythm Conceptualisation.

Using these three patterns, a rhythmical analysis of the etude can be completed, of which Example 3.33 provides the first section:



Example 3.33: György Ligeti, *Etude No. 8 "Fém"* (1989), bars 1-12, rhythmical analysis of Section A after implementing Rhythm Conceptualisation. Blue brackets highlight the right hand's 18-beat pattern, red brackets delimit the left hand's 16-beat pattern, green brackets emphasise the common 5-beat pattern and a brown circle illustrates where both hands fully synchronise in bar 12.

The greatest common divisor (gcd) of 18 and 16 is 2 since $18 = 2{\cdot}3^2$ and $16 = 2^4 = 2{\cdot}2^3$.[216] From there, it is deduced that the 18-beat pattern is to be repeated eight times and the 16-beat pattern is to be repeated nine times until both coincide. Therefore, as circled above, this cyclic rhythmic structure repeats every 12 bars, articulating this etude's main rhythmical phrasing. Consequently, Rhythm Conceptualisation's second step is to internalise the corresponding hand coordination of this 12-bar structure. Accordingly, pitch is alternatively removed and restored, as different combinations are practised, which involve performing the patterns both without pitch and with pitch, hands separately and together. For the latter, four combinations are used, in which hands are either crossed or interchanged. Here, *crossing hands*

[216] This can be seen using Euclid's algorithm for computing gcd(18, 16), which provides that gcd(18, 16) = gcd(16, 2) = gcd(2, 0) = 2. Further details on this algorithm and the greatest common divisor (gcd) can be found in section 3.2.1 of this chapter.

means that both hands perform their corresponding patterns but exchange positions, whereas *interchanging hands* involves one hand's pattern being played by the other hand and vice versa. Thus, simultaneously crossing and interchanging hands implies these exchanging positions and patterns. Figure 3.12 summarises all possible combinations:

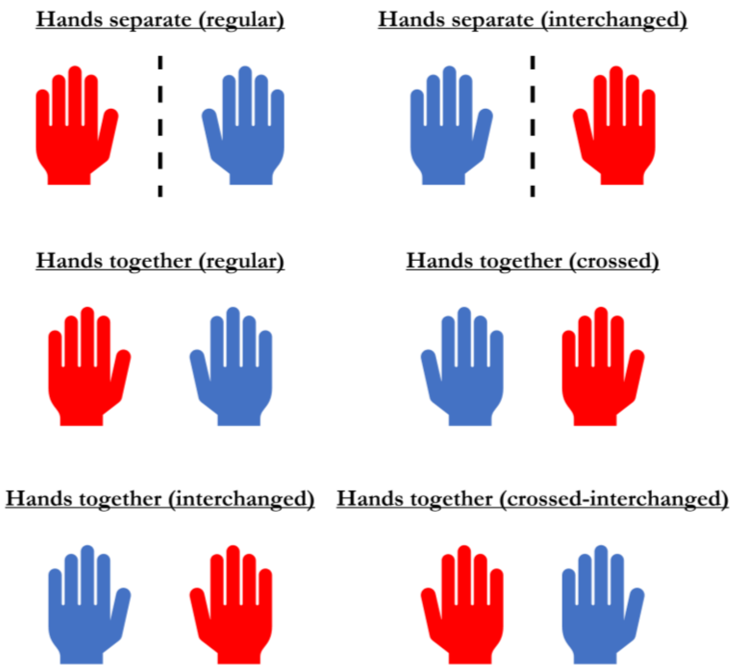


Figure 3.12: Summary of the six proposed hand-and-pattern combinations with which the 12-bar cyclic rhythmic structure of György Ligeti's *Fém* can be practised. These exercises shall help in confidently internalising both the 18-beat and the 16-beat patterns, strengthening the resulting hand coordination.

After practising all combinations in a percussive manner, for each section, these are practised again but with the corresponding pitches. This last step is flexible to the challenges and limitations encountered. Since rhythmical switches are thoroughly practised with the above exercises, restoring the original pitches provides an additional distinctive layer that reinforces memory further.[217] Consequently, Rhythm Conceptualisation and the hand-and-pattern combinations disassociate memorisation from the context of the patterns memorised (i.e.,

[217] Therefore, in some way, benefiting from the von Restorff effect. See Chee and Goh (2018), Eysenck (1979b), Hunt (2013), von Restorff (1933).

hands, pitches, position). Therefore, preventing the context-dependent memory effect,[218] and prompting the retrieval difficulty hypothesis,[219] which benefits retention when practice is challenged with additional levels of difficulty (e.g., crossing or interchanging hands). Furthermore, the advantages of tackling rhythm independently from pitch, and even 'away from the instrument' were also reported in observational studies.[220] The following strategy provides a broader approach for conceptualising patterns.

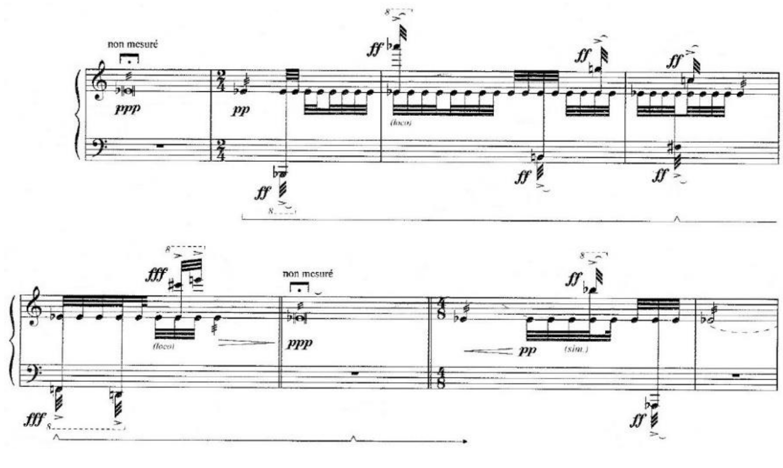
Pattern Conceptualisation

This strategy devises theoretical frameworks that combine several parameters at once (e.g., harmony, rhythm, dynamics, repetition, octaves). Accordingly, Pattern Conceptualisation summarises the music into conceptual guidelines, allowing to deduce and reconstruct all content. Such abstraction of general rules also facilitates monitoring the performance. Theoretical frameworks result from combining several simplifying strategies, revealing how layers of complexity interact at different levels. Furthermore, the strategy also relies on those mathematical structures identified in the musical work.[221] Concretely, this thesis focuses on translations, reflectional and rotational symmetries, glide reflections and permutations.[222] Nonetheless, these can be extended, including to other composition principles. For example, given Webern's Piano Variations (Example 3.34):

[218] Baddeley et al. (2020: 254-258), Glenberg (1997), Godden and Baddeley (1975), Mishra and Backlin (2007), Smith (1982), Smith and Vela (2001).
[219] Baddeley et al. (2020: 127-128), Bjork and Bjork (1992), Pyc and Rawson (2009).
[220] e.g., Soares (2015: 193).
[221] For example, see Benson (2011), Cross ([2003] 2010), Hodges ([2003] 2010), Hofstadter ([1979] 2010), Madden (2005; 2007), Papadopoulos (2014).
[222] See section 3.2.2.

Example 3.34: Anton Webern, Piano Variations Op. 27 (1936), 'Variation II', bars 1-14, to exemplify Pattern Conceptualisation.

Example 3.34 satisfies a mirror construction, conceptualised as a horizontal symmetry. This becomes clearer in Manoury's Piano Toccata (Example 3.35), with an explicit axis of symmetry (E♭-ostinato):



Example 3.35: Philippe Manoury, *Toccata pour piano* (1998), bars 1-8, to exemplify Pattern Conceptualisation.

The E♭-ostinato is repeated throughout the excerpt, therefore, regarded as a layer of complexity and removed (see Example 3.36).

Example 3.36: Philippe Manoury, *Toccata pour piano* (1998), bars 1-8, after removing the E♭-ostinato (Simplifying Pitch) as part of implementing Pattern Conceptualisation.

Similarly, a second layer of complexity is removed by transposing all notes to the same octave, as shown in Example 3.37:

Example 3.37: Philippe Manoury, *Toccata pour piano* (1998), bars 1-8, after removing the E♭-ostinato (Simplifying Pitch) and implementing Simplifying Octaves, as part of Pattern Conceptualisation.

Thus, if rhythm is also removed (third layer of complexity), two sequences are obtained:

RH: A♭-G-C-C♯-E-B♭

LH: B♭-B-F♯-F-D-A♭

After re-arranging these with an instance simplification approach, the underlying pitch organisation (horizontal symmetry) is identified, as Figure 3.13 illustrates:

B♭-B-C-C♯-D-E♭-E-F-F♯-G-A♭

Left hand **Right hand**

Figure 3.13: Analysis of the horizontal symmetry of Philippe Manoury's *Toccata pour piano*, to implement Pattern Conceptualisation.

Hence, with Pattern Conceptualisation the following equivalences (~) are established as pitch classes, using the above symmetrical structure:[223]

B♭ ~ A♭ / B ~ G / C ~ F♯ / C♯ ~ F / D ~ E

These pitch classes provide an important general rule for memorising: each note in the left hand is immediately succeeded or preceded by its symmetrical equivalent (see Example 3.38).[224] Therefore, memorising the relationships above permits deducing and reconstructing each hand from the other. Consequently, only half of the pitches need to be memorised:[225]

Example 3.38: Philippe Manoury, *Toccata pour piano* (1998), bars 1-8, after removing the E♭-ostinato (Simplifying Pitch), implementing Simplifying Octaves and Simplifying Rhythm, as part of Pattern Conceptualisation.

Another subproblem to tackle is rhythm, which is encoded with *solkattu*. Accordingly, syllables are assigned to each 32nd note ('ta-ke-di-mi, ta-ka-jha-nu'), obtaining the following:

Example 3.39: *Solkattu* syllables for Philippe Manoury's *Toccata pour piano*, to implement Rhythm Conceptualisation.

[223] The theoretical background of pitch classes, modular arithmetic and its implementation to music was explained in this chapter, section 3.2.2.
[224] Across the piece, Manoury transforms this simple horizontal symmetry into a fractal symmetry: see section 3.2.1 in this chapter for a definition of a fractal. For this purpose, he establishes a new axis of symmetry on each note to arrange an additional symmetrical structure that keeps being extended, mirroring a fractal construction. Nevertheless, when a new axis is located too close to the extreme registers, perfect symmetry cannot be respected since one of the two potential symmetrical pitches would be out of range. In that case, Manoury recalculates the pitch from the opposite register. Philippe Manoury explained this composition principle to me in a written interview on 12 April 2017, and later in a private masterclass on 27 July 2017, in which I performed the piece from memory for him.
[225] A similar approach can be done for the rest of the piece.

Example 3.40: Philippe Manoury, *Toccata pour piano* (1998), bars 1-8, after removing the E♭-ostinato (Simplifying Pitch), implementing Simplifying Octaves and *solkattu* syllables, as part of Rhythm Conceptualisation.

Syllables highlighted in Example 3.40 are used to trigger the written rhythm, while the basic syllables 'ta-ke-di-mi, ta-ka-jha-nu' are repeated to keep a steady groove for the 32nd-note basic pattern. The procedure to be followed was explained with *Solkattu* Verbalisation and Clapping, and should be repeated when restoring pitches, and the original octaves. Finally, the E♭-ostinato is also incorporated.

Manoury's Piano Toccata illustrates how to implement Pattern Conceptualisation with geometry and modular arithmetic. Concretely, the identified symmetry was used to define pitch classes: i.e., pairs of notes that are symmetrical, hence equivalent. Additionally, divide-and-conquer was used to identify two subproblems: pitch organisation and rhythmical structure. These were solved first individually and then combined, until the original excerpt was fully memorised. However, a different implementation of Pattern Conceptualisation can be illustrated with group theory and permutations, using Ruders' *Shooting Stars* (Example 3.41):[226]

[226] Permutations and cyclic permutations are explained in section 3.2.2.

Example 3.41: Poul Ruders, *Shooting Stars* (1999), bars 5-20, after implementing Pattern Conceptualisation.[227] The left hand presents a changing ostinato, whereas the right hand develops a cyclic permutation alternating the current ostinato with a variation of it. Different colours are used to highlight how the piece evolves: yellow emphasises the first ostinato and purple its extended version, both used in the first cyclic permutation. Colours orange and pink are used in a similar way for the second cyclic permutation. Then, this general pattern changes slightly, and so green is used to identify when the new ostinato appears in the right hand, forming the third permutation. From bar 18 onwards, further variations are introduced in the right hand forming a fourth permutation, and which are distinctly coloured accordingly. Additionally, red circles are used to emphasise when the right hand phases out of synchrony from the left hand.

Despite its uniformity and self-referencing features, Example 3.41 can be memorised using permutations. First, it is divided into two halves: A (b.5-13) and B (b.14-20). Furthermore, both halves are subdivided into two additional halves:

A = a_1 (1st cyclic permutation) + a_2 (2nd cyclic permutation)[228]

B = b_1 (3rd permutation) + b_2 (4th permutation)[229]

For each subsection, four different ostinatos (O) are identified with the following tetrachords:

O_{a_1} = A-C-E-F / O_{a_2} = A-C-E-F♯ / O_{b_1} = A-C-D-E / O_{b_2} = A-C-E-G

227 Retrieved from Myers (2001: 38-39).

228 a_1 corresponds to bars 5-9(1st beat) and a_2 to bars 9(2nd beat)-13. Note that the last step of the first cyclic permutation (i.e., when both hands should synchronise again) coincides with the beginning of the second permutation. In the latter, the ostinato is simply modified by substituting F for an F♯.

229 b_1 corresponds to bars 14-18(1st beat) and a_2 to bars 18(2nd beat)-20.

Therefore, section A is summarised with the following formula, only requiring remembering O_{a_1} since O_{a_2} is obtained by substituting the F in O_{a_1} for an F♯. Likewise, the respective extended versions of both ostinatos consist in adding a G at the end.

$$A = \quad a_1\binom{\mathrm{RH}}{\mathrm{LH}} \quad + \quad a_2\binom{\mathrm{RH}}{\mathrm{LH}} \quad =$$

$$= \begin{pmatrix} O_{a_1} + (O_{a_1} + G) \\ (O_{a_1})x2 \end{pmatrix} x4 + \begin{pmatrix} O_{a_2} + (O_{a_2} + G) \\ (O_{a_2})x2 \end{pmatrix} x4$$

Conversely, section B = $b_1 + b_2$ requires more work. First, the right hand in b_1 alternates O_{b_1} with the three following motifs (m):

Example 3.42: Poul Ruders, *Shooting Stars* (1999), bars 5-20, three motifs from subsection b_1.

Hence, the first step is to memorise these and O_{b_1} individually. Then, these motives are memorised sequentially according to their appearance in b_1's right hand, which satisfies the formula:

$$m_1 + m_2 + (m_1)x3 + m_3$$

Once this is memorised, O_{b_1} is restored, modifying the above formula as follows:

$$(m_1 + O_{b_1}) + (m_2 + O_{b_1}) + (m_1 + O_{b_1})x3 + m_3$$

After memorising the right hand, the whole subsection is finally memorised by restoring O_{b_1} as an ostinato in the left hand. Here, m_3 is regarded as a motif, but it belongs to the next subsection b_2. However, by incorporating it in the algorithm described above, the transition between both subsections is reinforced, avoiding potential hesitations: a frequent issue in fast and self-referencing pieces like this.[230] Another reason is that the end of the O_{b_1} ostinato coincides with the end of m_3. Finally, b_2 is similarly memorised, but with the following interspersing motifs, which can be regarded as an oscillation around C:[231]

m_4 m_5 m_6

Example 3.43: Poul Ruders, *Shooting Stars* (1999), bars 5-20, three motifs from subsection b_2.

Concretely, the sequence to be memorised for the right hand satisfies the structure:

$$(m_4 + m_5 + m_6) + m_5 + (m_4 + m_5 + m_6)$$

This sequence is then combined with the O_{b_2} ostinato in the left hand. Finally, according to divide-and-conquer's last step, memorised subproblems A, b_1 and b_2 are combined and practised from memory to integrate the whole passage. The rest of the piece is similarly tackled. While Example 3.41 was used to illustrate how Pattern Conceptualisation can be used in conjunction with permutations, it also introduced an approach to tackle switches, that is now detailed.

<u>Switches Conceptualisation</u>

This strategy is used for tackling switches.[232] These turning points might involve different arrangements, have their content incomplete, or resolve differently. Essentially, a switch is that specific point in a composition in which repetition of the same musical idea diverges from a previous version, taking a different track.[233] Switches can be found in themes that

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230 e.g., Fonte (2020: 158-159; 161; 163-164).

231 As stated, m_3 corresponds to $m_4 + m_5$, without the last note of the latter.

232 See also Chapter 2, sections 2.2.2.2 and 2.4.3.

233 Chaffin and Imreh (1997a: 325-326), Chaffin et al. (2002: 95-97).

repeat, each time with different features;[234] and in self-referencing content.[235] During performance, conscious decisions must be made for each switch, to decide which track is the right one. Failing to do so might imply suddenly performing a different but similar place of the composition.[236] Therefore, neither aural nor kinaesthetic memories suffice for 'automatically' choosing the correct track to switch (Chaffin et al., 2002: 206).[237] Instead, conceptual memory is required to know where switches are located; to swiftly make the right decision when needed; and should the wrong path be provisionally taken, to proficiently recover from that mistake.[238] Consequently, amongst all memorisation challenges, switches are the most unstable, hard to secure in memory, and dangerous during performance.[239]

Accordingly, switches constitute a memory maze with the potential to undermine a performance, even when using the score, and require prolonged deliberate practice.[240] Moreover, switches can also be misleading if not properly monitored.[241] Thus, Switches Conceptualisation is here exemplified in two different contexts: a recurring theme and a self-referencing texture. The first kind is illustrated with Fujikura's *Frozen Heat* (Example 3.44):

[234] e.g., Chaffin and Imreh (1997a: 325-326), Soares (2015: 122-123; 138).
[235] e.g., Farré Rozada (2018: 35-37), Fonte (2020: 155-156), Soares (2015: 127-128).
[236] Chaffin and Lisboa (2008: 132), Chaffin et al. (2002: 95-97).
[237] That is without an effortful combination of 'careful attention', 'conscious remembering' and 'monitoring of individual steps' (Baddeley et al., 2020: 148).
[238] See Chaffin and Imreh (1997a: 325-326), Chaffin and Lisboa (2008: 118; 132-133; 137), Chaffin et al. (2002), Fonte (2020: 161).
[239] Chaffin and Lisboa (2008: 132-133; 137), Chaffin et al. (2002: 206).
[240] Chaffin et al. (2002: 95-97).
[241] Fonte (2020: 155; 161), Soares (2015: 121-125; 138-139).

Example 3.44: Dai Fujikura, *Frozen Heat* (1998), bars 38-43, 75-79 and 92-97, highlighted in different colours as part of implementing Switches Conceptualisation. Differences across these three similar excerpts are framed with different colours. On the one hand, different arrangements are marked in blue, purple, red and pink. Concretely, the difference in the blue frame focuses on the low E, which permutates with the semiquaver silence; the purple frame highlights that the third time this element appears, the pitches in the second, seventh and eighth semiquavers are slightly modified; the red frame indicates that the first semiquaver in the right hand of bar 40 is transposed by a descending third minor in bar 94; and the pink frame shows that the D-octave in bar 41 is simplified into a simple repetition in bar 95. On the other hand, different resolutions are highlighted in orange and green. Clearly, the content of bars 40-41 and bars 94-95 marked in orange does not coincide with that of bars 78-79. Likewise, the green mark indicates a similar phenomenon between bars 43 and 97. Hence, all these differences provide the surrounding locations of switches in these excerpts, which are to be kept well in mind when performing. Also, note that bars 38-43 present a full version of the material that is interrupted in one way or another in the other two excerpts.

Example 3.44 shows several motifs and sections that either repeat without changes, are interrupted, or slightly modified. The locations of these differences are framed in different colours, since the first step is to identify where switches are located and compare them. Preferably, this analysis happens during the Triage and is reinforced with physical and mental practice later. Also, since switches are the places in which repetition diverges, the above-coloured frames are not the switches themselves, but the areas in which these are located.

Thus, the next step narrows these down to the specific points in which a decision needs to be made to stay right on track. This is summarised with Example 3.45:

Example 3.45: Dai Fujikura, *Frozen Heat* (1998), bars 38-43, 75-79 and 92-97, after implementing Switches Conceptualisation. All switches are circled using the same colour code as before. The main switches are highlighted with a continuous circle, whereas secondary switches are marked with a discontinuous circle. This is because secondary switches are likely to be automatised once all switches are thoroughly worked and assimilated, since these are not the main turning points.[242] Hence, eventually, only the main switches shall be kept as a reference to monitor performance and retrieve the appropriate content accordingly. However, it is important to be aware of secondary switches since a mistake on these could also be misleading, and these can also be used to verify that the right track was chosen.

Example 3.45 illustrates how switches can be reduced to a smaller number by combining some of these. At this stage, the most complete version of the material should be established as a model, for encoding all its divergences accordingly. Usually, this tends to be the first appearance of such content in the piece. Concretely, in Example 3.45, bars 38-43 present the

[242] In the context of Performance Cue Theory, Chaffin et al. (2002: 251-252) describes this process as *rechunking*.

fullest version of the main material presented, which is interrupted in different ways in bars 75-79 and 92-97. Therefore, the excerpt comprising bars 38-43 is taken as the model, being also the first time that this material appears in the whole piece. Using this as a template, there are three crucial switches that must be attended to when performing:

1) The blue-circled low E in the left hand of bar 38.

2) The first semiquaver of bar 40.

3) The first beat of bar 43.

Attending to that first switch permits correctly retrieving the model version, but also the alternative version when that same switch reappears in bar 76. Similarly, paying attention to the second switch in bar 40 alerts that bar 77 resolves differently, but also that the transposition in the right hand, circled in red, is essential for recalling correctly the version starting from bar 94. Failing to do so might imply missing the third main switch, circled in green, and returning to the model version for that section. However, this third crucial switch also permits jumping to the correct section, should the wrong path be previously taken. From this perspective, a three-level hierarchy is established:

I) The highest level: the three crucial switches just described, circled in blue, orange-red and green.

II) The intermediate level: other main switches reflecting different arrangements to bear in mind, circled in purple and pink.

III) <u>The lowest level:</u> secondary switches highlighted in blue and purple with discontinuous circles. These are likely to become automatic,[243] but it is important to be aware of them, especially during early learning and memorisation.

In summary, Switches Conceptualisation for a recurring theme or multiple motifs maps how switches are placed in the piece. This approach is backed by existing research on switches,[244] although the literature has not provided effective practice and memorisation strategies for these.[245] Instead, researchers observed how performers tackle these in their practice, explaining the results with Performance Cue Theory.[246]

Psychology theorises switches with *memory interference*:[247] i.e., when information retrieval is disrupted by similar content stored in memory.[248] Additionally, some exploratory sleep studies on musical memory suggested that learning similar material in a short period of time (e.g., the same session), might cause that the second component learned inhibits sleep-based enhancement for the first.[249] Concretely, Allen (2013: 798) tested four approaches for learning two similar melodies A and B in a 12-hour time frame. Her findings ordered these strategies from most to least effective as presented in Figure 3.14:

[243] Baddeley et al. (2020: 148), Chaffin et al. (2002: 251-252), Mishra (2004).
[244] e.g., Chaffin et al. (2002).
[245] For example, some studies that report switches' problematic but that do not provide effective ways of practising and memorising these are Chaffin and Imreh (1997a: 325-326), Chaffin and Lisboa (2008: 118; 132-133; 137), Chaffin et al. (2002: 95-97; 206), Fonte (2020: 155-156; 161), Soares (2015: 121-128; 138-139).
[246] e.g., Chaffin and Imreh (1997a), Chaffin and Lisboa (2008), Chaffin et al. (2010), Fonte (2020: 118-196; 287-308), Ginsborg and Chaffin (2011a; 2011b), Soares (2015: 34-70; 119-127; 138-139).
[247] Baddeley et al. (2020: 285-307), Chaffin et al. (2002). See also Chapter 2, section 2.2.2.
[248] Anderson (2003), Baddeley et al. (2020: 285).
[249] Allen (2013), Duke and Davis (2006).

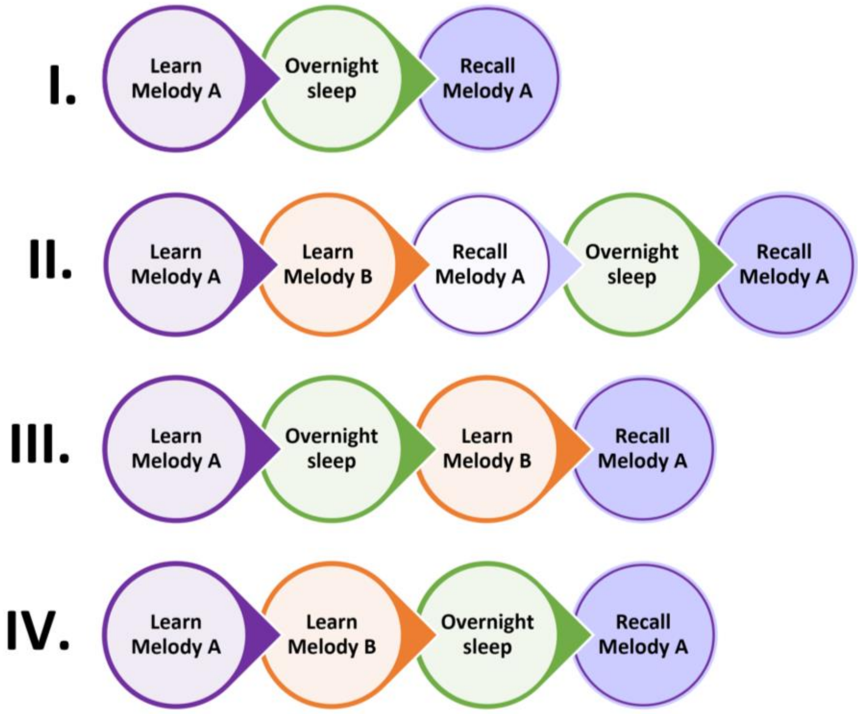


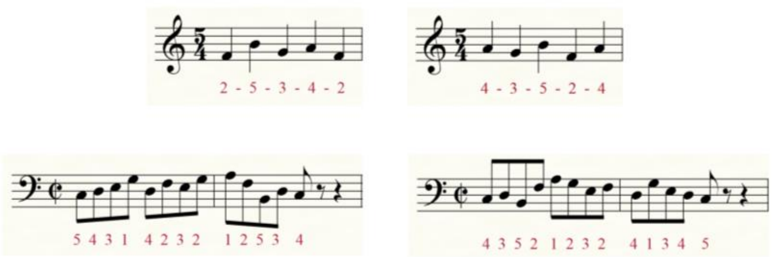
Figure 3.14: The four approaches for learning two similar melodies A and B tested by Allen (2013) and ordered in decreasing order of effectiveness.

According to Allen (2013), two similar melodies are best learned on different days, allowing at least a gap day in between, to enable sleep-dependent consolidation for both melodies.[250] Duke and Davis (2006: 117) found similar results for shorter melodies and without practice, indicating that allowing a two-day gap between learning each melody could be even better.[251] Next, Allen's (2013: 799) second most effective strategy is learning both melodies in the same session, to then recall the first melody learned. This prevents the second melody from interfering with the first's overnight enhancement. Otherwise, not recalling the first melody again before sleeping leads to Allen's fourth approach, which is the least effective: a result also found by Duke and Davis (2006: 117) and Walker et al. (2003: 617-619). Finally, Allen's third most efficient strategy involves learning each melody on consecutive days. However,

250 See also Cash (2009), Duke et al. (2009), Simmons (2012), Simmons and Duke (2006).
251 Duke and Davis, 2006 (116-118).

learning the second melody prior to recalling the first one impairs the latter's overnight improvements.

These findings could be adapted into effective strategies for switches, but important limitations are noted. First, the similarity of the melodies tested in Duke and Davis (2006) and Allen (2013) does not satisfy the definition of switches.[252] Instead, these are resemblant in tonality, length, metre and rhythm (see Example 3.46), but without presenting misleading turning points that could prompt accidentally switching from one melody to the other.



Example 3.46: The two melodies tested in Duke and Davis (2006), and the two melodies tested in Allen (2013). In the first row, the two melodies tested in Duke and Davis (2006: 115). In the second row, the two melodies tested in Allen (2013: 797-798). Numbers in red indicate the fingerings provided by the researchers to their corresponding participants. The melodies from Duke and Davis (2006) were recreated by me from the authors' descriptions to facilitate visual comparison of all melodies, since only the corresponding fingering sequences were provided to participants.

Secondly, both studies focused on explicit procedural memory, accuracy and speed in performance. However, participants were not required to memorise the melodies, since the studies targeted motoric automaticity.[253] Also, participants were not extensively trained musicians,[254] thus, the given task did not exceed their abilities. Finally, Duke and Davis' (2006: 115) participants could not hear their performances and melodies were presented in the form of fingering sequences. Concretely, these melodies were adapted from Walker et al.'s (2003)

[252] Chaffin et al. (2002: 95-97).
[253] In psychology, *automaticity* describes the process of practising a skill until 'significant attentional monitoring' is no longer needed when performing it. Consequently, less effort is required (Baddeley et al., 2020: 148).
[254] Duke and Davis' (2006: 115) participants were non-music majors enrolled in music classes at the university, whereas Allen's (2013: 796) participants were music majors enrolled in undergraduate and graduate courses.

finger-tapping tasks, resulting in whole-tone melodies not following standard pitch organisation.[255] Furthermore, lacking auditory feedback during practice has detrimental effects on memorisation.[256]

Despite this, Duke and Davis (2006: 119-120) did not replicate Walker et al.'s (2003) findings, failing to identify an inhibiting or eliminating effect on sleep-dependent consolidation.[257] Instead, consolidation happened for both melodies trained in the same session, although the second was further enhanced. They also found that off-line improvement across a 48-hour span (two nights) was significantly inhibited or reduced when a competing melody was trained in between.[258] Notwithstanding, previous sleep-dependent enhancements were not lost, contradicting Walker et al.'s (2003) results. Also, Duke and Davis (2006: 120) could not identify the reasons for such divergence in the results. Instead, their data analysis focused on memory consolidation, omitting the potential impact of the participants' pre-existing musical knowledge and training when performing the given task.[259] The literature on expertise could explain their findings.

Walker et al.'s (2003) participants were not experts on the finger-tapping task and faced it as novices,[260] whereas Duke and Davis' (2006: 115) participants were musically trained and closer to an expert profile. Consequently, Walker et al.'s participants had to devise their own system for mastering the finger-tapping sequences, while Duke-and-Davis' could use their

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255 Huron (2006), Jonaitis and Saffran (2009), Krumhansl (1979).
256 e.g., Highben and Palmer (2004).
257 Brashers-Krug et al. (1996), Walker et al. (2003).
258 Duke and Davis (2006: 119).
259 Bower et al. (1969), Brewer (1987), Chaffin and Logan (2006), Chaffin et al. (2002), Ericsson (1988), Ericsson and Charness (1994), Ericsson and Kintsch (1995), Ericsson and Oliver (1989), Gobet (2015), Hallam (1997), Halpern and Bower (1982), Johnson (1970), Koelsch et al. (1999; 2002), Krumhansl (1979), Krumhansl and Shepard (1979), Lehmann and Gruber (2006), Mishra (2005), Oura and Hatano (1988), Rosenbaum (1987), Schulze and Koelsch (2012), Sloboda et al. (1985).
260 See also Walker et al. (2002: 210) related study.

domain of expertise (e.g., pre-existing knowledge of tonal theory),[261] and adapt it to whole-tone melodies.[262] Also, interspersing an additional task does not hamper expert memory:[263] experts identify familiar patterns and chunk them accordingly.[264] Nevertheless, Duke and Davis' (2006) participants should not be fully regarded as experts, given their limited musical training, potentially explaining why an inhibiting effect on sleep-dependent consolidation was identified.[265] Finally, consolidation is significantly enhanced by a certain familiarity with the content to be learned.[266] Again, such acquaintance with the materials tested in Duke and Davis (2006) came from the participants' previous musical training. Furthermore, given the brevity of the melodies involved, participants could have also identified even-odd patterns, black-and-white combinations, or how fingering is distributed. All these arguments might explain why Walker et al.'s (2003) and Duke and Davis' (2006) results diverge.

Considering these limitations, van Hedger et al. (2015) studied how sleep influences piano performance. Previously, the effect of sleep was only evaluated for melodies and procedural explicit memory.[267] Thus, they tested the impact of overnight consolidation on procedural-motor training and declarative-abstract understanding. That is, how the acquisition of motor and conceptual sequences evolves with practice and sleep, due to off-line learning.[268] Accordingly, they used tonal excerpts involving both hands,[269] participants were more trained than Duke and Davis' (2006) and Allen's (2013), and data analysis dissociated procedural

[261] Gobet (1998; 2015), Mishra (2005).
[262] Duke and Davis (2006: 115), Tsintzou and Theodorakis (2008).
[263] e.g., Charness (1976).
[264] Chaffin and Logan (2006), Chaffin et al. (2002), Ericsson and Charness (1994), Gobet (2015), Hallam (1997), Halpern and Bower (1982), Mishra (2005), Oura and Hatano (1988), Schulze and Koelsch (2012), Sloboda et al. (1985).
[265] Duke and Davis, 2006: 119.
[266] Tse et al. (2007), van Kesteren et al. (2012).
[267] Allen (2007; 2013), Cash (2009), Duke and Davis (2006), Duke et al. (2009), Simmons (2007; 2011; 2012), Simmons and Duke (2006), Wilson (1983).
[268] Karni et al. (1998), Luft and Buitrago (2005), Mazza et al. (2016), Peigneux et al. (2001), Rasch and Born (2013), Stickgold et al. (2001), Walker (2005), Wamsley (2022).
[269] van Hedger et al. (2015: 165). These excerpts were taken from the study Palmer et al. (2012).

from declarative learning when assessing the impact of sleep.[270] Excerpts were resemblant in rhythmical uniformity, tonality, length and metre, but more challenging and featured switches. However, participants were also not required to memorise the excerpts, but to perform these with the score, each time at a faster tempo.[271]

Their results indicated 'that sleep strengthens the conceptual (but not specifically motor) representation of music' (van Hedger et al., 2015: 176). Hence, declarative and procedural memories were not equally enhanced during sleep. Instead, sleep-dependent consolidation significantly enhanced declarative memory, particularly conceptual learning and abstract understanding.[272] These findings align with previous non-musical studies,[273] although, during sleep, declarative and procedural memories are processed independently and simultaneously.[274] Motor skills are also enhanced with overnight consolidation,[275] leading to greater accuracy and speed of performance, and less susceptibility to interference.[276] Moreover, the extent to which memories are consolidated overnight is also determined by emotions and purpose:[277] two parameters that can cancel potential interference effects.[278]

Van Hedger et al. (2015) recognised that their participants were constantly reminded to improve note accuracy over other performing elements, which might have prompted participants to develop conceptual memory of the excerpts (e.g., tonality, pitch organisation), forming a salient piece of information within the overall content learned. Accordingly, during

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270 Recruited participants in van Hedger et al. (2015: 164) had received on average 11.6 years of private piano training. Additionally, they also had to pass a sight-playing test before engaging in the actual experiment.
271 van Hedger et al. (2015: 166).
272 van Hedger et al. (2015: 175-176).
273 Albouy et al. (2013), Dumay and Gaskell (2007), Fenn et al. (2013).
274 Brown and Robertson (2007a; 2007b), Diekelmann and Born (2010), Fischer et al. (2006), Robertson (2009), Robertson et al. (2004a).
275 Fischer et al. (2002), Korman et al. (2007), Maquet et al. (2003b).
276 Korman et al. (2007).
277 Cohen et al. (2005), Marshall and Born (2007).
278 Fischer and Born (2009: 1586).

overnight consolidation, sleep-dependent memory triage would have selectively enhanced such salient information.[279] This would explain why the participants' conceptual understanding significantly improved after a night's sleep, whereas no significant improvement was identified for procedural memory. This argument is supported by Fischer and Born (2009), who found equivalent results for procedural memory. Concretely, their participants were trained on two finger-tapping sequences, being promised a reward for performance improvement on only one of them. As a result, sleep-dependent enhancement was significantly greater for the sequence potentially rewarded. Furthermore, Robertson et al. (2004a) found that only when explicit instructions are given on how to perform a task (e.g., learning a sequence), sleep-dependent enhancement is observed. Thus, van Hedger et al. (2015: 176-177) reasoned that should they have instructed participants to improve another parameter rather than note accuracy, the observed overnight gains would have favoured this factor instead.[280] This suggests that emphasising certain information determines how new knowledge is enhanced during sleep.[281] Consequently, 'the way in which a memory is initially encoded' crucially determines its overnight improvement (van Hedger et al., 2015: 177).[282]

This review on sleep and interference demonstrates why this field needs further study, especially in the musical domain. However, existing research indicates potential effective ways for tackling switches, as a form of interference that musicians frequently deal with.[283] Concretely, for a recurring theme, similar features are considered (e.g., melody, rhythm, structure), or any other parameter that originates switches. Here, Switches Conceptualisation was implemented within this context, by developing a hierarchical categorisation of switches.

[279] Stickgold and Walker (2013). In Chapter 2, section 2.2.2.2, further details are provided on how the sleep-dependent memory triage operates.
[280] For example, see also Lewis et al. (2011).
[281] e.g., Fischer and Born (2009).
[282] See also Darsaud et al. (2011).
[283] Chaffin et al. (2002).

However, how switches should be practised is summarised below, building on the studies just discussed:

1) Related switches should not be mixed at an early stage, avoiding working in similar sections and passages during the same session, day or consecutive days. This is to preserve sleep-dependent consolidation from competing material's inhibiting effects. Instead, practice on similar excerpts should be separated by at least a two-day gap.[284] Furthermore, separately internalising related switches prevents cross-referencing.

2) Once these switches are internalised, recalls of all their possible variations should be interspersed, so retrieval becomes progressively faster and overnight consolidation does not favour one version more than another.[285] Recalls should be attempted both with physical and mental practice, although the latter might be more effective for this purpose.[286]

3) Previous knowledge of the content accelerates consolidation,[287] reason why developing a hierarchical categorisation of switches prior to physical practice is so important. This scheme highlights crucial points in the score as salient information, that are favoured with sleep-dependent memory triage.[288] Such conceptual representation of the piece should be explicitly recalled and emphasised during practice, prompting further overnight enhancement.[289]

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284 Allen (2013), Duke and Davis (2006).
285 Allen (2013), Duke and Davis (2006), Fischer and Born (2009).
286 Chaffin et al. (2002: 224).
287 Tse et al. (2007), van Kesteren et al. (2012).
288 Stickgold and Walker (2013).
289 Fischer and Born (2009), Robertson et al. (2004a), van Hedger et al. (2015).

4) Off-line learning enhances procedural memory effortlessly. When this knowledge is exclusively implicit, this happens during wakefulness; whereas when this is combined with explicit knowledge, it happens during sleep.[290] However, practising switches inattentively and exclusively based on repetition should be avoided: unconscious monitoring can lead to internalising mistakes.[291] Additionally, practice based on unattended repetition is inefficient, even when attended but reproduced identically.[292] Instead, less but meaningful repetition should be pursued, interspersing it with wakeful rest or sleep, so off-line learning is consciously incorporated into the practice routine.[293] Both short naps and overnight sleep are useful, especially for challenging declarative content[294] (e.g., switches).[295]

Performance Cue Theory tackles switches with structural cues. These are used to label the specific locations of switches in a piece, defining landmarks that practitioners pay attention to during learning and memorisation.[296] However, no strategy or method is provided for practising switches efficiently: those practitioners observed basically combine monitored repetition with deliberate practice. Also, sleep research's findings are neglected.[297] Alternatively, I proposed approaching switches for a recurring theme by merging Conceptual Simplification with sleep research findings related to interference.[298] Despite exploratory, these advise musicians in that 'practice on similar tasks in a single training session may interfere with subsequent consolidation-based enhancement of the task learned first' (Allen,

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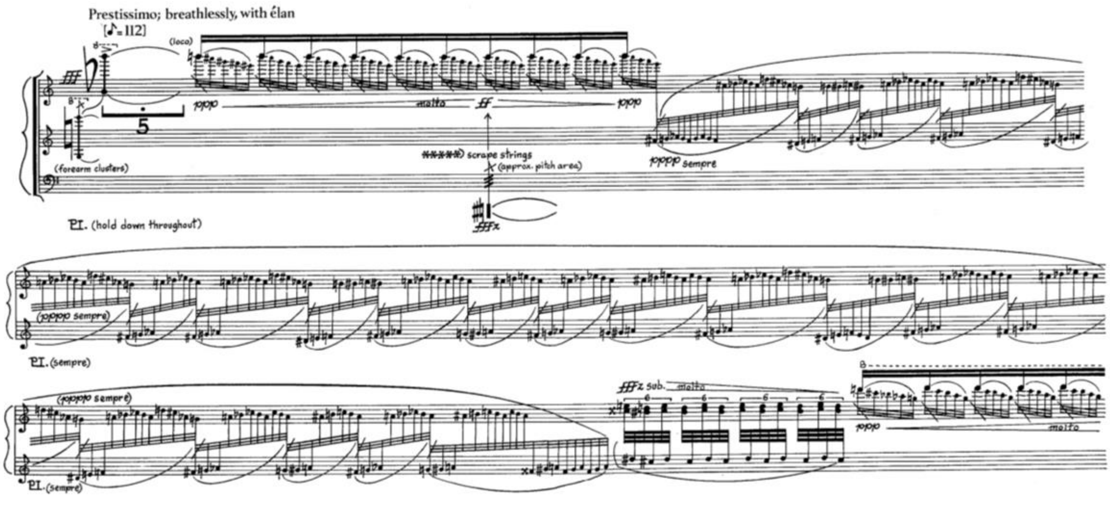
290 Robertson et al. (2004a).
291 Anderson et al. (1994), Chaffin et al. (2002).
292 Mishra (2004; 2010; 2011), Mishra and Backlin (2007), Naveh-Benjamin and Brubaker (2019), Rubin and Kontis (1983).
293 Karni et al. (1998), Mazza et al. (2016), Mednick et al. (2002). See also Hennies et al. (2014).
294 Lahl et al. (2008), Mednick et al. (2003).
295 Chaffin et al. (2002).
296 e.g., Chaffin and Imreh (1997a), Chaffin and Lisboa (2008: e.g., 118), Chaffin et al. (2010), Chen (2015).
297 e.g., Chaffin and Lisboa (2008), Chaffin et al. (2002; 2010), Chen (2015), Fonte (2020), Soares (2015).
298 e.g., Allen (2013), Balas et al. (2007), Brashers-Krug et al. (1996), Dorfberger et al. (2007), Duke and Davis (2006), Fischer et al. (2005), Korman et al. (2003), Shadmehr and Brashers-Krug (1997), van Hedger et al. (2015), Walker et al. (2003).

2013: 800). Accordingly, switches could be tackled more effectively by interspersing distributed practice with sleep.[299] Furthermore, switches' hierarchical categorisation, exemplified with Fujikura's etude, should be explicitly recalled and engaged during practice, since emphasising certain content significantly increases its sleep-dependent consolidation.[300] This approach should also be applied with switches in a self-referencing context, which is now discussed.

Although self-referencing pieces are problematic, especially for memory, this context is significantly less discussed in the literature,[301] with only some exceptions.[302] Therefore, Switches Conceptualisation is now exemplified for self-referencing, with Crumb's *Spring-Fire*.

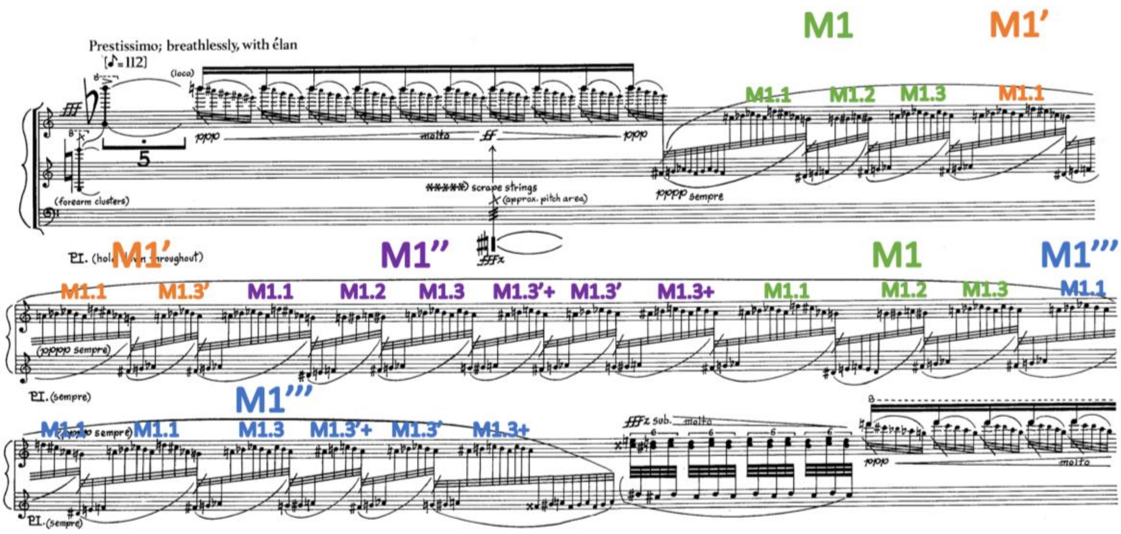


Example 3.47: George Crumb, *Makrokosmos I* (1972), 'Spring-Fire', beginning, to exemplify a post-tonal self-referencing context for switches.

The first step is to determine the beginning and end of each switch using thematic analysis. However, unlike with recurring themes, here switches are narrowed down to essential cells.

[299] Such an approach was suggested by Mazza et al. (2016) for verbal content.
[300] Fischer and Born (2009), Stickgold and Walker (2013), van Hedger et al. (2015).
[301] e.g., Chaffin and Lisboa (2008), Chaffin et al. (2002; 2010), Chen (2015), Ginsborg and Chaffin (2011a; 2011b).
[302] Fonte (2020), Soares (2015).

Concretely, for Example 3.47, these cells are only three (M1.1, M1.2, M1.3), from which the whole excerpt can be reconstructed by understanding how these are repeated or modified.



Example 3.48: George Crumb, *Makrokosmos I* (1972), ‘Spring-Fire’, beginning, after implementing Switches Conceptualisation in a self-referencing context. Thematic analysis identifies the essential cells, which is the first step for implementing Switches Conceptualisation for a self-referencing context. Colours are used to highlight further the macrostructure. Here, M1 is the constituent section, whose three elemental cells (M1.1, M1.2, M1.3) generate the whole excerpt, either by strict repetition or slight variation. Hence, these are used for analysing the rest by comparison, revealing three additional sections (M1’, M1”, M1’”). Furthermore, three different kinds of variations are identified for M1.3. First, M1.3’ stands for a shorter version in which the last three descending notes are omitted. Secondly, M1.3+ reflects the ascending chromatic transposition of M1.3. Thirdly, M1.3’+ is used for indicating an ascending chromatic transposition of M1.3’. This analysis also makes evident that the only difference between sections M1” and M1’” is that the former starts with the combination (M1.1) + (M1.2), whereas the latter does so with (M1.1) + (M1.1). Notwithstanding, beyond this slight difference, both sections proceed with the common pattern: (M1.3) + (M1.3’+) + (M1.3’) + (M1.3+).

The above analysis reveals the macrostructure M1-M1’-M1”-M1-M1’”. In this, M1 provides the essential information to reconstruct the whole passage, M1’ is a variation of M1, and M1” and M1’” present greater divergences. Nonetheless, M1” and M1’” are resemblant. This analysis results from assigning labels to every cell in the right hand, reflecting repetitions and variations. Since the left hand has an ornamental role, this is removed as a layer of complexity. Accordingly, the content to memorise summarises into the cells M1.1, M1.2 and M1.3; and M1.3’s three possible variations (M1.3’, M1.3+, M1.3’+). Once these right-hand cells are internalised, it only requires memorising the structure, practise it by sections, and integrate these, either in forward or backward motion (i.e., Simplifying Structure and Preceding Structure). After completing this process for the right hand, it is repeated hands together.

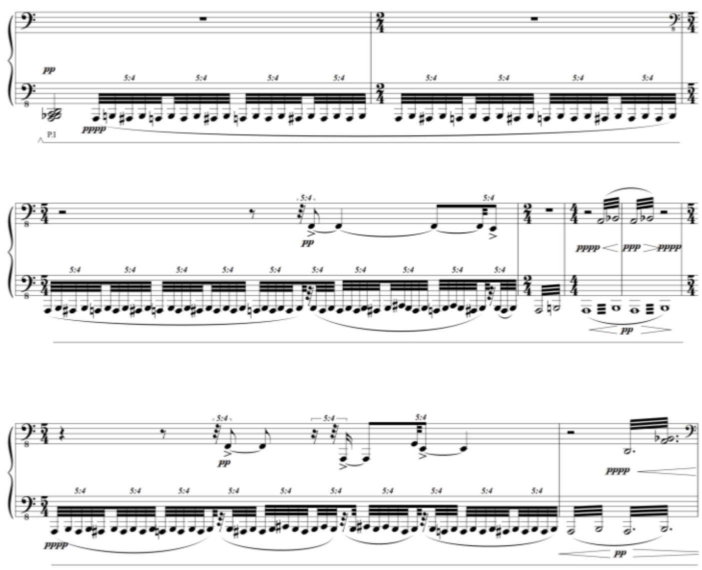
This working method establishes the right hand's leading role in monitoring performance, preventing hesitation.

Therefore, implementing Switches Conceptualisation in a self-referencing context requires identifying the least amount of information to memorise. In Example 3.48, this consisted of elemental units (i.e., right-hand cells), which combined in different ways compose a larger chain of information. Accordingly, fragments are respectively labelled with tags that are later used to trigger each cell, revealing the underlying structure of how all these cells interact, including the location of switches. Then, distributed sectional practice follows, interspersed with sleep. As with recurring themes, related switches should not be mixed early on, although self-referencing switches tend to be merged with each other. Thus, in this case, different sections should not be mixed but practised individually instead, not proceeding until confidently memorised. Concretely, in self-referencing contexts, sections can be spotted using noticeable changes in the texture.[303] Hence, following the divide-and-conquer paradigm, Switches Conceptualisation is fully implemented by sections, until all these are memorised and can be combined in the final step of the algorithm.

Additionally, Switches Conceptualisation merges sleep-research's findings with simplifying strategies, analysis, segmentation and the mapping of switches. However, unlike Performance Cue Theory, this strategy does not merely flag switches but reveals the underlying patterns, and with these, the macrostructure. Segmentation into meaningful parts and memorisation according to the structure was reported for tonal[304] and post-tonal music.[305] However, self-

[303] e.g., Example 3.47 presents an introduction and interruption that delimit the self-referencing chain.
[304] e.g., Chaffin and Imreh (1997a; 2001), Chaffin and Logan (2006), Chaffin et al. (2003; 2010), Miklaszewski (1989), Nielsen (1999a), Rubin-Rabson (1937), Williamon and Valentine (2002).
[305] e.g., Chaffin (2007), Chueke and Chaffin (2016), Fonte (2020), Noice et al. (2008), Soares (2015), Tsintzou and Theodorakis (2008).

referencing contexts were only occasionally discussed. Fonte (2020: 123) defines these as *switch sequences*, memorising these with performance cues in Guess' *If You Were Here*.

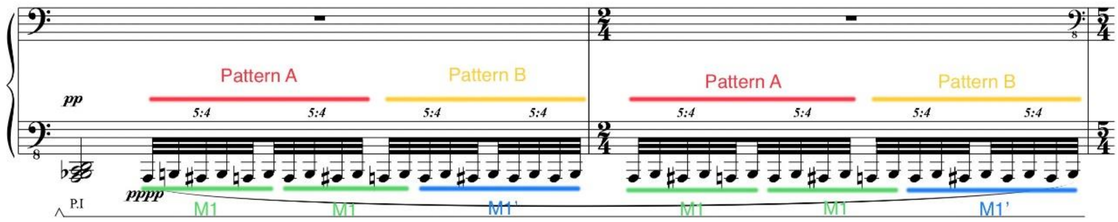


Example 3.49: Wynton Guess, *If You Were Here* (2015), bars 25-32, to exemplify switch sequences. This excerpt illustrates the self-referencing context that Fonte (2020: 123, 156) describes as *switch sequences*, which are located in the left hand.[306]

However, Fonte's (2020) approach to switch sequences presents three main limitations that could be improved with Switches Conceptualisation. First, Fonte does not analyse switch sequences prior to physical practice, but struggles with these until realising the patterns. Therefore, not optimising practice.[307] Secondly, her understanding of these switch sequences is not holistic, but determined by chromatic and non-chromatic intervals, used as 'intervallic cues' for monitoring the alternating patterns (Fonte, 2020: 156). However, this strategy results ineffective for supervising the performance at the required fast tempo,[308] resulting in a strong dependence on kinaesthetic memory.[309] Thirdly, this unsystematic procedure for tackling switch sequences has two important consequences. On the one hand, it implies a

[306] Score retrieved from Fonte (2020: 364-374). Bar numbers are given following Fonte's (2020: 123; 156) counting reference.
[307] Fonte (2020: 134; 138; 155-156; 160-161).
[308] Fonte (2020: 158-159; 161; 163-164).
[309] Fonte (2020: 156).

time-consuming process since these are mostly practised with an additive strategy,[310] adding 'one beat at a time' (Fonte, 2020: 156, 137).[311] On the other hand, Fonte reports lacking confidence in performing the piece from memory, due to a persistent struggle with memorising these switch sequences.[312] Eventually, the approach followed does not produce a bulletproof performance, as indicates a memory lapse during the premiere.[313] Considering all these problematics, Example 3.50 exemplifies how Fonte's approach could be simplified with Switches Conceptualisation:



Example 3.50: Wynton Guess, *If You Were Here* (2015), bars 25-26, to compare Fonte's (2020) proposed patterns with the potential implementation of Switches Conceptualisation. On top, Fonte's (2020: 156) proposed patterns A and B for encoding the switch sequences located in the left hand. The distinct feature used as a performance cue is whether the first three notes of each pattern obey a chromatic or a non-chromatic structure. However, Fonte (2020: 123) does not provide a thorough analysis of these patterns, beyond briefly exemplifying that these are slightly different.[314] At the bottom, the patterns M1 and M1' that I propose for encoding those same switch sequences, after having identified the essential cells with Switches Conceptualisation. Such analysis makes clear that each bar satisfies the sequence M1-M1-M1'. In this, M1 is a trill based on B that evenly alternates A and A♯, whereas M1' is a slight variation of the former: i.e., two 32nd notes longer and with A♮ only appearing once at the beginning.

Fonte's (2020: 156) proposed patterns A and B might seem the most effective for encoding this self-referencing texture: the content is labelled by beat units, based on the distinct feature that Pattern A starts with a chromatic three-note structure, whereas Pattern B starts with a non-chromatic one. However, two limitations are identified. First, the left hand is essentially a trill centred on pitch B, unequally alternated between pitches A and A♯. Analysing the

[310] Mishra (2005: 80-81; 2010: 14; 2011: 61).
[311] Fonte (2020) confuses segmentation and the additive processing strategy (i.e., when a segment of music 'is systematically lengthened' (Mishra, 2010: 14)) with the divide-and-conquer paradigm. Instances of this are found in pages 152-153, 155-156, 181, 314, 327, 330. This is further discussed in the last section of this chapter.
[312] Fonte (2020: 138; 155).
[313] Fonte (2020: 161).
[314] Fonte (2020: 123, 156). An explanation is also not provided on how each variation and the rest of switch sequences in the piece were memorised.

frequency of appearance of these pitches demonstrates that the resulting patterns do not satisfy one-beat units, but instead, slightly out-of-sync cycles, that synchronise again at the beginning of the following bar. Accordingly, a more intuitive encoding would be using the sequence M1-M1-M1', as shown. Secondly, chunking this passage as a combination of two different but slightly similar patterns A and B creates additional switches between both patterns' transitions. This contributes to increasing interference and hesitation, as reviewed in this section. Alternatively, the M1-M1-M1' labelling system simply consists in repeating the same pattern three times, and monitoring that for the third repetition, pitch A stays sharp throughout. Finally, Fonte's (2020: 118-196) strategies for encoding these switch sequences consist of idiosyncratic cues for monitoring performance (e.g., how pitches A and A♯ alternate). However, a system beyond chunking according to these two patterns and relying on kinaesthetic memory is not reported. Moreover, Fonte's proposed encoding does not work for all appearances of this material,[315] and no details are provided of other patterns or cells identified throughout the piece, besides acknowledging these being different.[316] All this suggests that her system for tackling self-referencing passages might be inefficient.[317]

Likewise, Soares (2015) presents two different approaches for tackling self-referencing switches. First, an idiosyncratic combination of standard performance cues (e.g., structural, expressive, basic)[318] with his own developed cues (e.g., sonic-resonance, melodic),[319] to engage different kinds of memory (conceptual, linguistic, visual, emotional).[320] Secondly, identifying the minimal amount of information (i.e., note-cell), to encode all its permutations. These are translated into a sequence of intervals, which he encodes mostly using hand-shape

[315] The full score can be retrieved from Fonte (2020: 364-374).
[316] Fonte (2020: 123, 155-156). The full score can be retrieved from Fonte (2020: 364-374).
[317] Baddeley et al. (2020: 172-173), Fonte (2020: 134, 137-138, 155-156).
[318] Chaffin and Lisboa (2008: 118).
[319] Soares (2015: 119-125).
[320] Soares (2015: 122).

cues.[321] However, this procedure does not produce a labelled structure for triggering each permutation, as suggested with Switches Conceptualisation. Instead, Soares (2015: 128) internalises a sequence of gestures that progressively evolve from triggering specific intervallic cues to hand-shape cues, and a conceptual 'awareness' of its corresponding differences and similarities. Consequently, not combining, associating and organising all this information into a hierarchical structure, as suggested with Switches Conceptualisation, is a limited and unsystematic memorisation approach.[322] Nonetheless, Soares' (2015: 127-128) level of detail on this approach is scarce, for which this criticism should be taken cautiously.

Therefore, although switches within a self-referencing context and post-tonal music were explored by Soares (2015) and Fonte (2020), their findings and proposed strategies present limitations, which could be addressed with Switches Conceptualisation. Finally, the last conceptualisation strategy for dynamics is now reviewed.

Dynamics Conceptualisation

This strategy highlights distinct dynamics for securing memory further: e.g., passages or patterns involving repetition or self-referencing, but in which dynamics vary.[323] The same strategy is also used for mapping dynamics with the formal structure. However, the implementation discussed here is how Dynamics Conceptualisation assists in devising a conceptual framework, when dynamics vary substantially, as in Stockhausen's *Klavierstücke* (Example 3.51):

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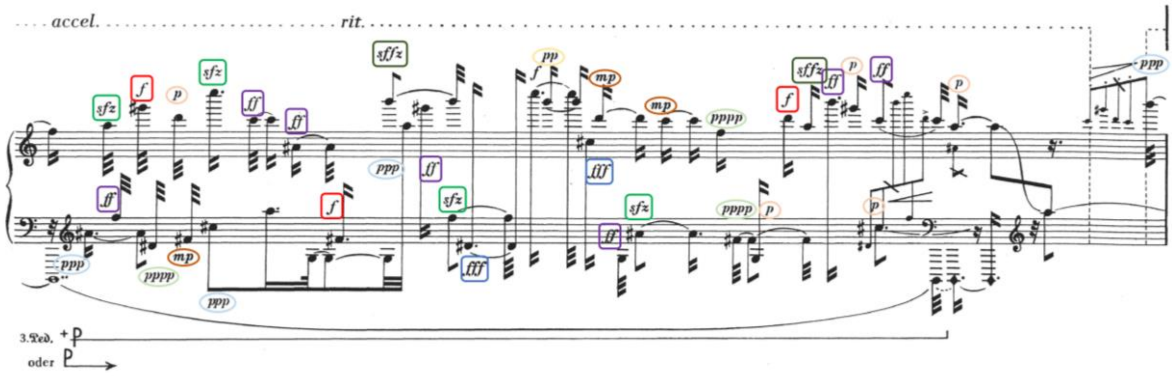
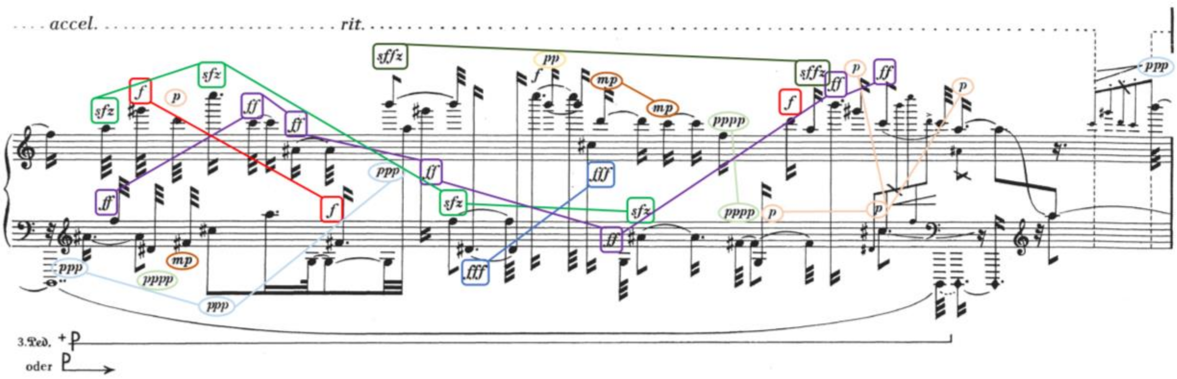
321 Soares (2015: 127-128).
322 Baddeley et al. (2020: 179), Bower et al. (1969).
323 In other words, this means satisfying the von Restorff effect, which is further explained in Chapter 2, section 2.2.2.1. See also Chee and Goh (2018), Eysenck (1979b), Hunt (2013), von Restorff (1933).



Example 3.51: Karlheinz Stockhausen, *Klavierstück V, No. 4* (1954), beginning of page 6, with coloured circles as part of the implementation of Dynamics Conceptualisation. In this, dynamics are highlighted with different colours: *pppp*, *ppp*, *pp*, *p*, *mp*, *f*, *ff*, *fff*, *sfz* and *sffz*.

In Example 3.51, colours emphasise what dynamics predominate when, and how these relate with each other. Consequently, certain connections are identified, as illustrates Example 3.52:



Example 3.52: Karlheinz Stockhausen, *Klavierstück V, No. 4* (1954), beginning of page 6, after implementing Dynamics Conceptualisation. Here, the previous colour code is further emphasised with lines that connect dynamics' predominant appearances.

Connecting all instances of certain dynamics clarifies how these are distributed. For example, *ff* appears throughout the excerpt, either followed or preceded by *sfz*. This tendency is further emphasised with two important *sffz*, establishing the boundaries of the excerpt's three-part structure. Each of these parts is distinguished by those dynamics that predominate. For instance, in the first part, the two upper voices mostly alternate between *ff* and *f*, with a single exception on *p*, whereas the lowest voice unfolds on a significantly softer plane, ranging from *pppp* to *mp*. However, these roles are exchanged in the next part, in which softer dynamics are located on the top, while the lower register is louder. Finally, the last part is predominantly *piano*, only interrupted a couple of times with *ff* pointillistic interventions.

Performance Cue Theory addresses dynamics memorisation with expressive cues, but these mostly use sound-changing turning points for triggering a section or passage.[324] Hence, expressive cues make certain moments or sections of the piece content-addressable, by integrating these cues within a broader hierarchical retrieval structure.[325] However, an independent conceptual framework for dynamics is not explicitly developed. Likewise, a similar criticism can be applied to Li's (2007: 38-60) musical mnemonics.

After discussing all Conceptual Simplification's strategies, the following section reviews how this method relates to a larger frame of learning and memorisation.

3.4 Summary

Conceptual Simplification adapts divide-and-conquer and other computer science paradigms to the musical domain, in combination with number theory, geometry and group theory. This aims at optimising analysis, learning and memorisation. Despite including some existing strategies, this systematised method for musicians is proposed for the first time with this thesis. To my knowledge, there are no previous attempts of this, except for some mentions of divide-and-conquer in Fonte (2020).[326] However, Fonte (2020) presents a problematic understanding of what divide-and-conquer is, repeatedly confusing it with segmentation, an

[324] Chaffin and Lisboa (2008), Chaffin et al. (2002; 2010).
[325] Baddeley et al. (2020: 241-242), Chaffin and Imreh (2002), Chaffin et al. (2010; 2013), Chueke and Chaffin (2016), Ericsson and Oliver (1989), Fonte (2020), Ginsborg and Chaffin (2011a; 2011b), Soares (2015), Williamon and Egner (2004), Williamon and Valentine (2002).
[326] See Fonte (2020: 152-153; 155-156; 181; 314; 327; 330).

additive strategy,[327] or regular practice strategies (e.g., playing hands separately or without the rhythm).[328] This could be attributed to lacking a scientific background[329] and only referencing Riley and Hunt (2014).[330] The latter is a book of general dissemination on computational thinking with only a brief outlining of divide-and-conquer and a scarce bibliography,[331] providing an initial overview for computer science outsiders. Accordingly, its scope for misunderstanding and superficiality are not ideal as a sole point of academic referencing. This might explain, for instance, why Fonte (2020) keeps citing divide-and-conquer simply as a 'strategy',[332] instead of an algorithm paradigm. Fonte's (2020) misinterpretation of divide-and-conquer,[333] could be addressed using the decrease-and-conquer paradigm instead, by reframing the participants' reported strategies as simplifications. Nevertheless, regardless of terminology, the strategies that Fonte (2020) presents as divide-and-conquer[334] are instinctively taught in piano pedagogy, as this chapter reviewed.[335]

Conceptual Simplification provides guided and systematic procedures for transforming a given input (e.g., a musical work or texture) until the essential patterns are identified. This permits scaffolding analysis, learning and memorisation, by establishing comfortable frameworks of complexity: an approach that aligns well with Bloom's (1956) taxonomy of learning.[336] This paradigm was not used in post-tonal music before, as reviewed in this chapter and Chapter 2, providing an improved method for the musical domain. While

[327] This processing strategy is reported by Mishra (2005: 80-81; 2010: 14; 2011: 61).
[328] See all instances of this in Fonte (2020: 152-153; 155-156; 181; 327).
[329] Fonte (2020: 73; 121).
[330] Fonte (2020: 153; 314). See Riley and Hunt (2014: 104-106; 112-114; 124).
[331] See Riley and Hunt (2014: Chapter 4). Riley and Hunt's (2014) bibliography for the relevant chapter discussing divide-and-conquer can be found in page 124 of this book.
[332] Fonte (2020: 152; 155; 181; 314; 330).
[333] Fonte (2020: 155-156; 181; 314; 330).
[334] Fonte (2020: 314; 327; 330).
[335] It should also be noted that the author of Fonte (2020) was the supervisor of my master's thesis (Farré Rozada, 2018) at the Royal College of Music (London), in which I provided a first prototype of Conceptual Simplification.
[336] See Bloom (1956) and its revision by Anderson et al. (2001).

Conceptual Simplification's implementation might be conditioned by the individual's learning style, the method is flexible enough to incorporate further strategies useful to the practitioner. Hence, encouraging the development and expansion of the method's existing possibilities. Conceptual Simplification's effectiveness was tested in this thesis with three studies, and the methodology is discussed in the next chapter.

Chapter 4: Methodology

4.1 Introduction

This chapter exposes the methodology, starting with the philosophical and theoretical underpinnings of this research. Then, it is divided into three main sections, one for each study. First, the Self-Case Studies observed my practice while memorising two commissioned works. Secondly, the Interviews explored how the memorisation procedures of established practitioners differ from Conceptual Simplification. Thirdly, the Study with Participants tested Conceptual Simplification's effectiveness with other practitioners. For each study, the research design, sampling, participants, materials, procedure and verifying and reporting are specified. Then, data analysis, ethical considerations and limitations are discussed.

4.1.1 Methodological Framework

The Research Questions (RQ) presented in Chapter 1 investigate which strategies positively impact memorisation and performance of post-tonal piano music, and what parameters influence this process. These RQ aim to generate findings and knowledge transferable to other pianists for enhancing memorisation. The paradigm is pragmatist,[1] following a mixed methods approach,[2] and both deductive and inductive reasoning are employed.[3] This design was chosen to understand the complex phenomenon of memorisation, which is an internal process difficult to observe.[4] Hence, while involving quantitative and qualitative methods, this research is predominantly qualitative. Since the goal is to reach an ecological validity of results, real-world settings and materials are used whenever possible:[5] studies are conducted

[1] Creswell and Plano Clark (2011: 40), Lukenchuk (2013: 66), Williamon et al. (2021: 21-22).
[2] Williamon et al. (2021: 42-51).
[3] Cohen et al. (2018: 34).
[4] Aguado (2019), Baddeley et al. (2020), Bartlett ([1932] 1995), Ebbinghaus ([1885] 1913), Mishra (2002: 76), Odendaal (2019), Smith and Osborn (2007), Svard and Mack (2002), Williamon et al. (2021: 24).
[5] Williamon et al. (2021: 199).

in the participants' work environment, using existing compositions or commissions.[6] Concretely, in testing, extending and formalising Conceptual Simplification (see Chapter 3), this practice-led research is problem-centred and oriented on the trial and error of memorisation strategies, while observing the practitioners' experience.[7] The participants are myself and recruited pianists consisting of students and professionals.

The qualitative approach aims to capture the participant's perspective and experience of memorisation. Hence, it focuses on documenting and describing immediate experiences, to understand why certain strategies work.[8] A phenomenological strategy was used to design self-case studies and a study with recruited participants that present memorisation-related challenges to those practitioners involved.[9] Then, such experiences were disclosed and examined from the participants' point of view with observation, interviews and further documentation, gaining insight into the 'subjective world of the music performer' (Williamon et al., 2021: 33).[10]

However, qualitative methods are limited by the participants' idiosyncratic experiences, sometimes challenging its generalisation, and potentially biased by my double role as researcher and participant. Thus, the selected methodology also measures, tests and describes memorisation quantitatively, to generalise further the findings, facilitating future replications by other researchers and samples.[11] Accordingly, quantitative methods (e.g., questionnaires, quasi-experiments) are used to gather objective numerical information.

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6 Cohen et al. (2018: 289).
7 Cohen et al. (2018: 38), Ericsson and Simon (1993), Ginsborg (2014), Haseman (2006: 100-104). See also Chen (2015), Fonte (2020), Ginsborg et al. (2012), Li (2007), Soares (2015).
8 Cohen et al. (2018: 49-50), Smith and Osborn (2007: 53-80).
9 Stake (2000).
10 See also Holmes and Holmes (2013).
11 Williamon et al. (2021: 37-38).

A mixed methods approach permits triangulation,[12] convergence in the results, corroboration and complementarity, since qualitative and quantitative data inform each other: words, pictures and narrative illustrate numbers, while numbers provide precision to those. It also reveals incongruencies that lead to reframing the research design, using a method's findings to inform the development of another.[13] Following Onwuegbuzie and Teddlie (2003), the seven stages implemented were data reduction (e.g., thematic analysis), to lessen qualitative data dimensionality; data display, presenting data in an ordered and concise manner (e.g., tables, graphs); data transformation, converting quantitative data into narrative, to analyse it qualitatively, and converting qualitative data into numerical that can be quantised; data correlation; data consolidation, to create new data sets; data comparison; and data integration. Moreover, data triangulation is embedded in the methodology, by using contrasting sources of information (e.g., different participants and repertoire) throughout the studies.[14]

4.1.2 Researcher's Positionality

I am a mathematician and an international concert pianist, specialised in post-tonal music. As a soloist, I always perform from memory, combining my background in music and mathematics to develop practice and memorisation strategies. Therefore, Conceptual Simplification evolves with my growing repertoire. In this PhD, some of these strategies were tested with other pianists, and new strategies were developed during the Self-Case Studies.

I also collaborated with several composers, many featured in this thesis, giving over 50 premieres of their works. Additionally, I auditioned for and secured contemporary music residencies, extending my knowledge in this field; and released commercial CDs, featuring

[12] Cohen et al. (2018: 265-267), Williamon et al. (2021: 43-44; 49-50).
[13] Johnson and Onwuegbuzie (2004: 21-22).
[14] Cohen et al. (2018: 43).

post-tonal repertoire.[15] I feel to some extent confident at sight-reading; I neither have perfect pitch nor experience synaesthesia; I use mental practice and sleep in my performance routine; and I sometimes use my emotions to memorise. Throughout the thesis, my role is of an insider researcher.[16]

After defining the philosophical and theoretical underpinnings of this thesis, the methods used for each study are now detailed, starting with the Self-Case Studies since Conceptual Simplification developed from my own experimentation with memorisation.[17] Then, I proceed with the Interviews with experienced pianists in performing post-tonal music from memory; and the Study with Participants, in which Conceptual Simplification is tested with other practitioners.

4.2 Self-Case Studies

Design: Two sequential self-case studies were completed while learning and memorising two commissioned works, which were world-premiered, replicating real-life performing experiences. The aim was to test Conceptual Simplification's effectiveness for unknown pieces in two different performing contexts: solo and soloist with orchestra. This permitted identifying those strategies used, assessing whether these were conditioned by the repertoire, and developing new strategies to refine Conceptual Simplification.

[15] See further details at my professional website: www.laurafarrerozada.com
[16] Chen (2015), Farré Rozada (2018), Fonte (2020), Ginsborg (2014), Ginsborg et al. (2012), Haseman (2006: 100-104), Jónasson and Lisboa (2015; 2016), Li (2007), Schechner (2002), Soares (2015).
[17] See Farré Rozada (2018).

During the Self-Case Studies, I adopted the role of practitioner-researcher:[18] 'the process of making an artistic product' was 'under scrutiny', although the commissioned works were not 'the main output of the research' (Williamon et al., 2021: 89). This allowed documenting and studying my performing experience in 'real-life musical contexts', benefitting from my 'dual role' and 'the insights gained through an "insider" perspective on the phenomenon under observation': learning, memorisation and public performance (Williamon et al., 2021: 85).[19]

The roles of practitioner and researcher were consciously separated, to prevent my expectations as an academic interfering with my involvement as a participant.[20] However, I could not completely dissociate myself from my knowledge of existing literature findings, and previous expertise gained from my practice and this doctoral research. This also included the methods used and the purpose of the research design. Consequently, I developed a protocol to report my practice and performing decisions, to ensure that my role as participant was as unbiased and genuine as possible. During video-recorded sessions, this involved verbalising my thoughts and decisions, and marking the scores. At completion, I video-recorded a summary of that session, saved copies of the score,[21] and wrote a report in a practice diary.[22] This process encouraged reflection and followed similar protocols for observing practice in self-reporting research.[23]

[18] e.g., Chen (2015), Chueke and Chaffin (2016), Fonte (2020), Ginsborg and Chaffin (2011a; 2011b), Li (2007), Soares (2015).
[19] e.g., Chaffin and Imreh (1997a), Chaffin et al. (2010), Chueke and Chaffin (2016), Fonte (2020), Ginsborg and Chaffin (2011a; 2011b), Soares (2015).
[20] Fonte (2020: 118-196), Soares (2015: 34-188), Williamon et al. (2021: 86).
[21] Both commissioned works resulted from a collaboration with living composers. This means that the scores were not fixed but regularly amended at first. Consequently, I used different versions of these.
[22] This diary was included in the data collection to improve the standard method used in similar case studies. Reporting in writing each session's content provided a backup, should the video file be lost or corrupted.
[23] e.g., Chaffin (2007), Chaffin and Lisboa (2008), Chaffin et al. (2002), Chueke and Chaffin (2016), Fonte (2020: 118-288), Ginsborg et al. (2006a; 2006b), Soares (2015: 34-188).

This research design implied several advantages. First, the Self-Case Studies were more substantial than any potential study with recruited pianists. The pieces involved were significantly more extensive than the excerpts from the Study with Participants. Hence, data collection documented a much richer experience, within a real-life and professional setting. Moreover, it is unlikely that recruited participants could replicate the Self-Case Studies and commit to this volume of work, including the corresponding data collection just described, and secure the required public performances.[24] Thus, the design chosen was optimal given the resources available. Also, being both the practitioner and researcher provided me with 'comprehensive self-analysis and unparalleled access to a performer's thought-process' (Soares, 2015: 36).[25]

Secondly, the self-reflecting nature of these studies could potentially bias the results. However, this limitation was addressed by cross-referencing and triangulating first-person accounts with behavioural data. Further details are given later in this section. Also, my expertise as a specialised concert pianist provided me with a greater understanding of the strategies used and why, including how these fit within Conceptual Simplification. Hence, this insider perspective was both the strongest and weakest aspect of these studies.

Finally, the results were triangulated with those from the Interviews and the Study with Participants. All these involved discussing and implementing different strategies to a greater variety of repertoire by different practitioners. Thus, providing objectivity and enhancing the potential transferability of the proposed memorisation strategies in this thesis.

[24] Covid-19 restrictions made this approach even more impractical for recruited participants.
[25] See also Fonte (2020: 118-196).

Sampling: Convenience sampling was used to run two sequential self-case studies with myself, enabling to study memorisation from '"insider" and "outsider" perspectives simultaneously' (Williamon et al., 2021: 86). This sample did not represent the entire population, but it permitted running phenomenological research on my own performing experience, which was triangulated with recruited participants and interviewees. Being both participant and researcher facilitated running the study, but also prevented generalising the results.[26]

Participants: Me, the composers commissioned, and the orchestral musicians involved in the Piano Concerto.[27] Professional biographies of both composers are provided in Appendix D.

Materials: The Self-Case Studies involved the Piano Concerto Case Study and the Solo Piano Piece Case Study. For the first study, I commissioned the Piano Concerto *La flor de l'atzavara [The Agave Flower]* (2020) with string orchestra from Catalan composer Feliu Gasull.[28] This was given its world-premiere with Camerata Eduard Toldrà[29] conducted by Edmon Colomer[30] on 7 February 2021 at Auditori 'Eduard Toldrà' in Vilanova i la Geltrú (Barcelona),[31] with a second performance on 11 February 2021 at Centre Cultural Municipal in Valls (Tarragona).[32] Also, two pre-concert talks were given by the composer, the conductor

[26] Cohen et al. (2018: 217-218).
[27] Orchestral musicians are listed as participants in making possible the performances of the Piano Concerto.
[28] Feliu Gasull (2009) *Feliu Gasull*. Available at: www.feliugasull.com/ [Accessed 22 April 2022].
[29] Associació Musical Eduard Toldrà (2022) *Camerata Eduard Toldrà*. Available at: https://cameratae duardtoldra.cat/ [Accessed 22 April 2022].
[30] Edmon Colomer (2016) *Edmon Colomer*. Available at: https://www.edmoncolomer.com/ [Accessed 22 April 2022].
[31] Videos from the world-premiere are available as follows:

I. Impromptu (https://youtu.be/6qUaBrcUYq8?si=RqmF1TWjGERWVHTd).
II. Passeig (https://youtu.be/zuferpjuj6Y?si=690LydKS8NcFvcVR).
III. Racons (https://youtu.be/eiGVRNjgbQ0?si=d9c5Ip2uDZbSz-st).
IV. Postludi (https://youtu.be/lij1H9l4Klk?si=weuKPxaeITytFjtI).

[32] The video of this second performance is available here: https://youtu.be/BfVSuTxQqV4?si=6ylj2ofVgqvJn1m8

and myself on 21 January and 9 February 2021. For the second study, the solo piece *The Butterfly Effect* (2021) was commissioned from Israeli-American composer Ofer Ben-Amots.[33] This is based on the Fibonacci sequence, chaos theory and the butterfly effect, and the world-premiere was on 3 December 2021 at Centre Cívic Matas i Ramis (Barcelona), with a second performance on 4 February 2022 at Casa Golferichs (Barcelona); and a third performance on 15 September 2022 at Civivox Condestable (Pamplona-Iruña) within the NAK Festival.[34] Composers were only conditioned by the given instrumentation. For the solo piece, I agreed with Ben-Amots on the mathematical background of the commission.

Therefore, the materials used were the commissioned scores,[35] a piano and a video-camera. All composers and musicians verbally agreed to be video-recorded during meetings, rehearsals and performances, provided this was necessary for data collection.

Procedure: Data collection started from the first contact with the pieces and included all performances, rehearsals and sessions with composers. Practice sessions were video-recorded, including verbal summaries of my practice and discussions of larger aims beyond a specific session. My role as practitioner concluded after completing all public performances for both pieces, proceeding then to data analysis.[36]

During practice, I verbalised all my thoughts and decisions, which were also annotated on the scores.[37] To prevent losing any nuances on these, and altering or interrupting my

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[33] Ofer Ben-Amots (2022) *Ofer Ben-Amots, composer*. Available at: www.oferbenamots.com/ [Accessed 22 April 2022].
[34] The video of this performance is available here: https://youtu.be/Wclq0w5kP1o
[35] The piano scores of the commissioned pieces can be retrieved from Appendix K.
[36] e.g., Fonte (2020: 118-196), Soares (2015: 34-188).
[37] e.g., Chaffin et al. (2002; 2010), Fonte (2020: 118-286), Lisboa et al. (2011; 2015), Noice et al. (2008), Soares (2015: 34-188).

thoughts, I always spoke in my mother tongues (Catalan, Spanish). Once all comments were transcribed, these were translated into English and analysed. Besides the recordings, I kept a practice diary, summarising the strategies used.

Daily practice sessions for each piece were limited to one hour, considering each concerto movement a single piece. This facilitated feeling focused while preventing overloading practice sessions. However, this premise was flexible: schedules were intensified when needed, particularly when public performances were looming. Additionally, for each session, 15-minute alarms were set to raise awareness of the time used, as a metacognitive strategy for optimising practice and planning. It also prevented me from obsessing on difficult passages, leaving them once understood or being successful. Mistakes were embraced as opportunities to learn better the music, to anticipate potential memory lapses and to develop strategies to prevent them. At the end of each session, I planned the next one, reminding myself again of those goals before resuming practice.

During the studies, I followed my usual practice routine, reporting the achievements and strategies in a diary at completion. For each session, I also verbalised concurrent and retrospective comments.[38] This procedure tracked all my thoughts related to memorisation,[39] without incurring post hoc rationalisation: e.g., documenting a practice session long after this happened might alter the content reported.[40]

To ensure a critical distance, the following data was collected:

[38] Ericsson and Simon (1980; 1993), Fonteyn et al. (1993). See also, for example, Chaffin et al. (2010), Fonte (2020: 118-286), Lisboa et al. (2011).
[39] Ericsson and Simon (1998), Fonteyn et al. (1993), Lisboa et al. (2011), Williamon et al. (2021: 88).
[40] Lisboa et al. (2011), Sloboda (1985), Williamon et al. (2021: 148).

- <u>Behavioural data:</u> Chronological video-recordings of all meetings with composers, practice sessions, rehearsals and performances. The latter combined with score samples indicating divergences.

- <u>First-person accounts:</u> A written practice diary summarising each session, including strategies used by sections and my emotional state, to assess productivity. Verbal comments and annotated scores were stored chronologically, documenting performing decisions.

Behavioural data and first-person accounts were labelled and catalogued when collected, providing a detailed archive that included both objective and subjective data. Video-recordings involved unedited raw footage that reported my actions objectively; while self-reports consisted of written and verbal accounts, reflecting which of these actions I highlighted and why. Hence, behavioural data was used to validate first-person accounts, allowing to triangulate and confirm the accuracy of the information consciously reported.[41]

<u>Verifying and reporting:</u> The Self-Case Studies provided insightful results, by reflecting on my behaviours towards learning and memorisation, ranging from productive days to frustrating sessions. No attempts were made to control the experience: data was not collected in a laboratory, but in real-world settings within professional contexts. Hence, prompting ecological validity in these studies and their results.[42]

[41] e.g., Chaffin et al. (2010), Chueke and Chaffin (2016), Fonte (2020), Soares (2015).
[42] Williamon et al. (2021: 199).

4.3 Interviews

Design: Three professional pianists specialised in post-tonal music were interviewed. The aim was to identify and compare different memorisation strategies used by established soloists, collect different views on performing this repertoire from memory, and analyse what are the reasons and problematics behind these choices.[43] Interviews were the most effective method for enquiring those 'thought processes or feelings' related to memorisation of highly occupied practitioners, otherwise more difficult to observe (Williamon et al., 2021: 130).

The semi-structured interviews included open-ended questions, some of these tailored to each pianist's profile and background.[44] Any previous assumptions were validated during the interview.[45] To prevent bias and ensure that all outlined topics were covered, my role during the interviews was only to prompt and probe when necessary.[46]

Sampling: Purposive sampling was used to invite a series of concert pianists with broad experience in performing post-tonal music from memory. The goal was to interview 'knowledgeable people' (Cohen et al., 2018: 219), without pretending to represent the wider population.[47] Recruitment excluded similar soloists that perform this repertoire from the score, because the study focused on memorisation. Since the resulting sample was similar in age and gender, several attempts were made to mitigate this limitation. However, potential candidates were not available to interview.[48]

[43] Anderson and Arsenault (1998: 124).
[44] Cohen et al. (2018: 511).
[45] Cohen et al. (2018: 534-535).
[46] Fowler (2009: 139).
[47] Ball (1990), Cohen et al. (2018: 218-220).
[48] Before the Covid-19 restrictions, I planned a trip to Paris to interview in person five additional soloists with this profile, based in France or the USA, and who were in the city during those days. However, these interviews could not be rescheduled later. These soloists' identities are not disclosed to protect their anonymity.

Interviewees were asked about their experience with sight-reading, perfect pitch, synaesthesia, emotions and sleep, and how these influence their memorisation process. Table 4.1 summarises their responses, which could significantly vary with a different sample. All interviewees gave consent to be named in the thesis.

Table 4.1: Main features of the interviewees.

INTERVIEWS			
Interviewee	Hayk Melikyan	Ermis Theodorakis	Jason Hardink
Age	41	43	48
Gender	Male	Male	Male
Performs from memory	Sometimes[49]	All solo music	All solo music
Sight-reading	Yes	Yes	Yes
Synaesthesia	Not sure	No	No
Perfect pitch	Yes	Yes	No
Uses emotions to memorise	No	To some extent	Not consciously
Performance anxiety	Yes	No	Yes
Memorisation strategies	To some extent	Yes	Yes
Sleep	No	Sometimes	Sometimes

[49] In fact, Hayk Melikyan was also recruited for representing pianists that perform post-tonal music with the score. As a student and during competitions, he used to perform from memory all his repertoire. However, he cannot do that anymore because, as he stated in the interview, his repertoire is 'continuously growing'. Nonetheless, he has experience in performing from memory André Boucourechliev's *Orion III* (1982), Ichiro Nodaira's *Pas de résonance* (1999-2000), Alfred Schnittke's *Piano Sonata No. 1* (1987), György Ligeti's *Musica Ricercata* (1951-1953) and some *Piano Etudes* (1985-2001), and Luciano Berio's *Rounds* (1967). Thus, Melikyan's profile represented both performing options.

Participants: Pianists interviewed were Armenian Hayk Melikyan,[50] Greek and Germany-based Ermis Theodorakis,[51] and American Jason Hardink.[52] All are international concert soloists with experience in commissioning and collaborating with living composers. Additionally, they teach advanced piano students, and Melikyan and Theodorakis are also composers themselves. Finally, Theodorakis is co-author of a study on memorisation strategies for atonal music.[53] Professional biographies of these pianists are available in Appendix C.

Materials: Consent forms, a recording device and a list of questions. During the interviews, the topics covered were:

- General approach to musical memorisation.
- Influential parameters for memory.
- Practice and performance strategies for memorising.
- Experience with performance anxiety.
- Reasons for performing from memory.
- Previous memorisation training.
- The memorisation process of solo works written from the 1940s onwards, to illustrate their working methods.

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[50] Hayk Melikyan (2022) *Hayk Melikyan*. Available at: https://www.haykmelikyan.com/ [Accessed 19 April 2022].
[51] Ermis Theodorakis (2022) *Ermis Theodorakis*. Available at: https://www.ermis-theodorakis.com/ [Accessed 19 April 2022].
[52] Jason Hardink (2019) *Jason Hardink, pianist*. Available at: https://www.jasonhardink.com/ [Accessed 19 April 2022].
[53] See Tsintzou and Theodorakis (2008).

Procedure: Interviews were completed via conference calls (Skype, Zoom). These lasted approximately two hours, except for Hayk Melikyan, who requested a written interview instead. A list of the intended questions was provided in advance so interviewees could be well-prepared and make suggestions. Following this procedure, Hayk Melikyan completed the written interview on 14 August 2021, Ermis Theodorakis was interviewed on Skype on 6 August 2021 and Jason Hardink was interviewed on Zoom on 11 August 2021.

Verifying and reporting: Theodorakis and Hardink requested revising and editing their interviews' transcriptions to clarify further the content, but without altering the meaning of their original responses.

4.4 Study with Participants

Design: This study tested Conceptual Simplification with other pianists, to assess and compare its effectiveness with their strategies when memorising post-tonal excerpts. A concurrent embedded design was chosen to run a Pilot Study and a Main Study.[54] My role as a researcher benefitted from my knowledge as a practitioner and experience in this domain.

The study consisted of a Questionnaire, a Logical Reasoning Test (LRT), and a Memorisation Test, which involved a Morning Memorisation Test (MMT), an Afternoon Recall (AR) and a Next-Day Recall (NDR). Participants completed all memorisation tests on a piano on two consecutive days, following the schedule below (see Table 4.2).

[54] Williamon et al. (2021: 49). e.g., Jónasson and Lisboa (2015; 2016).

Table 4.2: Schedule of the Memorisation Test.

DAY 1	DAY 2
Morning: Morning Memorisation Test (MMT)	**Morning:** Next-Day Recall (NDR)
Afternoon: Afternoon Recall (AR)	

The MMT and NDR were scheduled from 8 am, whereas the AR was scheduled around 7 pm.[55] The goal was to leave a 12-hour gap between each test, to enable off-line learning and test the spacing effect.[56] However, this premise was flexible to accommodate the participants' needs and schedule constraints. Eventually, all tests were spaced by several hours.

Participants were expected to complete the MMT in 2 hours and 30 minutes. This involved memorising and performing the given excerpts, recording themselves and submitting all materials. The given timeframe was divided into indicative timings for each excerpt, allowing more time if necessary. After the MMT, a 30-minute interview followed. Similarly, for both the AR and NDR, participants had 30 minutes to recall all excerpts from memory and record themselves. Then, a 10-minute interview followed. Participants were advised to sleep for 8 hours between Day 1 and Day 2.[57] This was intended as a sleep-quality benchmark,[58] to avoid 'neurobehavioral and physiological' malfunctioning (Banks and Dinges, 2007: 526),[59] while setting the proper conditions to observe sleep-dependent consolidation.[60] Moreover, results would be more representative if participants felt well-rested.

[55] The time range in which the ARs were scheduled went from 4 pm to 7:30 pm. This is the reason for which the label 'Afternoon Recall' seemed more appropriate. Furthermore, the exact turning point between afternoon and evening hugely varies among different cultures.
[56] Both off-line learning and the spacing effect are discussed in Chapter 2, section 2.2.2.
[57] The World Health Organization (WHO) and the National Sleep Foundation stipulate an average of eight hours of sleep per night for adults (Walker, 2017: 3).
[58] Lewis (2014), Randall (2013), Walker (2017: 108).
[59] The three stages of sleep are light NREM sleep, deep NREM sleep and REM sleep. If a good quality sleep is not ensured (e.g., sleeping less than needed), one of these essential stages is not completed or even started, and this can lead into 'brain impairment' (Walker, 2017: 108).
[60] Lewis and Durrant (2011), Maquet et al. (2000; 2003a), Rasch and Born (2013), Stickgold and Walker (2013), Walker (2005), Walker and Stickgold (2006), Walker et al. (2002), Wamsley (2022).

Both the Pilot Study and Main Study had the same structure and number of tests. The AR and NDR were not preceded by further practice, and participants could not look at the scores or practise the excerpts under any circumstance. Originally, a written recall was planned to assess participants' retention, days after the Memorisation Test. This is a standard procedure for testing music recall,[61] which aimed to further measure their memorisation,[62] while overcoming detrimental factors (e.g., performance anxiety, execution errors). Nevertheless, this additional task requested more time and effort, and was only optional for Pilot Study participants, who agreed, assessing their retention after at least five days.

Participants were divided into a control Group X and an experimental Group Y. Both groups memorised the same excerpts, but the experimental group had a list of instructions, indicating how to implement Conceptual Simplification. Interviews after the MMT, AR and NDR allowed participants to comment on the strategies used, including their effectiveness.

The Memorisation Test was designed according to studies testing the role of sleep in learning and memorisation,[63] concretely, in musical performance.[64] These train and test participants on a declarative or procedural task in different moments of the day, interspersing rests in between with or without sleep, to assess participants' off-line learning.[65] These tests are also known as repeated-measures experiments.[66] The same studies also follow a between-groups

[61] Chaffin et al. (2002: 212-216; 2010: 17), Fonte (2020: 186-191), Ginsborg and Chaffin (2011a), Lisboa et al. (2009a; 2009b).
[62] Lisboa et al. (2009a; 2009b).
[63] e.g., Brashers-Krug et al. (1996), Karni et al. (1994), Kuriyama et al. (2004), Lahl et al. (2008), Lewis et al. (2011), Maquet et al. (2003a), Mazza et al. (2016), Peigneux et al. (2001; 2003; 2004), Rasch and Born (2013), Walker and Stickgold (2004), Walker et al. (2002; 2003), Wamsley (2022), Wilson (1983).
[64] Allen (2007; 2013), Cash (2009), Cash et al. (2014), Duke and Davis (2006), Duke et al. (2009), Simmons (2007; 2011; 2012), Simmons and Duke (2006), Timperman and Miksza (2019), van Hedger et al. (2015), Wilson (1983).
[65] Brashers-Krug et al. (1996), Brown and Robertson (2007b), Cohen et al. (2005), Karni et al. (1998), Kuriyama et al. (2004), Luft and Buitrago (2005), Mazza et al. (2016), Rasch and Born (2013), Robertson (2009), Robertson et al. (2004a; 2004b), Stickgold et al. (2001), Walker (2005), Walker and Stickgold (2004), Walker et al. (2002; 2003).
[66] Williamon et al. (2021: 212-213).

design,[67] to compare the results of the control and experimental groups according to different parameters.[68] Two main reasons led to choosing this design. First, it allowed comparing Conceptual Simplification's effectiveness against alternative strategies. Secondly, it permitted exploring sleep-dependent consolidation on post-tonal music memorisation. This was only tested for tonal excerpts,[69] or tonal and modal single-hand melodies.[70] However, none of these studies requested their participants to memorise, but to perform with the score as fast as possible.

Van Hedger et al. (2015) is the closest design to my study, although this differed in using tonal excerpts purposely created for a laboratory setting with controlled conditions,[71] and their participants' not-memorised performances were MIDI-recorded during timed sessions. Additionally, Tsintzou and Theodorakis (2008) and Jónasson and Lisboa (2015; 2016)[72] also informed my study. These compared their participants' memorisation strategies for post-tonal music, although neither followed a between-groups design nor included further memory recalls. Consequently, their designs resemble the MMT, but with a single group instead. However, Tsintzou and Theodorakis (2008) and Jónasson and Lisboa (2015; 2016) did not provide guidelines to participants on how to memorise, but only observed their procedures, recording both their practice and final performances. Therefore, participants' comments complemented those behaviours observed in the recordings. Concretely, Jónasson and Lisboa's (2015; 2016) phenomenological approach promoted a dynamic

[67] Williamon et al. (2021: 203-204).
[68] e.g., Allen (2013), Cash (2009), Cash et al. (2014), Duke and Davis (2006), Kuriyama et al. (2004), Mazza et al. (2016), Mednick et al. (2008), Simmons and Duke (2006), Timperman and Miksza (2019), Walker and Stickgold (2004), Walker et al. (2002).
[69] van Hedger et al. (2015).
[70] Allen (2007; 2013), Cash (2009), Duke and Davis (2006), Duke et al. (2009), Simmons (2007; 2011; 2012), Simmons and Duke (2006).
[71] These excerpts are available at van Hedger et al. (2015: 165). See also Palmer et al. (2012).
[72] Jónasson and Lisboa (2015) and Jónasson and Lisboa (2016) are essentially the same study, but the latter is focused on addressing issues on musical education and curriculum. Therefore, although their results are the same, these are analysed slightly differently. For this reason, it is worth citing both.

exchange between participants and the first researcher, who played an active 'dual role' (Lyons and Coyle, 2011: 36), to comprehend what processes participants went through when memorising.[73] Nevertheless, trying to adopt the participants' perspectives and engaging in dialogue with them might not guarantee easier access to their world: a participant's statements and experience do not necessarily relate. Also, the researcher is aware of certain aspects and processes that the participant might find difficult to express, or even be unaware of.[74] However, this phenomenological approach allowed Jónasson and Lisboa (2015; 2016) instantly verify what their participants were doing, while I had a distant following of my participants, as later explained.[75] Finally, Tsintzou and Theodorakis' (2008: 4) participants could listen to the given piece beforehand and during practice 'as many times as they wanted'. Therefore, all participants had an aural model that facilitated fulfilling the task. However, the study ignored whether participants were perfect-pitch possessors that could memorise by ear,[76] having an advantage over relative-pitch possessors.[77] Nonetheless, following Svard and Mack's (2002) taxonomy of learners,[78] although Tsintzou and Theodorakis' (2008) design favoured aural learners, not providing a recording might have favoured those participants with better sight-reading skills instead.[79]

My Study with Participants focused on identifying effective memorisation strategies, that were also useful for simplifying complexity and boosting the participants' learning styles. It also intended to determine which musical parameters influenced long-term retention. Ultimately, the study explored which of these strategies were generalisable to major works

[73] Smith and Osborn (2007: 53).
[74] Lyons and Coyle (2011: 163).
[75] This is explained to some extent throughout this section, but most explicitly in sections 4.5 and 4.7.
[76] e.g., Ginsborg (2004: 130-131).
[77] Deutsch (2013), Ross and Marks (2009), Takeuchi and Hulse (1993).
[78] See Chapter 2, section 2.4.2.
[79] As illustrated by the recruited participants' profiles (see upcoming section on Sampling), not all perfect-pitch possessors reported confidence in sight-reading/sight-playing. Likewise, not all confident sight-readers had perfect pitch.

and transferable to other pianists. Therefore, it had a broader approach than Tsintzou and Theodorakis (2008), which principally focused on segmentation; and explored further Jónasson and Lisboa's (2015; 2016) research questions on memorisation strategies and types of memory, adapting these to pianists instead of guitarists. Unlike Jónasson and Lisboa (2015; 2016) or van Hedger et al. (2015), the excerpts were not specifically composed for the study and were not significantly modified as in Tsintzou and Theodorakis (2008). These were a selection of existing pieces aiming for a real-world experiment,[80] were considerably different and ordered in increasing difficulty. Also, my participants were suggested indicative timings to memorise the excerpts,[81] were not given aural models and could upload two recordings for each excerpt.[82] Furthermore, participants' practice sessions were not recorded. Instead, they explained their memorisation procedures during individual interviews, only submitting audio-recorded performances and annotated scores. This decision aimed to promote a comfortable space for them, facilitating a closer experience to their usual performance practice.[83] Additionally, not video-recording participants preserved their privacy and anonymity, without being an obstacle for this research, since the study did not observe practice. Like Jónasson and Lisboa (2015; 2016), the Main Study was informed by a Pilot Study to validate the methods used and assess whether any changes were needed. However, unlike Jónasson and Lisboa (2015; 2016), the excerpts in the Main Study were the same as the Pilot Study, and different participants were recruited each time. Additionally, both the Pilot and Main studies involved sequential recalls at specific time intervals, while including the effect of sleep in the research design.[84]

[80] Williamon et al. (2021: 199).
[81] Participants were given indicative timings, suggesting how much time they should need to memorise each excerpt. However, they were also told that they could use more time, if needed, to fully memorise the excerpts.
[82] Further details are given later in this section when discussing the procedure of the Study with Participants.
[83] Williamon et al. (2021: 199).
[84] e.g., Maquet et al. (2003a), van Hedger et al. (2015), Walker et al. (2002).

Finally, the Study with Participants was moved online due to Covid-19. Therefore, the tests were completed in isolation without the researcher being present: the participants memorised the excerpts on a familiar piano and space, instead of in a laboratory setting.

Sampling: Two methods were used for recruiting participants. First, convenience sampling to select potential participants, because the targeted population of advanced pianists (students, professionals) is large and widely dispersed.[85] This method intended to recruit a group of comparable participants with similar recent training, while previous and distinctive training would be identified with a questionnaire.[86] Secondly, quota sampling was used to recruit participants with different levels of expertise: piano students with different academic experiences and professional performers. Accordingly, I distributed a call for participants at the Royal Birmingham Conservatoire (RBC) and other musical institutions in the UK, aiming to recruit piano students who attended an institution ruled by British educational guidelines.[87] I also contacted graduates from the Royal College of Music (RCM) who had been my peers there; and distributed the call to American musical institutions, which could potentially provide an additional group of English-speaking participants.[88] Contacting different institutions aimed at providing sample diversity, while mitigating potential bias resulting from focusing on a single institution.[89] In total, I recruited three participants from RBC, seven participants from RCM and one participant from a USA-based institution. Concretely, these were two 2nd-year BMus piano students, one bachelor's graduate, three master's graduates pursuing further postgraduate studies, one PhD student, two professional pianists, one organ

85 Cohen et al. (2018: 218).
86 Williamon et al. (2021: 198-199).
87 Calls were distributed at the Royal College of Music, Royal Academy of Music, Cardiff University, University of Huddersfield, University of York, Guildhall School of Music and Drama, Royal Conservatoire of Scotland and Royal Northern College of Music.
88 Calls were distributed at Juilliard School, Boston University, Colorado College and University of Colorado (Colorado Springs).
89 Cohen et al. (2018: 218).

tutor and piano accompanist, and one amateur with 15 years of experience in piano playing.[90] Hence, recruitment was completed by targeting those pianists who were willing and available to participate. Therefore, the data collected could be biased, since these participants 'may have a particular view on or interest in' my research topic, potentially omitting other performers' profiles (Williamon et al., 2021: 52). Nonetheless, this recruiting procedure was the only feasible option for completing the study during Covid-19.

Participants were allocated to memorisation groups (Group X, Group Y) according to their responses to an anonymous questionnaire. The determining parameters were their level of education, and whether they:

- Always performed from memory.
- Felt confident at sight-reading.
- Experienced synaesthesia.
- Had perfect pitch.
- Consciously used their emotions to memorise.
- Had explicit memorisation strategies.
- Used sleep (e.g., regular naps), as part of their practice routine.

These outcomes were complemented by the Logical Reasoning Test (LRT) results. A summary of the recruited participants' profiles for the Pilot Study and the Main Study is provided in Table 4.3 and Table 4.4, respectively.

[90] In addition to these recruited participants, a master's graduate from the Royal College of Music also agreed to take part in the study: Participant I (PI). However, due to Covid-related health problems, PI had to withdraw before data collection started.

Table 4.3: Allocation of participants for the Pilot Study.

PILOT STUDY			
	Group X		Group Y
Participant	PB	PC	PA
Gender	Male	Male	Female
Education	Professional	BMus 2	BMus 2
LRT	60-69%	More than 80%	50-59%
Performs from memory	Sometimes	Sometimes	Yes
Sight-reading	Yes	Yes	To some extent
Synaesthesia	No	No	No
Perfect pitch	Yes	No	No
Uses emotions to memorise	No	No	Sometimes
Memorisation strategies	Yes	To some extent	Yes
Sleep	No	Sometimes	No

Table 4.4: Allocation of participants for the Main Study.

MAIN STUDY								
	Group X		Group Y					
Participant	PH	PK	PD	PE	PF	PG	PJ	PL
Gender	Female	Male	Female	Female	Female	Male	Female	Female
Education	Professional	PG	PG	PhD	Professional	Amateur	BMus 4	PG
LRT	Less than 50%	More than 80%	70-79%	Less than 50%	70-79%	60-69%	70-79%	60-69%
Performs from memory	Sometimes	No	Yes	Sometimes	Sometimes	Yes	Yes	Yes
Sight-reading	To some extent	Yes	Yes	No	Yes	No	To some extent	To some extent
Synaesthesia	No	No	No	Sometimes	No	No	Sometimes	No
Perfect pitch	No	Yes	Yes	Yes	No	No	Yes	Yes
Uses emotions to memorise	Yes	No	Sometimes	No	No	No	No	Sometimes
Memorisation strategies	Yes	To some extent	Yes	To some extent	To some extent	To some extent	To some extent	To some extent
Sleep	Yes	No	Sometimes	No	No	Sometimes	Sometimes	Yes

Accordingly, the participants' profiles are summarised in Table 4.5:

Table 4.5: Comparison of the participants' profiles between Group X and Group Y for the Pilot and Main Study.

STUDY WITH PARTICIPANTS		
	Group X	**Group Y**
Participants	4	7
Gender	1 Female 2 Males	6 Females 1 Male
Education	<u>1 Bachelor's student</u> 1 <u>Postgraduate</u> student 2 <u>Professionals</u>	1 Amateur <u>1 Bachelor's student</u> 1 Bachelor's graduate 2 <u>Postgraduate</u> students 1 PhD student 1 <u>Professional</u>
LRT	<u>1 Less than 50%</u> 1 Between <u>60-69%</u> 2 More than 80%	<u>1 Less than 50%</u> 1 Between 50-59% 2 Between <u>60-69%</u> 3 Between 70-79%
Performs from memory	<u>2 Sometimes</u> 2 No	5 Yes <u>2 Sometimes</u>
Sight-reading	3 Yes 1 To some extent	2 Yes 3 To some extent 2 No
Synaesthesia	4 No	2 Sometimes 5 No
Perfect pitch	2 Yes 2 No	4 Yes 3 No
Uses emotions to memorise	1 Yes 3 No	3 Sometimes 4 No
Memorisation strategies	<u>2 Yes</u> 2 To some extent	<u>2 Yes</u> 5 To some extent
Sleep	<u>1 Yes</u> 1 Sometimes 2 No	<u>1 Yes</u> 3 Sometimes 3 No

Finally, all participants reported not receiving any training on memorisation.

Participants: The Pilot Study was run with three participants, as detailed in Table 4.6. Data related to institutions attended was removed to preserve their anonymity.

Table 4.6: Description of the participants' profile for the Pilot Study.

ID	Group	Age	Gender	Years Learning Piano	Program & Year of Study
Participant A (PA)	Y	19	Female	10	BMus 2
Participant B (PB)	X	54	Male	50	Organ tutor & Piano accompanist
Participant C (PC)	X	19	Male	8	BMus 2

Once validated and refined, the Main Study was run with eight participants, completing a total sample of 11 for the whole study, which permitted triangulation and saturating the results.[91] Further details of the Main Study participants are found in Table 4.7. Amongst these, participants PD and PK received extensive training in recent post-tonal music.

Table 4.7: Description of the participants' profile for the Main Study.

ID	Group	Age	Gender	Years Learning Piano	Program & Year of Study
Participant D (PD)	Y	27	Female	19	Postgraduate
Participant E (PE)	Y	27	Female	20	PhD (Year 1)
Participant F (PF)	Y	32	Female	17	Professional
Participant G (PG)	Y	34	Male	15	Amateur, Private Study
Participant H (PH)	X	30	Female	21	Professional
Participant J (PJ)	Y	22	Female	15	BMus 4

[91] Cohen et al. (2018: 43; 265-267).

Participant K (PK)	X	26	Male	20	Postgraduate
Participant L (PL)	Y	27	Female	22	Postgraduate

Finally, to clarify the findings of this study (see Chapter 7), from now on, participants' IDs are complemented with their group label: e.g., PD-Y, PH-X. Furthermore, they are described in gender-neutral language since no differences in their results could be correlated to gender.

Materials: A participant information sheet that described the study and a consent form.[92] Participants also completed an anonymous questionnaire regarding musical education, challenging repertoire performed or studied, and performance experience.[93] This Questionnaire was structured in themed sections: overview of memory, parameters that influence memorisation (e.g., sight-reading, synaesthesia, perfect pitch, emotions); practice linked to memorisation, including the effect of mental practice and sleep; performance, education and training. The Questionnaire also asked participants to explain a strategy used for memorising a post-tonal piece.

Existing questionnaires, such as Mishra's (2007: 11), identify memorisation strategies and how the Sensory Learning Styles are used for this purpose.[94] However, these focus on the 'correlation between musicians' preferred perceptual learning modalities and memorisation styles' (Mishra, 2007: 8).[95] Mishra's questionnaire or similar versions,[96] involve rating scales

[92] The consent form and the participant information sheet are available at Appendix G.
[93] This Questionnaire is available at Appendix H.
[94] Mishra (2004: 233).
[95] See also Odendaal (2019).
[96] e.g., Davidson-Kelly et al. (2012), Herrera and Cremades (2014).

framed into descriptive and empiric-analytic methods within a positivist paradigm,[97] differing from the underpinnings and goals of this research.

Similarly, the Goldsmiths Musical Sophistication Index (Gold-MSI)[98] was also considered, which is a standard musical questionnaire[99] used in similar studies.[100] However, it required too much time from participants. Therefore, Gold-MSI's most relevant aspects (i.e., general information, education, musical experience) were included in the Questionnaire, while other specific musical tests (e.g., genre sorting task, melody memory task, beat alignment perception and production tasks) were not relevant: the recruited participants were highly trained musicians, in contrast to the 'general Western population' at which aims the Gold-MSI measure (Müllensiefen et al., 2013: 3).

Therefore, the resulting Questionnaire combined dichotomous, multiple-choice and open-ended questions with rating scales. This diversity aimed at collecting the best possible data for each category: quantitative data describes more precisely certain phenomena than qualitative data, and vice versa.[101] This was collated as a Microsoft Forms linked to their university's email accounts, to protect the participants' privacy. The results informed the list of questions used for interviewing participants. These semi-structured interviews followed Gibbs' (1988) reflective cycle:[102]

1) Description of the experience.
2) Feelings and thoughts about the experience.
3) Evaluation of the experience.

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97 Albert (2007), Rodriguez and Valldeoriola (2009).
98 Goldsmiths University of London (2019) *The Goldsmiths Musical Sophistication Index (Gold-MSI)*. Available at: www.gold.ac.uk/music-mind-brain/gold-msi/ [Accessed 07 December 2019].
99 Müllensiefen et al. (2014).
100 e.g., Hadley (2016: 91).
101 Cohen et al. (2018: 475-485).
102 The script of this semi-structured interview is available at Appendix I.

4) Analysis to make sense of the situation.

5) Conclusion on what was learned and what could have been done differently.

6) Action plan for how the participant would deal with similar situations in the future, or general changes that might be appropriate.

Gibbs' (1988) cycle of reflection presents similarities with Interpretative Phenomenological Analysis' (IPA) standard reflections: What is the participant trying to achieve? Were there any unintended actions? Am I aware of something that is happening or happened that the participant has not realised?[103] Hence, it focuses on how participants interpret their experiences.[104] Furthermore, although structured interviews facilitate analysis, these limit participants when describing their experiences.[105] Alternatively, Gibbs' (1988) reflective cycle prompted a guided and flexible self-reflection, enabling participants to convey the implicit complexity of musical performance in terms of perception,[106] motion,[107] spatial mapping,[108] cognition,[109] emotion,[110] learning[111] and memory,[112] and how all these integrated. Accordingly, simpler models such as the three-stage ERA cycle (experience, reflection, action),[113] and the four-stage Experiential Learning Cycle (experience, reflective observation, abstract conceptualisation, active experimentation)[114] were rejected. Additionally, since studies on post-tonal piano music memorisation with participants are scarce, a structured interview could have omitted or missed important aspects of this topic and the participants'

[103] Smith and Osborn (2007), Williamon et al. (2021: 245-248).
[104] e.g., Aiello (2000), Chen (2015), Fonte (2020: 77-117), Ginsborg (2000), Hallam (1997), Holmes (2005), Humphreys (1993), Jónasson and Lisboa (2015).
[105] Smith and Osborn (2007: 57-59).
[106] Brancucci and San Martini (1999; 2003), Brancucci et al. (2005; 2008; 2009a; 2009b; 2012), Franciotti et al. (2011), Meister et al. (2004), Wong and Gauthier (2010).
[107] Behmer and Jantzen (2011).
[108] Stewart et al. (2004).
[109] Gunter et al. (2003), Schön and Besson (2002), Stewart (2005).
[110] Jäncke (2008), Schubert (2013).
[111] Stewart (2005), Stewart et al. (2003).
[112] Simoens and Tervaniemi (2013).
[113] Jasper (2013).
[114] Kolb (1984).

experiences.[115] Therefore, the semi-structured interview was a suitable method for allowing participants to be 'experiential experts on the subject' (Smith and Osborn, 2007: 59).

The Memorisation Test initially involved three excerpts selected from existing post-tonal piano works I had performed from memory. However, the Pilot Study results indicated that an additional atonal excerpt (Excerpt 4) was needed. I selected this by sight-playing all piano works included in the ABRSM *Spectrum* collection,[116] identifying the most suitable for the purpose of the study. Then, I learned and memorised it, to develop a list of instructions that Group Y could follow.

All excerpts challenged memory differently,[117] avoiding technically demanding passages. Full works were discarded to facilitate recruitment, prevent dropouts from the study and compare Conceptual Simplification's effectiveness with other strategies in contrasting excerpts. The MMT had two versions: one for Group X; and another for Group Y, who was given instructions to memorise.[118] All strategies suggested in these came from my performance practice. Participants strictly followed the instructions given, without any previous training or demonstration. Both tests were implemented as a Google Form, that supported image

[115] Lyons and Coyle (2011: 13-15, 20).

[116] This is an ABRSM series of commissioned piano works from living composers of different styles and consists of five volumes. See further details here: https://shop.abrsm.org/shop/ucat/Spectrum/1225

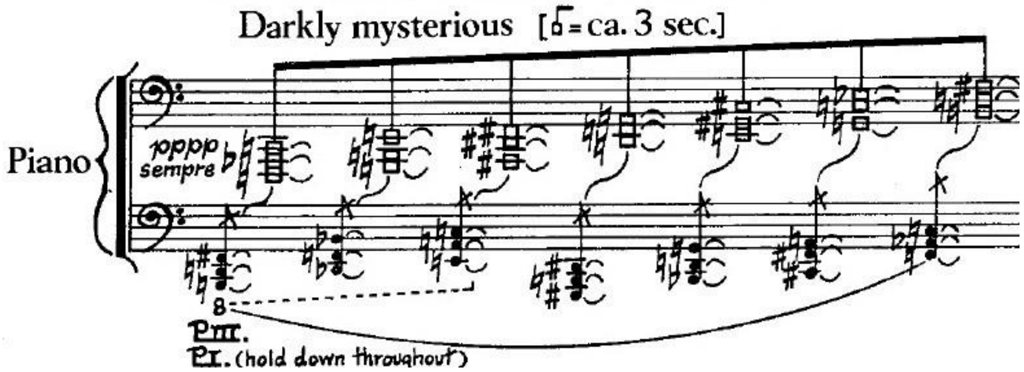
[117] Chamber music and solo piano parts with accompaniment were excluded, to focus on solo repertoire. Similarly, extended techniques and electronics were avoided to simplify the task: recruited participants would not necessarily be familiar with these performing resources before, since these are only present in repertoire not commonly included in the syllabus of most institutions (Fonte, 2020: 84; Jónasson and Lisboa, 2016: 80). Additionally, both extended techniques and electronics require certain experience and familiarity to be incorporated naturally into a performance, equipment and tools. Therefore, including such features in the Memorisation Test added an unnecessary layer of complexity, altering the results and being distracting for all those involved.

[118] Group Y's list of instructions for the Pilot Study and the Main Study are available at Appendix E. All versions of the Memorisation Test are available at the original platforms:

Group X: MMT Pilot Study (https://forms.gle/F7QpvU7dzJokws2ZA)
Group Y: MMT Pilot Study (https://forms.gle/DAFQTjHUbWoEu8WW9)
Group X: MMT Main Study (https://forms.gle/BGP32KMc3NH7DcAE6)
Group Y: MMT Main Study (https://forms.gle/p2rs98fzqQigm2z66)
AR (https://forms.gle/dRxeA1nPbS2ocfXA8)
NDR (https://forms.gle/eASpygkHPwDHjzev7).

displaying, while allowing participants to upload audio-recordings and pictures. This platform worked for all content needed, while only linking the participants' submissions to their emails. The same form requested the timings needed for memorising each excerpt. Access to the Google Form was granted immediately before starting, to monitor the run of the test. Participants were also sent the excerpts in PDF, so they could optionally print them beforehand to work more comfortably. However, they were asked not to look at these until required in the instructions. Further details on Conceptual Simplification's implementation to all excerpts are found in Chapter 3 and Appendix E.

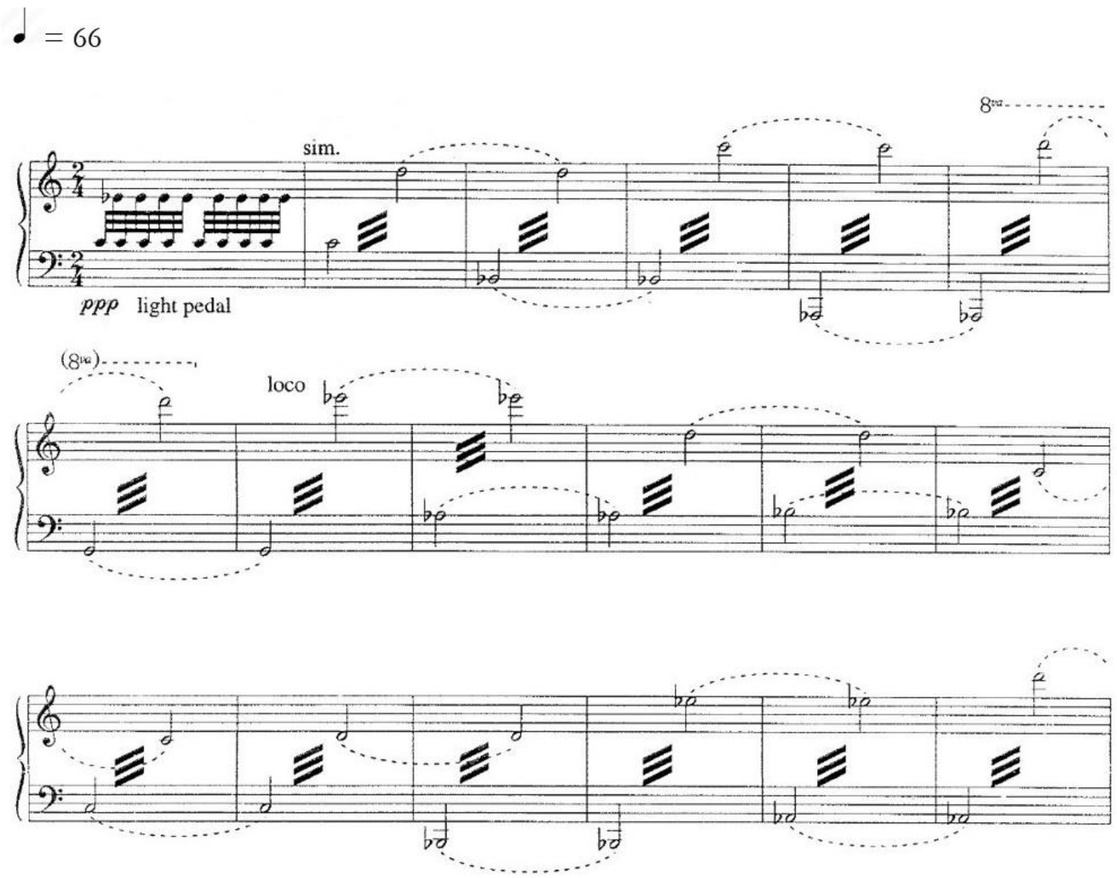
Excerpt 1 consisted of the beginning of Crumb's *Primeval Sounds* (Example 4.1),[119] with a performing length of 21 seconds. This involves a sequence of chords in the lower register of the piano, where pitches are less discernible, particularly aiming at challenging perfect-pitch possessors with a tendency to memorising by ear. Furthermore, understanding pitch organisation for this excerpt was needed for engaging conceptual memory, instead of exclusively relying on hand positions. According to my experience, participants were suggested a 15-minute indicative timing to memorise it.



Example 4.1: George Crumb, *Makrokosmos I* (1972), 'Primeval Sounds', initial 49 seconds, Excerpt 1.

[119] I worked this piece with the composer during a private masterclass at his home on 16 August 2017 in Media, Pennsylvania (USA).

Excerpt 2 consisted of bars 1-18 of Lang's *Cage* (Example 4.2).[120] This has a performing length of 32 seconds, and participants were given a 30-minute indicative timing to memorise it. This excerpt presents multiple switches in terms of melody, harmony and octave changing, within the context of a self-referencing texture.



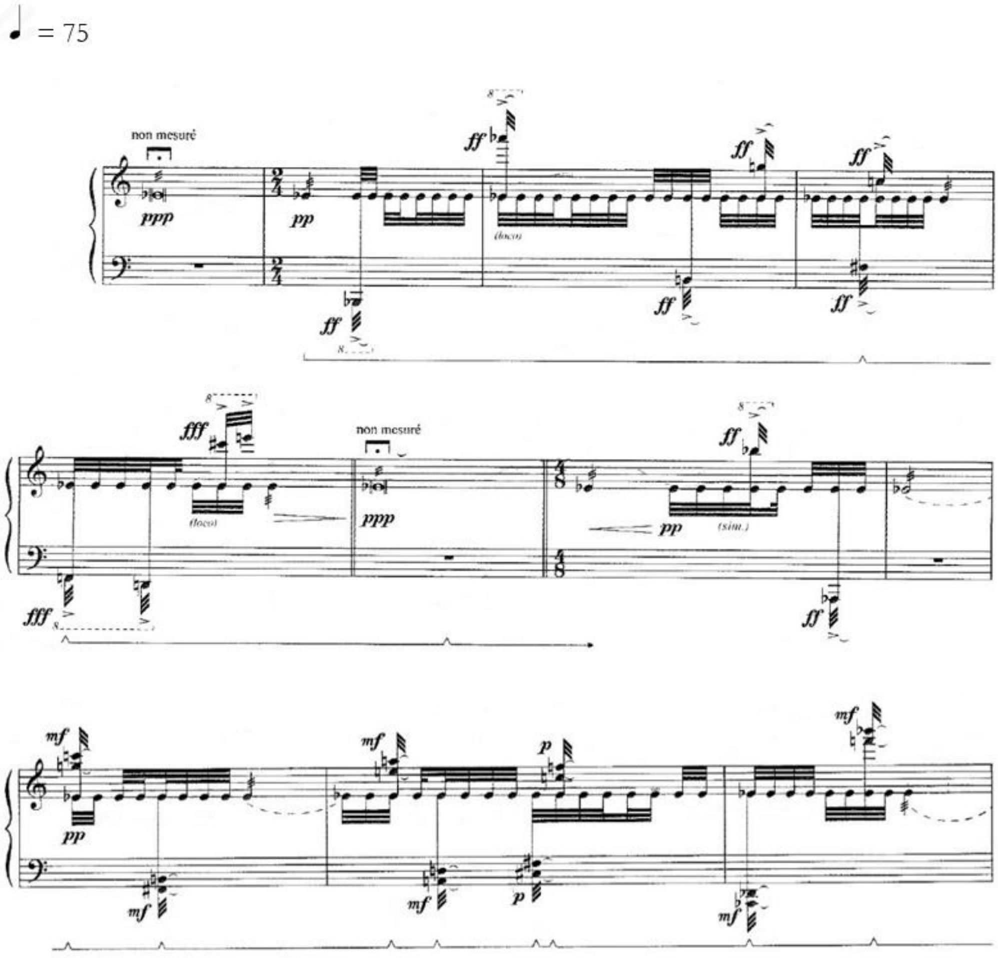
Example 4.2: David Lang, *Memory Pieces* (1992), 'Cage', bars 1-18, Excerpt 2.

Excerpt 3 consisted of bars 1-8 followed by bars 38-40 of Manoury's Piano Toccata (Example 4.3).[121] The excerpt lasts 47 seconds, and participants were expected to memorise it in 30 minutes. However, Pilot Study participants needed more time. Thus, for the Main

[120] I worked this piece with the composer during a public masterclass on 25 January 2017 at the Royal College of Music in London (UK). I also gave the Spanish Premiere of the piece during a recital in Barcelona in September 2019.

[121] I worked this piece with the composer during a private masterclass on 27 July 2017 at the Opéra-comique in Paris (France). I also gave four national premieres of the piece as part of my recitals in Spain (Barcelona, 2017), Bulgaria (Sofia, 2018), Canada (Montreal, 2019) and USA (Boston, 2019).

Study, the indicative timing was extended to 45 minutes. Excerpt 3 is based on a symmetrical pitch organisation, being particularly challenging in terms of rhythm and tempo.



Example 4.3: Philippe Manoury, *Toccata pour piano* (1998), bars 1-8 and 38-40, Excerpt 3.

Finally, Excerpt 4 consisted of bars 1-2 of Redgate's *Trace*, from the standard book of contemporary pieces *ABRSM Spectrum 1* (Example 4.4). This has a performing length of 4 seconds, and participants were expected to memorise it in 20 minutes. This atonal excerpt comprises two unrelated cells that do not present any discernible patterns.

Example 4.4: Roger Redgate, *Trace* (1996), bars 1-2, Excerpt 4.[122]

As stated, the study also included a Logical Reasoning Test (LRT) designed by the company AssessmentDay,[123] which consisted of 15 questions, each containing a grid of symbols. In each question, one of the symbols was missing, so participants had to choose which of the 12 possible answers best fitted (see Figure 4.1). There was no overall time limit, but each question had to be completed in 70 seconds. The LRT assesses the ability to comprehend the logic of a visual pattern and develop problem-solving strategies,[124] providing a standardised measure of logical-mathematical thinking.[125] In this research, the test aimed at estimating the participants' propensity in following an Analytical Learning Style when memorising the excerpts,[126] anticipating whether they might find Conceptual Simplification useful. Based on their results, participants were allocated to the memorisation groups, seeking a balance of profiles. Confronting participants with the challenge of finding meaning and identifying the rules of a visual pattern aimed at recreating the process of reading and making sense of a musical score,[127] without previous references.[128] A similar approach was tested by

[122] Retrieved from Myers (2001: 51-53).
[123] Retrieved from https://www.assessmentday.co.uk/aptitudetests_logical.htm. This Logical Reasoning Test (LRT) is available at Appendix J, and online as an interactive platform: https://www.assessmentday.co.uk/logic/free/LogicalReasoningTest1/index.php.
[124] Berardi-Coletta et al. (1995), Egan and Schwartz (1979), Gobet and Simon (1996d), Gobet et al. (2001), Marshall (2008), Miller (1956), Saariluoma (1990).
[125] Azaryahu and Adi-Japha (2020), García (2013), Gardner ([1983] 2011: 135-178), Sáenz de Cabezón ([2016] 2020).
[126] Chaffin and Imreh (1997a), Chaffin et al. (2003; 2013), Lisboa et al. (2011), Mishra (2004: 233; 2005: 81-83).
[127] Azaryahu and Adi-Japha (2020), Jaarsveld and Lachmann (2017), Lewandowska and Schmuckler (2020), Waters et al. (1998).
[128] Gardner ([1983] 2011: 146-152), Miller (1956), Waters et al. (1998).

Waters et al. (1998: 143-144), in which an incomplete four-bar excerpt was provided, and participants had to decide which of the given options fitted.[129]

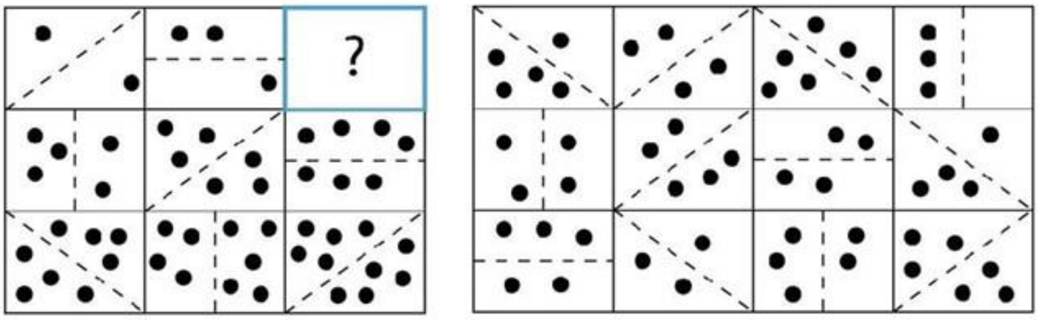


Figure 4.1: Excerpt from AssessmentDay's Logical Reasoning Test (LRT). Participants had to decide which of the 12 options on the right grid best fits the missing symbol on the left grid.

The LRT was used to substitute the Raven Progressive Matrices (RPM), which is a well-established measure for assessing non-verbal reasoning, widely used in educational settings and research (see Figure 4.2).[130] RPM are copyrighted, and permission was not granted for this thesis.[131]

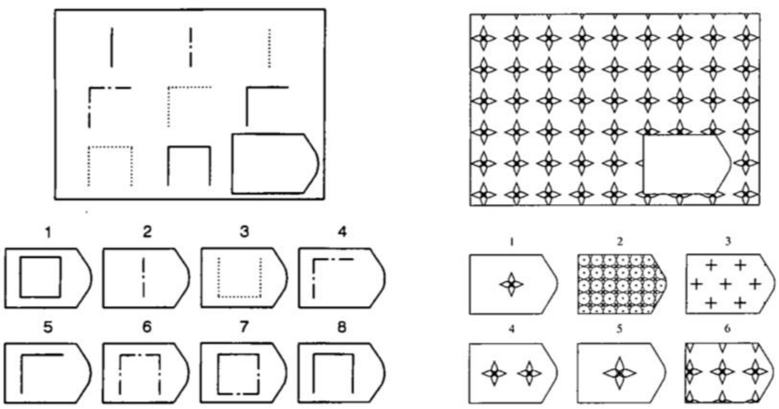


Figure 4.2: Standard Progressive Matrices (SPM) test of different difficulty (Raven, 2003: 224-225).

[129] The "wrong" alternatives involved incoherent melodic, rhythmic and harmonic variations. See Figure 7 in Waters et al. (1998: 143).
[130] Raven (2003), Raven et al. (1998a), Spearman (1927a; 1927b).
[131] This decision was discussed and validated with Dr Olga Fotakopoulou, who is a senior lecturer at Birmingham City University (BCU) on developmental and educational psychology. Her BCU profile is available at: https://www.bcu.ac.uk/social-sciences/about-us/staff/psychology/olga-fotakopoulou

Nevertheless, RPM provide a time limit to complete the test, which can interfere with measuring the participant's speed. For example, some participants might focus on attempting the more difficult problems, while others might skip these and focus on correctly solving the easier ones, obtaining higher scores. Consequently, producing an uneven invalid distribution of the scores across both types of participants. This limitation was mitigated with LRT's design, which times each set independently, although this still imposed a disadvantage to those participants 'who work more slowly and carefully' (Raven, 2003: 234). Accordingly, LRT results were only informative, at not providing conclusive outcomes on the participants.

Additionally, other logical reasoning tests were considered, such as Kahneman's (2012) cognitive reflection tests, which measure the tendency to override intuitive fast responses to problems and to prefer more analytical and effortful (eventually correct) responses, which is underpinned by the dual-process framework of judgment and decision-making. Similarly, Frederick (2005), and Thomson and Oppenheimer (2016) provide quick and simple measures of temptation and the lack of patience during reasoning. These are simpler and fast processes (i.e., intuition, labelled as System 1) that compete with slower and analytical judgment, and decision-making (i.e., reason, labelled as System 2). Alternatively, Oaksford and Chater (2001) provide a probabilistic approach to logical reasoning, while Ragni et al. (2018) focus on the importance of considering counterexamples when seeking a pattern's general rule. However, all these were discarded for lacking a visual component when assessing logical reasoning. This was crucial since the reasoning behind the comprehension of a visual pattern can be traced to the mental processes of learning a musical work.[132] Both involve the participant's abilities of reasoning, problem-solving, planning and abstract thinking.[133]

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[132] Azaryahu and Adi-Japha (2020), Brodsky et al. (2008), Miller (1956), Rubin-Rabson (1937).
[133] Williamon et al. (2021: 202).

Procedure: Each participant submitted a consent form, a Questionnaire, a Logical Reasoning Test, audio-recorded performances, voice-notes, timings and annotated scores. Their interviews were also recorded. For the Pilot Study, written recalls were collected for all participants and excerpts.

The Memorisation Test compared the effectiveness of the memorisation strategies used by the participants. However, two additional outcomes were also explored:

1) Whether the instructions provided to Group Y improved their average result over Group X.

2) Whether sleep positively influenced the participants' ability to recall the excerpts.

The Pilot Study was completed in December 2020 and the Main Study happened from July to December 2021. Participants signed consent forms after reading the information sheet. Then, they completed the Questionnaire (c.a. 20 min)[134] and the Logical Reasoning Test (LRT, c.a. 18 min) at a suitable time for them.[135] For the LRT, participants timed themselves, to ensure answering each question in 70 seconds. This was administered in a Google Form that displayed one question at a time. To prevent participants from exchanging solutions between them, correct answers were not identified, and participants were unaware of their final score throughout the study. Besides preserving the test's reliability, this prevented a potential negative effect on participants, should they score low. Participants were either allocated to the control Group X or the experimental Group Y, depending on their responses to the Questionnaire and LRT results. Experience towards sight-reading, synaesthesia, perfect pitch, emotions, sleep, mental practice and memorisation strategies were sought to

[134] The Questionnaire is available at Appendix H.
[135] The Logical Reasoning Test is available at Appendix J.

be equally represented in both groups. The allocation of participants was also randomised by the order of recruitment, their completion of the Questionnaire and LRT, and their availability for the Memorisation Test.[136]

For each participant, the Memorisation Test was scheduled at a mutually convenient time to monitor data collection, assist them should any issues arise, and interview them after they finished. When scheduling the tests, participants were asked to select times in which they could feel focused and not be interrupted. All morning tests were scheduled at similar times, leaving a gap of several hours before the first-morning test (MMT) and the afternoon recall (AR). Furthermore, participants chose the location, which had to satisfy the requirements of a silent environment with a piano, and an electronic device for submitting the forms and joining me via conference call.

During the MMT, participants memorised the excerpts, while during the AR and NDR, they recalled these from memory. In all these tests, they timed themselves and audio-recorded their performances. Participants were not allowed to use the scores after first memorising the excerpts but could provide two audio-recorded versions of each, including one at a comfortable speed and another at tempo. Submitting two attempts per excerpt permitted comparing the accuracy and extent of their memorisation, potentially discarding collateral effects from performance anxiety or technical inaccuracies: e.g., an involuntary slip of the finger. However, the Pilot Study results demonstrated that a better option was submitting a single recording and a voice-note, so participants obsessed less on the result at having the opportunity to comment on their performance and thoughts. They also submitted pictures of their annotated scores.

[136] Williamon et al. (2021: 203-204).

Participants were interviewed after the MMT, AR and NDR, once I had reviewed their submission. Interviews were hosted via conference calls (Microsoft Teams, Skype, Zoom), and were recorded. On average, these lasted 28 minutes (MMT), 8 minutes (AR), and 9 minutes (NDR). The interviews permitted assessing the participants' experience immediately after, including which strategies they used for memorising. It was also an opportunity to discuss the role of certain parameters (e.g., perfect pitch, sight-reading) when completing each task. Beyond that, it also provided further insight into their experience with memorisation and performance anxiety, to understand in what circumstances they completed the study. This topic was not covered in the Questionnaire, to prevent participants from recalling traumatic or upsetting experiences before the Memorisation Test.[137] Finally, they reflected on how sleeping before the NDR without further practice influenced their recalls. Also, in what ways their experiences differed for each test, to identify their peak of confidence. These conversations were articulated according to Gibbs' (1988) reflective cycle, for which I had a list of questions used as a prompt.

Verifying and reporting: The participants' diversity of results and background permitted triangulation,[138] by using the same methodology with different participants, aiming for concurrent validity.[139] Different display methods revealed underlying patterns in the data and broader tendencies.[140] Contact with participants was standardised to guarantee they all received the same instructions,[141] the only exceptions being the interviews, in which questions were tailored to the participant's profile and experience.[142]

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137 Williamon et al. (2021: 220).
138 Cohen et al. (2018: 265-267).
139 Williamon et al. (2021: 43).
140 Cohen et al. (2018: 315), Lyons and Coyle (2011: 20-21).
141 Leung (2015: 325), Robson and McCartan (2016), Williamon et al. (2021: 45).
142 Cohen et al. (2018: 511), Johnson and Onwuegbuzie (2004: 20).

The study prompted a trial-and-error approach of different memorisation strategies, in which Group Y followed a guided implementation of Conceptual Simplification. Furthermore, during the interviews, participants shared their impressions, including what were the most and least successful strategies, and their future potential. This permitted comprehending further the recordings submitted, complementing the mixed methods design.

To validate the methods used, the study was first run as a pilot, with the purpose to:

1) Ensure the methods' reliability, validity, and practicability.

2) Check the wording and clarity of the items, instructions and layout of the Questionnaire and tests. Collect feedback and eliminate ambiguities to ensure internal reliability.[143]

3) Identify omitted, redundant and irrelevant items. Identify commonly misunderstood or non-completed items, including unexpected responses.

4) Check the time taken to complete each task, and the difficulty involved.

5) Observe which excerpts were more challenging, to ensure that these were presented in increasing order of difficulty. Check whether excerpts were fully representative of the phenomenon being tested.

6) Identify which memorisation strategies participants used within the same or different groups.

7) Test data analysis' efficacy and appropriateness with a small sample. Devise and test mechanisms for being more efficient when facing a bigger sample.

All these served as a baseline and helped in refining the Main Study.[144]

143 Williamon et al. (2021: 45).
144 Cohen et al. (2018: 496, 583-584).

4.5 Data Analysis

This section discusses how different types of data were analysed for all studies. These are grouped into verbal and quantitative written data; video-recordings; and audio-recordings.

4.5.1 Verbal and Quantitative Data

Recordings from all interviews were transcribed using Otter.[145] Then, all transcriptions were revised while listening to the audio-recordings, to confirm that Otter's dictation was accurate. Transcriptions were also edited: words and expressions such as 'you know', 'uhm', 'yeah', 'like', and superfluous incomplete sentences were deleted. Stuttering and unnecessary repetitions were removed and replaced with '…'. Words added for clarification were written inside square brackets.[146] Finally, confusing statements, due to technology interferences or ambiguous responses, were highlighted in red, so interviewees or recruited participants could clarify these when revising the transcription.

Transcriptions were coded,[147] using both an inductive (bottom-up) and a deductive (top-down) approach,[148] bearing in mind the potential 'propensity' to 'look for patterns where none exist' (Cohen et al., 2018: 674),[149] which is a limitation of coding.[150] However, coding was the first step for applying thematic analysis:[151] the most suitable method for this kind of data, being flexible, easy and fast to execute. Also, this can be implemented 'within different theoretical frameworks' because it 'matches what the researcher wants to know' (Braun and Clarke, 2006: 80). Thematic analysis also permitted reducing the vast amount of data

145 Otter is an AI software for transcribing speech to text. See further details at: https://otter.ai/
146 Flick (2013), Kawahara (2007).
147 Flick (2009: 306-332).
148 Williamon et al. (2021: 236-243).
149 See also Adair and Pastori (2011: 32-33), St Pierre and Jackson (2014: 716-717).
150 St Pierre and Jackson (2014).
151 Braun and Clarke (2012: 58-59).

collected in all studies, while generating the same themes across different participants.[152] Alternatively, Interpretative Phenomenological Analysis (IPA) was discarded: despite IPA's suitability for small samples,[153] this generates themes for each participant, instead of common themes that reflect 'shared meaning' amongst them (Braun and Clarke, 2019: 589),[154] diverging from the aim and scope of this research. Moreover, any misunderstanding in the interviewees' perspectives can lead to 'overly subjective' conclusions (Williamon et al., 2021: 248). Additionally, content analysis was also considered,[155] since this 'can contribute to the development of a deeper understanding of the content and meaning of the text beyond paraphrasing and summarising it' (Flick, 2009: 317), which is one of the risks of thematic analysis.[156] Hence, after completing the latter, a content analysis was attempted, to check whether this method provided additional insight into the data. However, the results saturated those previously obtained, demonstrating that content analysis was not needed.[157] Also, content analysis tends to a quantitative 'numerical analysis of qualitative data', in which 'all data are swept and treated as equally important' (Cohen et al., 2018: 674-675).

Therefore, after performing a thematic coding,[158] a thematic analysis was completed on all transcriptions and questionnaires, following Braun and Clarke's (2012) six-step procedure:

1) Become familiar with the data.
2) Generate initial codes.
3) Search for themes.
4) Review potential themes.
5) Define and name themes.
6) Produce the report.

[152] Boyatzis (1998), Braun and Clarke (2006: 79-82), Fielden et al. (2011), Ryan and Bernard (2000).
[153] Smith and Osborn (2007: 57).
[154] See also Braun and Clarke (2006), Williamon et al. (2021: 243-248).
[155] Hsieh and Shannon (2005), Mayring (2014), Nichols (2013).
[156] Blikstad-Balas (2016: 9), Braun and Clarke (2006: 27-28), St Pierre and Roulston (2006: 677).
[157] Cohen et al. (2018: 43; 265-267).
[158] Flick (2009: 318-323).

Figure 4.3 and Table 4.8 illustrate how these were respectively implemented.

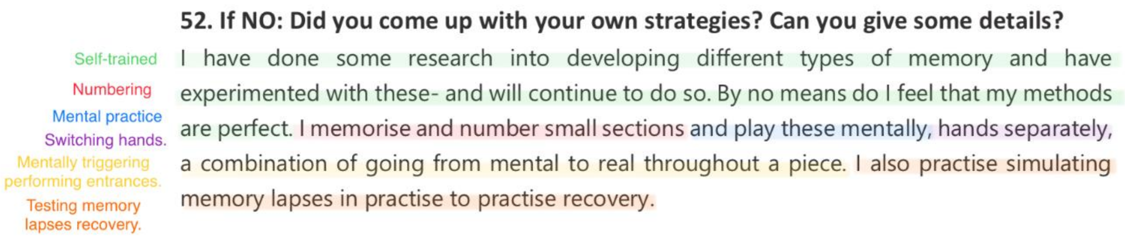

Figure 4.3: Example of the thematic coding implemented in PA-Y's Questionnaire, following both an inductive and deductive approach.

Table 4.8: Example of the thematic analysis implemented in all questionnaires from the recruited participants.

THEME 2: Memorisation approach conditioned by the learning styles.

Subtheme 2.1 Sensory Learning Styles (PA, PD, PE, PH, PL).

Code 2.1.1 *Visual memory (PA, PH).*

PA: *'My approach to memorisation in the past has been based more on visual shapes of chords as opposed to on an understanding of the underlying harmonic structure'.*

PH: *'Additionally, I use pictures or associations that help me memorise the piece'.*

Code 2.1.2 *Aural memory (PD, PE).*

PD: *'Now I use my ears to play the music inside my head as well, and that helps me play it on the keys. If I can get the music to stay in my head, then I can play it from memory'.*

PE: *'I rely a lot on listening'.*

Code 2.1.3 *Muscle memory (PE).*

PD: *'I rely a lot on muscle memory'.*

Subtheme 2.2 Analytical Learning Styles (PB, PE, PF, PG, PH, PJ).

Code 2.2.1 *Conceptual memory (PB, PE, PH).*

PB: *'I find that the more I feel that I understand the score, the more it "sticks"'.*

PE: *'I try to find patterns and analyse briefly the music I'm studying'.*

PH: *'I generally try and use logic in order to memorise music. I find it easy because if I can find logic in the music, it gives me a sense of security that I need in order to feel free when performing. It is a little more difficult with contemporary music, since it is often atonal. But even then I try to find patterns'.*

Code 2.2.2 *Segmented Processing Strategy (PF, PG).*

PF: *'I usually memorise a section at a time'.*

PG: *'I attempt to break the piece down into a basic theoretical structure'.*

PG: *'I make efforts to play parts/voices separate and together without the music and at different tempos'.*

Code 2.2.3 *Mental practice (PJ).*

PJ: *'I usually memorise away from the piano. I run the pieces through in my head as many times as possible, to find out where the weak spots are'.*

Subtheme 2.3 Interaction between learning and memorisation (PD, PL).

Code 2.3.1 *Memorisation as part of the learning process (PD).*

PD: *'I start trying to memorise once I start studying a piece'.*

Code 2.3.2 *Memorisation as an outcome of learning (PL).*

PL: *'I usually don't put much effort into memorising, it just comes'.*

For the Self-Case Studies, thematic analysis was also implemented in the practice diary to structure and label each stage of the learning process. This permitted categorising data by relevance, highlighting the main strategies used by learning periods. Since written reports detailed dates, pieces and bars in which each strategy was used, analysis was significantly accelerated: videos were linked to their content, without having to watch them for cataloguing purposes. Hence, analysis focused on the relevant videos, while having effortless access to secondary footage when needed.

Thematic analysis was also used for verbal commentaries,[159] which were transcribed following the same criteria as in the interviews, but without software.[160] Concretely, this was implemented to identify related keywords to Conceptual Simplification or the literature.[161] However, since I was the practitioner under observation, there was less risk to misinterpret data:[162] I could switch roles, from researcher to performer, and vice versa.[163] The results were further validated with the video-recordings and annotated scores.[164] From the literature, it was anticipated that annotations made on the scores would either correspond to performance cues;[165] or Conceptual Simplification, involving different forms of analysis and pattern conceptualisation. Additionally, the concerto's scores featured shared performance cues.[166]

Finally, the Questionnaire's closed questions were analysed quantitatively, along with the Logical Reasoning Test (LRT). Concretely, the LRT analysis was simple: AssessmentDay

159 Williamon et al. (2021: 100).

160 There is AI software available for transcribing in Catalan and Spanish, such as Sonix (https://sonix.ai/). However, this time the transcription process was part of the analysis of the video-recordings. Furthermore, since the verbal comments were sporadic, strictly related to the actions involved and mixed with the audio, it was necessary to transcribe them in the order of appearance, rather than all at once.

161 Hsieh and Shannon (2005: 1286).

162 Adair and Pastori (2011: 32-33).

163 e.g., Fonte (2020), Soares (2015).

164 e.g., Chaffin and Imreh (1997a), Chaffin et al. (2009; 2010), Fonte (2020), Ginsborg and Chaffin (2011a), Noice et al. (2008), Soares (2015).

165 e.g., Chaffin and Imreh (1997a), Chaffin et al. (2002; 2010), Chen (2015), Chueke and Chaffin (2016), Fonte (2020), Lisboa et al. (2015), Soares (2015).

166 Ginsborg et al. (2006a; 2006b; 2013), Lisboa et al. (2013a).

provides the sheet of solutions, leading to either a pass or fail. This was a faster procedure than for the Raven Progressive Matrices (RPM), which works on percentiles.[167] Conversely, answers to open-ended questions were coded,[168] using bottom-up and top-down approaches to apply thematic analysis.[169] This permitted summarising key and common features amongst participants, distinguishing further in what ways profiles differed.[170]

4.5.2 Video-Recordings

In music psychology, empirical observation of practice is commonly used for testing theories related to problem-solving, expert memory and motor control.[171] A frequent method for transcribing practice is Study Your Music Practice (SYMP):[172] an Excel-based software used to graphically summarise recorded practice sessions, facilitating the identification and analysis of those strategies used by the practitioner under observation.[173] Concretely, SYMP permits studying the learning and memorisation processes of a musical work, providing statistics and detailed analysis of how practice is structured, while highlighting the most challenging spots in a piece.[174]

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[167] Raven (2003).
[168] Flick (2009).
[169] Braun and Clarke (2012: 58-59).
[170] Braun and Clarke (2006).
[171] e.g., Allen (2013), Chaffin and Imreh (1997a; 2001), Chaffin and Logan (2006), Chaffin et al. (2002; 2003; 2010; 2013), Chueke and Chaffin (2016), Duke and Davis (2006), Fonte (2020), Gerling and Dos Santos (2017), Ginsborg (2002), Hallam (1997), Lisboa et al. (2004; 2011), Mishra (2002; 2011), Rubin-Rabson (1937; 1939; 1940a; 1940b; 1941a; 1941b; 1941c; 1941d), Soares (2015), van Hedger et al. (2015), Williamon and Valentine (2002).
[172] e.g., Chaffin et al. (2009), Fonte (2020), Lisboa et al. (2015), Soares (2015).
[173] Chaffin and Demos (2012), Demos and Chaffin (2009), Logan et al. (2009). See further details at: https://musiclab.uconn.edu/introduction/
[174] With SYMP, data can be more flexibly reviewed: e.g., by measures or beats, musical structure, type of practice, starts/stops, practice segments. This stands out from similar audio and video transcription software, by providing the option of representing data graphically, but also to analyse raw data with statistical software (Logan et al., 2009).

SYMP consists in transcribing the practice session by filling a worksheet with the timings in which the practitioner starts and stops playing. From these inputs, the software provides a visual graphic of the session's starts and stops. It also shows the relationship between these and the piece's musical structure. Since, during practice, the practitioner reports on the score all musical decisions about technique, interpretation and performance, these can be related to the graphical representation, by entering this information into the software. Moreover, SYMP also permits tracking the memorisation process, by detailing whether the musician played looking at the score and identifying changes in tempo.[175]

However, this analysis was not useful for identifying Conceptual Simplification strategies in the Self-Case Studies video-recordings. SYMP would only provide statistical insight into the performance cues developed during practice and the efficiency of the strategies used to learn the commissioned pieces. Hence, beyond its suitability to inform qualitative research, it is a quantitative method for analysing practice. Additionally, SYMP analyses recordings linearly, according to the piece's structure.[176] Notwithstanding, for the Self-Case Studies, it was more important to focus on the global conceptualisation and rationalisation of the piece, progressively refined by practice; and the strategies implemented or developed. Finally, regardless of all these reasons for not using SYMP, this software became obsolete.

Therefore, other methods were considered from similar studies. Tsintzou and Theodorakis (2008) analysed video-recordings by representing them on two-axe tables, one table for each hand, in which the horizontal axis was used to represent the pitches, while the vertical axis corresponded to the serial numbers of the trials that each participant attempted. These trials were represented as segments, showing where the participant started and stopped playing.

[175] Chaffin and Demos (2012), Demos and Chaffin (2009), Logan et al. (2009).
[176] e.g., Chaffin et al. (2009), Fonte (2020), Lisboa et al. (2015), Soares (2015).

Whereas, on the horizontal axis, each note was autonomous. Again, this method was not suitable since its graphical approach diverged from this research's goal. Alternatively, Jónasson and Lisboa (2015; 2016) summarised data with Interpretative Phenomenological Analysis (IPA), after prompting a dynamic exchange between participants and researcher, who played an active role during data collection.[177] However, since I was both researcher and practitioner, it was easier to understand my behaviour and decision-making during practice, and the perspective from where the verbalised thoughts were formulated. Nevertheless, lacking a true outsider perspective was limiting since objectivity could not be guaranteed.

Accordingly, the most appropriate method was the Lesson Activities Map (LAMap), which is used in educational research to observe audio- or video-recordings of 'subject-specific lessons' (Savona et al., 2021: 705). Like SYMP, this method provides a timing visual synthesis of each recording analysed (see Figure 4.4). However, LAMap summarises the content of the recordings into a series of symbols and icons that constitute a map of those actions taken toward a pedagogical objective: in Savona et al. (2021), this was to teach how to sing a song.

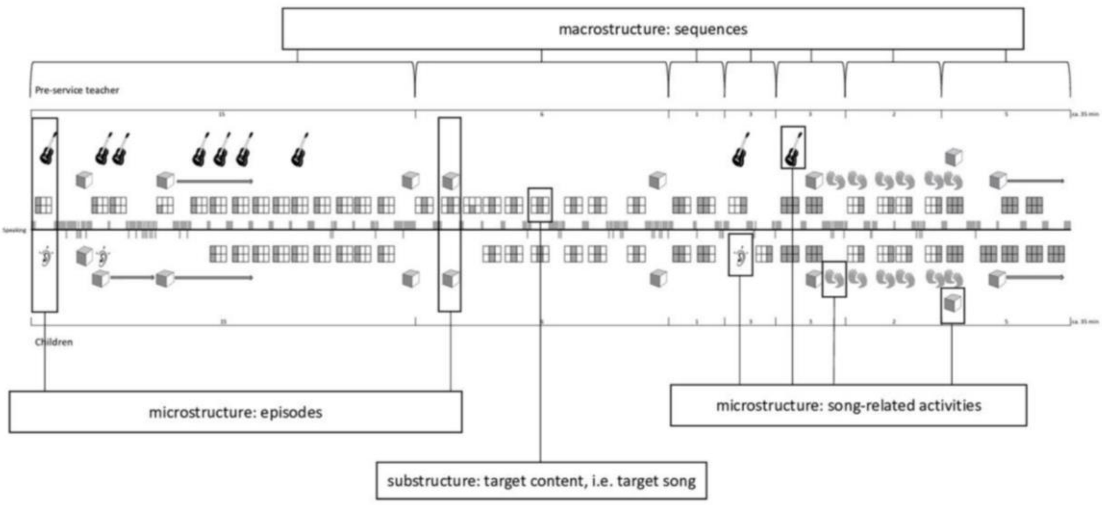

Figure 4.4: Original implementation of LAMap (Savona et al., 2021: 710).

[177] It is worth noting that the practice data collected during the pilot study of Jónasson and Lisboa's (2015; 2016) (i.e., the complete verbal and observation transcripts) was analysed using a thematic analysis, while an IPA analysis was used for the main study (Jónasson and Lisboa, 2015: 8; 2016: 83).

LAMap seemed the most appropriate due to the parallelism between observing and analysing those strategies used for teaching others, and the process of teaching myself with Conceptual Simplification. Another reason was the imprecision associated with transcribing non-verbal information (e.g., behaviours when memorising) into words.[178] While I verbalised all my thoughts during practice, not all meaning could be 'deduced from the transcription of the linguistic components or the analysis of individual frames alone' (Savona et al., 2021: 706). Rather, these verbal transcriptions provided greater understanding of my learning.[179]

Therefore, LAMap's adapted version consisted in viewing the video-recordings and transcribing all verbal comments. Concurrently, the content and structure of practice sessions were sketched by watching multiple times each recording and triangulating this with the written reports, the annotated scores and previously found themes. Hence, a practice session's visual synthesis was the 'result of a transcription methodology developed to facilitate the analysis of heterogeneous data at various levels' (Savona et al., 2021: 708). Videos from the public performances were also reviewed, annotating divergences on clean copies of the scores.

However, in LAMap's original version, the phenomenon observed was the interaction between teachers and students, while in my case, I was both teacher and student. Thus, observing my practice eventually implied reflecting on my metacognitive knowledge.[180] Furthermore, visualisation of practice sessions was primarily based on the pieces' formal structure, instead of the 'musico-linguistic structure' of a song (Savona et al., 2021: 708).[181]

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178 Moritz (2011).
179 Mey and Mruck (2014).
180 Berardi-Coletta et al. (1995), Colombo and Antonietti (2017), Fairbrother et al. (2021), Hallam (2001), Jabusch (2016), Karpicke et al. (2009), Ste-Marie et al. (2013), Veenman et al. (2006), Velzen (2017).
181 In Savona et al. (2021), the graphic representation of a song is based on using 'a single verse' as the 'minimum unit in the graphic representation', which involves a 'single-verse symbol' (Savona et al., 2021: 710). This is because 'a song is a complex type of content that is based on hierarchical musico-linguistic rules, such as how

Consequently, some notation adjustments were made to sketch the content of my practice sessions (see Figure 4.5). Nonetheless, the process of condensing and graphically reducing 'the complexity of the audio-visual data' preserved the temporal organisation of such events, and the frequency and variety of the strategies used, which were represented in the form of a timed map (Savona et al., 2021: 710).

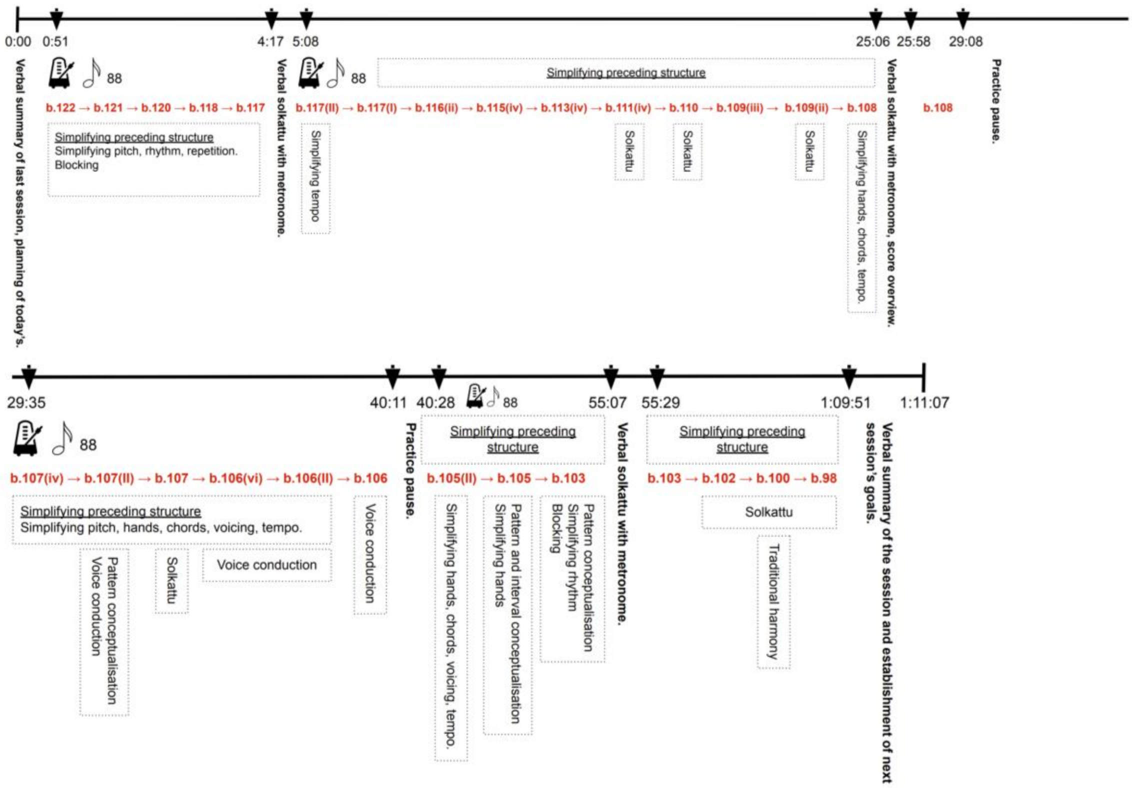


Figure 4.5: Example of LAMap analysis for the practice session of Gasull's Piano Concerto second movement on 5 January 2021.

syllables are combined with a tune' (Savona et al., 2021: 710). However, the commissioned pieces that I used were exclusively instrumental, therefore, the minimum unit used for this case was a bar.

4.5.3 Audio-Recordings

For the Memorisation Test, each participant provided at least 9 recordings for the Pilot Study and 12 recordings for the Main Study. For music recording analysis, an established empirical method is SYMP,[182] which was not suitable since participants only provided a recording of their final performance, and this software is now obsolete. Nevertheless, PB-X submitted several recordings for Excerpt 3, including verbalisations on mistakes and actions to correct them, making it possible to identify the main challenges and precise locations of lacunae.[183] Additionally, SYMP analyses recordings linearly, according to the piece's structure,[184] whereas this study focused on what aspects participants memorised more effectively and less. Also, how convincing and fluent their performances were. Consequently, other quantitative performing analysis methods (e.g., Watkins-Farnum performance scale) were dismissed.[185] Finally, further alternatives from similar studies were considered: Tsintzou and Theodorakis' (2008) analysis method for video-recordings, and Jónasson and Lisboa's (2015; 2016) phenomenological approach. However, as with SYMP, their methods were not applicable for the same reasons.

Consequently, a new method was developed to identify divergences between the excerpts and the participants' performances. The word "mistake" was avoided since this could either be a memory lapse or an execution error.[186] The method provided the following double assessment:

[182] e.g., Chaffin and Demos (2012), Chaffin et al. (2009), Fonte (2020), Soares (2015). See further details at: https://musiclab.uconn.edu/introduction/

[183] Anokhina (2015), Ginsborg and Chaffin (2011a: 339). The concept of "lacunae" is properly explained in Chapter 2, section 2.4.3.

[184] Chaffin and Demos (2012).

[185] Watkins and Farnum (1962).

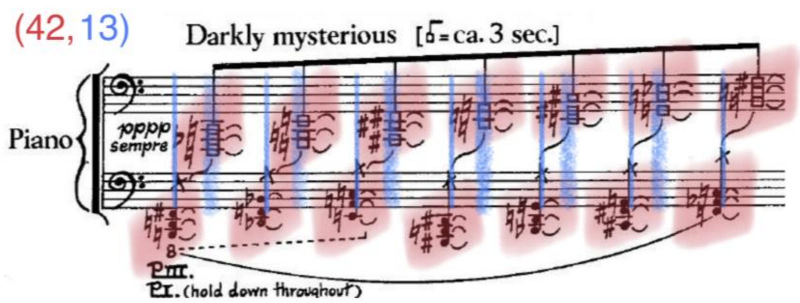
[186] Cook (2009).

1) Qualitative analysis: The first part required listening to the recording to acquire a general impression of the performance and its musicality. The benchmark used was Royal Birmingham Conservatoire's (RBC) performance marking criteria for Principal Study (Years 1 and 2), and RBC's recital marking criteria for BMus3 and BMus4. This provided a well-established measure of assessment. However, participants had limited time for memorising the excerpts and were not assessed on a live performance. Furthermore, audio-recordings' sound quality was generally poor, sometimes involving out-of-tune pianos. Accordingly, the marking criteria was not used strictly, but prompted a suitable selection of parameters: technical control, stylistic awareness, fluency and convincement. Recordings were listened twice: first, without the score; and then, with the score. This permitted capturing the performance's expressive component, and identify possible hesitations, to establish the participant's overall confidence.[187]

2) Quantitative analysis: The second part consisted of scoring a bidimensional measure (pitches, durations). Dynamics were ignored at not playing a significant role and being assessed in the qualitative analysis. For each excerpt, two scales were established: from 0 to p for pitches; and from 0 to d, for durations. Accordingly, p was the total number of pitches, and d the duration of these pitches. These scales were used to punctuate each recording. Therefore, given that the maximum score for each excerpt could be (p, d), each recording was scored with (x, y), where $x \leq p$ and $y \leq d$. Following this method, the maximum score for each excerpt was:[188]

[187] During this second listening, a copy of the score was annotated in blue.
[188] This time, the same copy of the score used before was annotated in red.

i. Excerpt 1: For the Pilot Study, this excerpt was analysed as 42 pitches and 7 durations, only considering the rhythmical figure between both hands. This was summarised as (42, 7). However, further data analysis made clear that the rhythmical precision between both hands and between each block of chords needed to be scored separately, since hesitations or rhythmical imprecisions could happen in both. This is 7 rhythms between both hands' chords, one for each block; and 6 rhythms between each block of chords, leaving a total of 13 rhythms and a maximum score of (42, 13). Consequently, the scores from the Pilot Study were adjusted by adding six additional points to the rhythmical parameter.

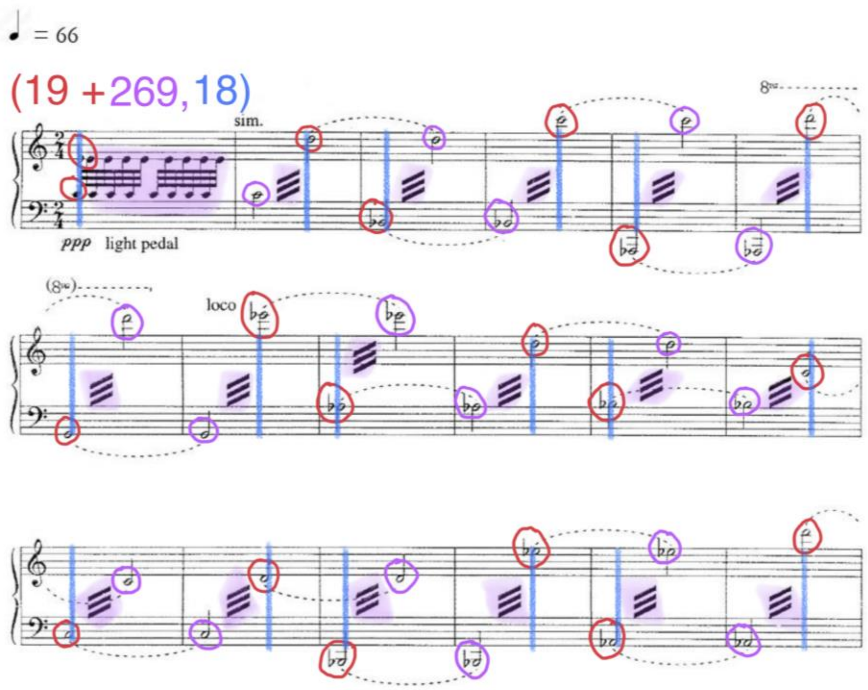


Example 4.5: George Crumb, *Makrokosmos I* (1972), 'Primeval Sounds', initial 49 seconds, to exemplify how Excerpt 1 was scored.

ii. Excerpt 2: For the Pilot Study, this excerpt was analysed as 19 pitches, by counting only when hands change pitches, but ignoring how many times each pitch is repeated (i.e., starting from the beginning, counting every time a new pitch appears); and 17 durations (starting to count from the right-hand's D in bar 2). Excerpt 2 presents rhythmical uniformity, which emphasises when a hand changes pitch. Therefore, this can be summarised as (19, 17). However, further data analysis revealed an incongruency. The maximum score of 19 pitches did not include repeated pitches. Nonetheless, whenever a pitch that had to be repeated was omitted, this would be subtracted from the main 19 pitches.

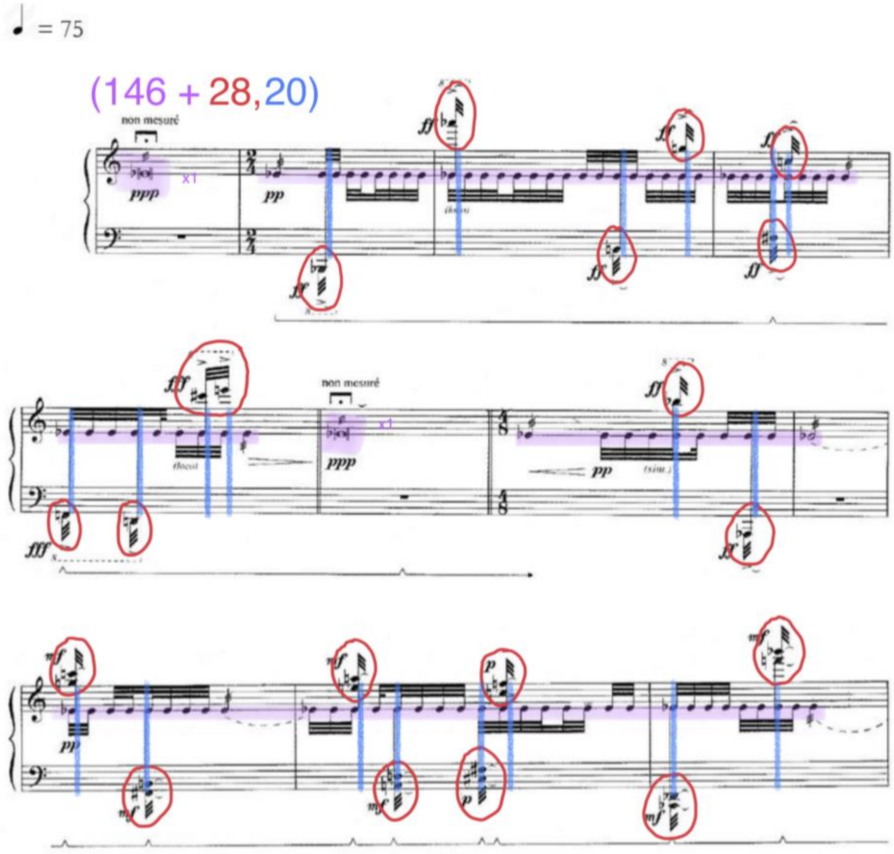
Initially, this intended to reflect each performance's precision and fluency but, at the same time, it was masking the real result: omitting a main pitch indicated a memory issue, while omitting a repeated pitch indicated a technical issue. Although this study did not test technical proficiency, results had to reflect participants' evolution for each recall. This was solved by counting how many repeated pitches the participant omitted and assessing whether all the main 19 pitches were correct. Then, the scoring was modified using a separate measure for the repeated pitches. Therefore, this excerpt consists of 18 bars with 16 pitches each, making a total of 288 pitches. These are arranged as 19 + 269: 19 main pitches and their respective 269 repetitions.

Additionally, how rhythmical figures were being counted (i.e., starting from the right-hand's D in bar 2) also did not reflect whether rhythmical inaccuracies happened in the first bar. Thus, an additional rhythmical figure was added, making a total of 18. This way, the new maximum score for Excerpt 2 was (19 + 269, 18). Scores from the Pilot Study were adjusted accordingly.



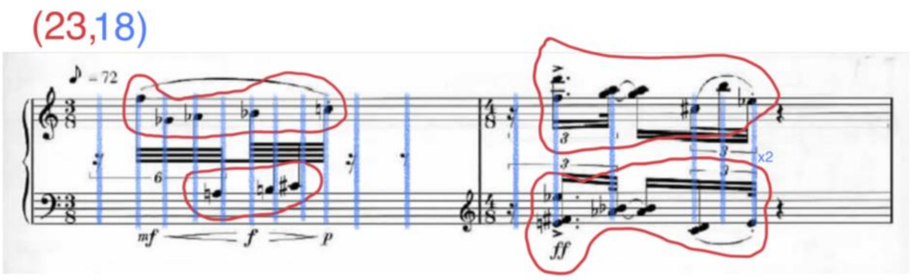
Example 4.6: David Lang, *Memory Pieces* (1992), 'Cage', bars 1-18, to exemplify how Excerpt 2 was scored.

iii. <u>Excerpt 3:</u> This excerpt consists of 146 E-flats and 28 main pitches. For non-measured bars, the whole bar was counted as 1, since each participant performed a different number of E-flats. In terms of rhythm, this excerpt presents an E♭-ostinato, with a uniform rhythmical pattern and some non-measured bars in between. Therefore, rhythmical figures were only counted for those interventions beyond the ostinato, which add up to 20. This was summarised as (146 + 28, 20). Omitted E-flats were counted, also when a participant forgot a bit of the excerpt. However, for rhythmical inaccuracies, omitted or additional E-flats were not counted: given the maximum scoring, counting them would only benefit those participants with a tendency to delay rhythmical figures, in detriment to those that tend to anticipate them. Therefore, the ostinato measure was a benchmark for the participants' motoric control of the repeated note.



Example 4.7: Philippe Manoury, *Toccata pour piano* (1998), bars 1-8 and 38-40, to exemplify how Excerpt 3 was scored.

iv. <u>Excerpt 4:</u> This has 23 pitches and 18 durations, and was summarised as (23, 18).



Example 4.8: Roger Redgate, *Trace* (1996), bars 1-2, to exemplify how Excerpt 4 was scored.

Therefore, audio-recordings were assessed on clean copies of the excerpts, as described above. This dual method permitted evaluating the participants' performances both qualitatively and quantitatively, tracing lacunae across recordings and providing snapshots of their retention. All voice-notes and verbalised comments were transcribed, these being a testimony of the participants' thoughts in a precise moment.[189] Finally, written recalls were analysed and scored following the same quantitative approach for the audio-recordings. Also, it was noted when participants correctly recalled the excerpt but notated it differently, which indicated understanding and conceptual memory engagement.[190]

4.6 Ethical Considerations

All participants were adults, volunteers and were recruited following RBC's and Birmingham City University's (BCU) guidelines. Participants were fully informed of the nature of the project and signed consent forms. All studies were given ethical approval by the relevant panel at BCU and were developed following British Education Research Association's (BERA) ethical guidelines for educational research.[191] The studies were also adjusted to ensure these were carried out safely under the Covid-19 restrictions: both the Interviews and the Study with Participants were moved online following BCU's guidelines.

Participants could withdraw or have data excluded from the research up to the point of analysis, or up to six months after data collection, to guarantee the completion of this thesis. Depending on the study, permission was sought to audio- or video-record the interviews and performances. Furthermore, they were given the option of sharing information "off the record", although none requested me to stop recording.[192] Interviewees agreed to not be anonymised, whereas all data from recruited participants was anonymised, including

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189 Mey and Mruck (2014).

190 Azaryahu and Adi-Japha (2020), García (2013), Gardner ([1983] 2011: 135-178), Mishra (2004: 233; 2005: 82; 2007), Quian Quiroga (2012a; 2012b), Sáenz de Cabezón ([2016] 2020).

191 British Educational Research Association [BERA]. (2018) *Ethical Guidelines for Educational Research* (4th Edition). London: BERA. Available at: www.bera.ac.uk/researchers-resources/publications/ethical-guidelines-for-educational-research-2018 [Accessed 04 December 2019].

192 The set of questions for these interviews is available at Appendix F.

authorised quotes included in this thesis, and further publication or dissemination of the study. Interviewees and recruited participants also agreed for me to transcribe the interviews with Otter. All data collected was confidential and stored securely, not subject to open access. Data was only accessed by me and my supervisors, and only the analysis and findings were shared publicly.

When necessary, participants were provided with copies of copyrighted excerpts, which were only used during the Memorisation Test. Additionally, I made annotations on copies of copyrighted works. Some of these annotated scores are included in the thesis, along with other excerpts to illustrate and address some points.

According to the guidelines of exceptions of copyright applied to research from the UK's Intellectual Property Office, researchers and students are allowed to copy limited extracts of copyrighted works (e.g., musical scores) for the purpose of their studies and non-commercial research. The amount copied should be limited to the strictly necessary, avoiding full copies. However, when the latter is needed, a licence from the copyright owner is required.[193] In all cases, a sufficient acknowledgement of the copy should be provided, identifying the author, title, or another description of the work copied.[194] However, such acknowledgement is not required when impossible for practical reasons.[195] If the work to be copied contains a performance, the exceptions to copyright also apply to the performer's related rights. The

[193] Further information on obtaining a licence available at Intellectual Property Office (2019) *How copyright protects your work: License and sell your copyright*. Available at: www.ipo.gov.uk/types/copy/c-other/c-licence.htm [Accessed 26 November 2019].
[194] Intellectual Property Office (2019) *Exceptions to copyright: Research, October* 2014, p.1-5 [pdf] Newport: Intellectual Property Office. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/375954/Research.pdf [Accessed 26 November 2019].
[195] Gov.uk ([2014] 2019) *Exceptions to copyright*. Available at: www.gov.uk/guidance/exceptions-to-copyright [Accessed 26 November 2019].

researcher is not required to delete the copies, but these may not be shared, sold or made available to others.[196]

The UK Government's guidelines for copyright exceptions state that copyrighted works can be used for educational purposes if these are sufficiently acknowledged and involve minor uses. Performing, playing or showing copyrighted works in an educational institution is also allowed, provided that the audience is limited to teachers, students and other individuals directly connected with the activities of the institution. It is also allowed to make copies using a photocopier or similar device of the institution for non-commercial instruction if there is no licensing scheme in place.[197]

Since the Logical Reasoning Test is copyrighted, written permission was granted from AssessmentDay through BCU's Library to use and reproduce it in this thesis, since this was a free sample with open access.

[196] Intellectual Property Office (2019) *Exceptions to copyright: Research, October* 2014, p.1-5 [pdf] Newport: Intellectual Property Office. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/375954/Research.pdf [Accessed 26 November 2019].
[197] Gov.uk ([2014] 2019) *Exceptions to copyright*. Available at: www.gov.uk/guidance/exceptions-to-copyright [Accessed 26 November 2019].

4.7 Limitations

The limitations fall within research design, sampling and materials, and are orderly discussed.

First, completing the Interviews and the Study with Participants fully online due to Covid-19 changed the research design, not allowing me to be in the same space as interviewees and participants. Nevertheless, this implied the advantage of completing the studies in more natural settings, while facilitating the parallel schedule of tests and interviews. Moreover, digital data collection made it easier to catalogue and process. However, some limitations must be noted. First, a limited virtual contact with all recruited pianists. Not meeting them in person impeded further interaction, such as them playing some examples for me: they had access to their pianos, but it was not feasible to illustrate certain points on the instrument. Furthermore, running online the Study with Participants discarded an authentic experimental study with controlled conditions, having to delegate all data collection to participants, while relying on their good practice in submitting honest data. Therefore, I could not verify whether participants were strictly following the instructions provided,[198] and the same criteria: while some participants only submitted their final recordings, others uploaded several versions and incomplete attempts, including verbalised comments. These were useful for getting further insight into the results but challenged any linear comparison across participants, creating the dilemma of which version should be evaluated. It also questions some outcomes of the study, including which participants did better at each test. This issue was addressed by analysing all versions submitted, but only using the first one for comparison. This decision could have altered some participants' performance at the test, potentially biasing the overall results and analysis. However, this was partly mitigated by including all scorings and clarifying incomplete data. One conventional method for

[198] Williamon et al. (2021: 45).

processing datasets with missing data would be deleting all evidence collected from the affected participants,[199] but this was not an option given the small size of the sample. Also, the participants' qualitative input was important, including the reasons behind these omissions. This problem was addressed in the Main Study by only allowing one recording and one voice-note per excerpt. However, participants kept recording their performances many times, and submitting their best one, causing another important limitation: each participant needed a different number of takes for succeeding at the same task. Thus, making their results not comparable. Nevertheless, it could be argued that this also permitted observing how far participants could improve their performances in a limited timeframe.

Therefore, giving control to participants over data collection benefitted their experience, but was an obstacle for analysis. Their reported timings were not always representative of the actual time needed to memorise, since participants had different criteria towards their performance: some were unreservedly perfectionists, while others just focused on pitch accuracy, to the detriment of rhythm, dynamics, tempo or pedalling. Moreover, timings and scores ceased to be representative whenever participants looked or used the scores, and recognised or had previous knowledge of the excerpts. This provided an advantage over those participants who followed the rules or did not know the music being tested.[200]

Furthermore, my assessment of the audio-recordings should not be taken as an absolute, since these could fail in being representative of what the participants played,[201] due to the following:

[199] Given the case that this was randomly distributed within the whole data set (Williamon et al., 2021: 264-265).
[200] Also, each time participants discussed the excerpts with me, they inevitably remembered them. Hence, strengthening their memory further in a form of mental practice.
[201] e.g., Repp (1996).

1) Sometimes sound quality was poor, becoming even more problematic with out-of-tune pianos and electronic keyboards.

2) I have relative pitch and no software was available for processing into a score such recordings, considering that most of them lacked enough quality or were made with poor instruments. Therefore, even when using a tuned piano as a reference, the distortion of sound was misleading, especially for Excerpt 1.

All these issues required using the interviews, the only set of data that was collected in my presence; and the questionnaires, the only test in which was less likely that participants altered their submissions, as the main body of reliable data. Accordingly, audio-recordings were complementary and illustrative. Nevertheless, conference calls did not always ensure good sound quality, sometimes experiencing interferences that challenged understanding the participants' responses. Also, not all unintelligible statements could be re-interpreted, even with the participants' assistance. Finally, written content in the tests (e.g., questionnaires, written interviews, instructions) implied the risk of being misinterpreted.

These limitations could have been prevented by being in the same room with participants during data collection. Nonetheless, my presence might influence their response and performance during the Memorisation Test. Thus, following a less intrusive procedure,[202] which involved giving more control to participants; allowing them to work in familiar environments; providing flexible timings; and not being present until necessary, could have diminished the *Hawthorne effect*:[203] participants conditioning their actions at being aware that

[202] Cohen et al. (2018: 289).
[203] Cohen et al. (2018: 265-267), Williamon et al. (2021: 207).

they are observed, which was noticed in similar studies.[204] Hence, it was expected that the more comfortable participants were, the better would be their performance during the study, prompting ecological validity of the results.[205] Furthermore, participants memorised and retrieved the excerpts in the same environment and instrument, benefitting from the encoding specificity principle and the context-dependent memory effect.[206] Similarly, during the Self-Case Studies, a minimal Hawthorne effect was pursued by positioning the camera behind me, to avoid visual cues that reminded me of its presence. Moreover, the protocol followed for data collection minimised the risk of false rationalisations of my actions.[207] Nonetheless, sometimes I could have failed on verbalising my thoughts, for being absolutely immersed on my practice.

Also, during the Self-Case Studies, the camera occasionally ran out of memory and broke during Ben-Amots' case study. Hence, not all sessions could be properly recorded. Despite exploring some recording alternatives (e.g., phone, computer), these were not feasible due to lack of storage or quality, either disrupting my practice or being not suitable for data analysis. Nonetheless, this issue did not significantly affect data collection since it happened after having memorised and publicly performed Ben-Amots' piece twice. Also, practice was self-reported in a written format throughout. Finally, not all rehearsals could be properly documented. Any physical or mental rehearsal that happened during a practice session was video-recorded, unless in the circumstances previously described. However, given mental practice's spontaneous nature, it was impossible to document all daily situations in which I mentally rehearsed the pieces. While I kept written track of these, in certain situations, this

[204] For example, the implications of this effect can be observed in participants *Emma* and *Harry* of Fonte's (2020) multiple-case study. For the former, see Fonte (2020: 213; 482, lines 4363-4365; 268). For the latter, see Fonte (2020: 268; 299-300; 502, lines 5199-5202).
[205] Cohen et al. (2018: 264; 381-382; 543), Williamon et al. (2021: 199).
[206] Baddeley et al. (2020: 245; 254-258), Mishra and Backlin (2007).
[207] Ericsson and Simon (1993), Lisboa et al. (2011), Williamon et al. (2021: 148).

was simply not possible. Therefore, the unpredictability of this task made it sometimes unfeasible to capture all my thoughts on the pieces.

Secondly, further limitations relate to sampling. Covid-19 restrictions challenged participant recruitment, with two major implications. On the one hand, resulting in a small and homogenous sample of interviewees, which conditioned getting further data on certain topics and memorisation strategies for different parameters (e.g., pitch, rhythm, dynamics).[208] On the other hand, not all recruited participants had a common educational background. Furthermore, the Self-Case Studies were based on a single practitioner and a limited repertoire, because the scope of a doctoral thesis makes it impractical to include a large collection of works, given the amount of data to be analysed. Additionally, the implicit subjectivity of self-reporting can trigger wrong conclusions along with potential partiality when evaluating the object of study. Self-reports can elucidate the content and nature of a performer's thought processes, but it might not fully capture the complexity of how certain cognitive systems operate. Consequently, the objectivity of a third-person perspective was previously used in similar research to provide insight into the practice habits of a performer.[209] However, this thesis simply aims at examining my memorisation strategies and refining Conceptual Simplification, to enhance its potential transferability.

Furthermore, it is impossible to assess whether my learning and memorising approaches were the "best" ones since I cannot learn the same piece twice. Hence, I cannot compare two different procedures. The obtained results simply provided first-hand insight, illustrating my own implementation of Conceptual Simplification in two contexts. Moreover, any research

[208] In Chapter 6, the main implication of this limitation is that specific memorisation strategies for pitch, rhythm and dynamics can only be reported for Ermis Theodorakis.

[209] e.g., Chaffin and Imreh (1994; 1997a; 1997b), Chaffin et al. (2002; 2003; 2010; 2013), Ginsborg and Chaffin (2011a; 2011b), Ginsborg et al. (2006a; 2006b), Lisboa et al. (2015).

based on a single practitioner, while allowing for deep insightful observation, leads to the possibility 'that the individual might be highly atypical', therefore, 'ultimately misleading' (Baddeley et al., 2020: 75). Accordingly, two parameters conditioned the results: general musicianship and repertoire. The findings of the Self-Case Studies and the resulting version of Conceptual Simplification are intrinsically related to my background and abilities regarding sight-reading, perfect pitch, synaesthesia or mental practice. Therefore, the strategies used satisfy my own learning and memorisation style, potentially differing from other pianists, who might identify alternative patterns and approach the pieces differently.

Thirdly, some limitations resulted from the methods used. Interviewing other pianists pretended to understand how they think and feel about memorisation, but also how they approach it in their performance practice. However, their descriptions and their actual actions might not coincide due to a lack of accuracy when recalling certain events in the past; or at providing a divergent rationale from the action being described (post hoc rationalisation).[210] Consequently, using interviews 'to understand actions' was triangulated with observation.[211] Particularly, with the Self-Case Studies and the Study with Participants, this limitation was mitigated by verbalising my actions in the moment or immediately after finishing, and by interviewing the participants after each test. Also, using a semi-structured interview provided flexibility in exploring topics not initially considered in the original script, but making it more difficult to compare data: additional themes could not be covered in all interviews.[212] Therefore, findings presented in this thesis focus on triangulated results.

Another potential limitation results from not anonymising interviewees, conditioning them to choose what kind of information to reveal and emphasise, devising their own "official

[210] Lisboa et al. (2011), Williamon et al. (2021: 148).
[211] Williamon et al. (2021: 149).
[212] Obviously, for Melikyan, this was out of the question since the format of his written interview was closed.

version" of their experiences.[213] However, this should be regarded as part of their individual experience with this topic,[214] which is what this research aimed for. Additionally, my role as an interviewer might have influenced my interlocutors, regardless of whether they were anonymised or not. First, by unconsciously encouraging certain answers with my questions, or how I was formulating these, thus introducing partiality in the data. Secondly, the interviewees' perception and assumptions, including how comfortable they felt during the conversation, might have also influenced their responses.

Finally, interviewing participants during the Memorisation Test made them reflect on the excerpts and how they memorised them, conditioning their memory and off-line learning.[215] Furthermore, the study benefitted from the participants' diverse backgrounds, although generalisation of results requires a larger sample.[216] Also, observations and perceptions, especially in the circumstances of the Study with Participants, do not provide a pure version of reality, particularly when dealing with human beings. Therefore, none of the methods used were wholly objective: there is always a selective approach, 'attending to some aspects of whatever we are looking at more than others' (Lyons and Coyle, 2011: 13). Consequently, 'all research products are the result of a dynamic and inescapable interaction between the accounts offered by participants and the interpretative frameworks of the researcher' (Lyons and Coyle, 2011: 20). This limitation is equally valid for the Interviews and the Self-Case Studies.

Additionally, further methodological limitations could be identified. First, the brevity of the Study with Participants generated two important limitations. On the one hand, the study

213 Jenkins (2002).
214 Williamon et al. (2021: 149).
215 Darsaud et al. (2011), Fischer and Born (2009), Lewis et al. (2011), Robertson (2009), Robertson et al. (2004a; 2004b), Stickgold and Walker (2013), van Hedger et al. (2015), Walker (2005).
216 Williamon et al. (2021: 43-47).

aimed to test in a short timeframe a method for securing LTM, when participants were mostly relying on STM.[217] Consequently, some of them opted for using less effective but more familiar strategies to meet the test's requirements. However, this was also a positive outcome, providing evidence of which strategies could be less reliable without practice or in a relatively longer term. On the other hand, unlike similar studies,[218] participants had limited time to memorising the excerpts. Concretely, Group Y followed a novel method without previous training. Also, both the pressing deadline and novelty of the musical genre might have contributed into making the test harder. Therefore, it was expected that not all participants would perform at their best or stick to the instructions. Accordingly, RBC's marking criteria was only used as a prompt for reflection. Also, the participants' ability to focus and personal circumstances also influenced the results: PD-Y and PE-Y were in holiday mood; PL-Y just completed a stressful period; and PB-X and PG-Y expressed their preference for memorising in distributed shorter sessions. Additionally, Group X was not externally conditioned on how to memorise the excerpts, therefore their timings were not constrained to a series of steps. However, at not receiving guidelines on how to memorise, Group X might have felt more clueless than Group Y.

Finally, Raven Progressive Matrices (RPM) were substituted for the Logical Reasoning Test (LRT), which was the closest alternative. Unlike the RPM,[219] a demonstration of how to proceed with the LRT was not provided. Despite participants not raising any issues, the LRT is a timed test which can cause stress. Also, no musical studies were found to use LRT, thus lacking references for analysing the implications of the results.

[217] Bangert and Altenmüller (2003), Chai et al. (2018), Cowan (2008a; 2008b), Kelley et al. (2018).
[218] e.g., Fonte (2020: 197-286), Jónasson and Lisboa (2015; 2016), Tsintzou and Theodorakis (2008).
[219] Raven (2003: 234).

This thesis' research questions emerge from a gap in the literature. Hence, all these studies ensured contextual validity.[220] The use of interviews was validated by 'cross-referencing data collected from different participants' and using 'different methods', prompting concurrent validity.[221] Finally, since I was the only practitioner being observed in a longer term, findings were harder to generalise. However, the outcomes and new strategies developed could be further tested. Concretely, some Conceptual Simplification strategies, also used during the Self-Case Studies, were tested in the Study with Participants, triangulating the results.[222] Likewise, a representative sample of the post-tonal piano repertoire was selected, comprising the main challenges towards memorisation.

This chapter discussed the methodological decisions of this thesis. The following chapters present the findings of the studies, starting with the Self-Case Studies.

[220] Williamon et al. (2021: 43).
[221] Cohen et al. (2018: 245-284).
[222] Williamon et al. (2021: 49-50).

Chapter 5: Findings from the Self-Case Studies

5.1 Introduction

This chapter presents the results from the Self-Case Studies, which identified the strategies I used for memorising two commissioned piano works. The aim was to compare both learning and memorisation processes, including whether the strategies implemented were the same across the pieces or differed. Additionally, the chapter identifies what parameters conditioned learning and memorisation. Since data analysis focused on evaluating memorisation strategies, other performing aspects (e.g., expressiveness, articulation, rubato, pedalling) are not discussed for being beyond the scope of this thesis. The main findings were:

1) Conceptual Simplification was significantly restructured after completing these studies.[1] The strategies were refined and reorganised as presented in Chapter 3, and different hierarchical levels were established.

2) The strategies used were generally the same across the pieces, despite the commissioned works being substantially different. Hence, this illustrates how generalisable and flexible Conceptual Simplification can be across different repertoire. Concretely, these studies explored the method's possibilities for unknown pieces, for which I did not have any previous references.

3) Conceptual Simplification's successful implementation was not conditioned by my expertise on a specific composer or composition principle. This means that the

[1] An additional self-case study was completed during this PhD with a 30-minute commissioned Piano Concerto from composer Angela Elizabeth Slater. However, this was postponed multiple times due to Covid-19, and data analysis could not be completed in time for this thesis. Despite this, the corresponding performing practice, self-reflection and data collection substantially informed Conceptual Simplification's final version presented in Chapter 3. The data from this self-case study shall be used in future research.

method allowed me to identify non-standard patterns, despite these not matching my previous knowledge, and to use them to chunk and encode the music effectively.

4) A different learning periods model emerged from data analysis, which varies from those proposed by the literature.

Thus, to discuss these findings, the main challenges faced in terms of repertoire are reviewed, followed by the learning periods model identified and what parameters conditioned the resulting differences and similarities. Then, those Conceptual Simplification strategies used in the commissioned works are presented, following the method's structure (see Chapter 3), and illustrating a further generalisation of Conceptual Simplification's possibilities. Finally, a summary of the findings is provided, followed by a concluding section on how Conceptual Simplification evolved with this doctoral research.

5.2 Repertoire's Main Challenges

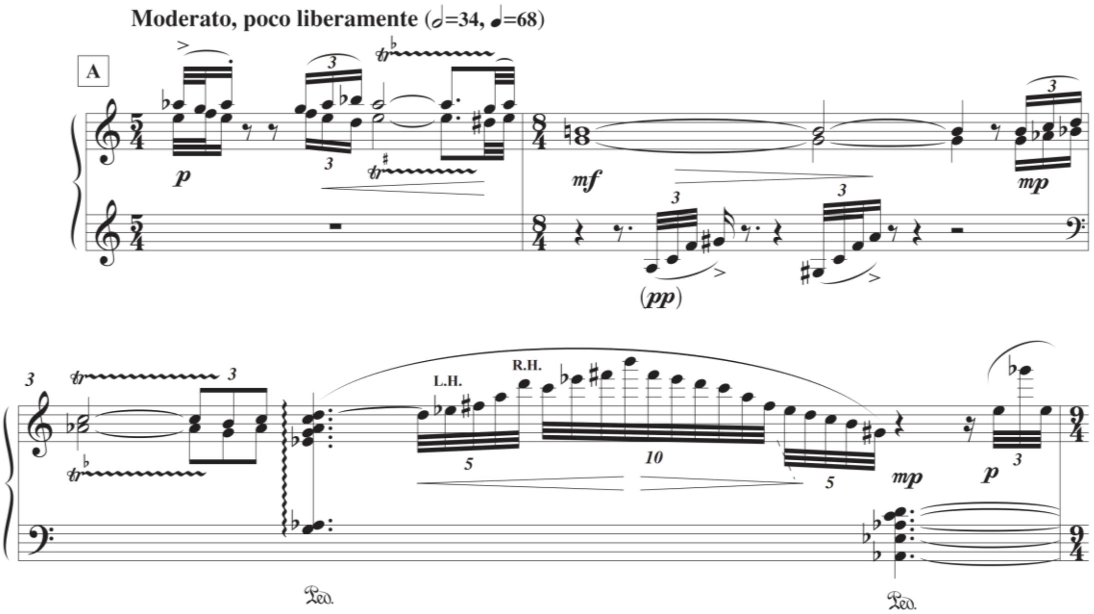
The commissioned works presented significant differences.[2] Gasull's 28-minute Piano Concerto consists of four movements and 617 bars: I. Impromptu (b.1-157), II. Passeig (b.1-168), III. Racons (b.1-81) and IV. Postludi (b.1-211). These involve different extended techniques, including hand percussion on the strings and wood, pizzicato and glissando with a plectrum, muting strings, producing harmonics and whistling. Furthermore, orchestral rehearsals required additional preparation in terms of aural cues and conductor's references. Hence, both the orchestra and conductor were treated as an additional layer of complexity. Contrastingly, Ben-Amots' 10-minute solo piece consists of a single movement of 137 bars.

[2] The annotated scores of both pieces are available in Appendix K.

It does not involve extended techniques but presents multiple changes of tempo, character and technical challenges. Table 5.1 summarises all these elements and examples 5.1-5.2 provide samples of both works:[3]

Table 5.1: Main differences faced when learning and memorising the commissioned works for the Self-Case Studies.

	Piano Concerto Case Study (Gasull)	**Solo Piano Piece Case Study (Ben-Amots)**
Musical form	A four-movement work	A single-movement work
Instrumentation	Piano with String Orchestra	Solo piano
Technique	Traditional playing combined with extended techniques	Traditional playing with clusters
Tempo references	Conductor	Self
Soloist's musical speech	Several entrances connected by orchestral interludes	Continuous
Working schedules	Individual practice sessions and orchestral rehearsals	Individual practice sessions
Notation and score	Handwritten general score	Software-notated individual part



Example 5.1: Ofer Ben-Amots, *The Butterfly Effect* (2021), bars 1-3, as a sample of the challenges faced during the Solo Piano Piece Case Study.

[3] Full annotated scores for both commissioned works can be found in Appendix K.

Example 5.2: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 94-99, 'Passeig', bars 50-54, 'Racons', bars 1-3, 'Postludi', bars 151-154, as samples of the challenges faced during the Piano Concerto Case Study.

Another important challenge had to do with expertise, both mine and that of the composers. First, when conceiving the piece, Ben-Amots had written several piano works, whereas the concerto was Gasull's first major piano work. Furthermore, Gasull's main instrument is the guitar, whereas Ben-Amots had piano playing experience. These factors conditioned my learning and memorisation for two main reasons. Gasull's concerto was less idiomatic for the instrument than Ben-Amots' piece, hindering the effectiveness of sight-playing: I had to find comfortable fingering and hand arrangements before I could proceed with the preview. Therefore, sight-reading was more effective, instead, to gain an overview of Gasull's concerto. Furthermore, Ben-Amots provided a more definitive score, with only a few typos to amend, whereas the collaborative work with Gasull required reviewing and amending certain aspects of the piano part, to ensure its playability or the desired effect. Hence, different versions of the score were provided, first handwritten, and then, software notated.

Concretely, the concerto's learning periods were conditioned by score delivery: some periods had to be extended due to the score's lack of clarity, whereas others had to be shortened since the composer delivered the score later than expected. A software-notated version of the piano part was not provided almost until the end of the learning process. Consequently, I started working with the handwritten general score from which I collated my own parts, to eventually move to software-notated individual scores. Switching the score's visual appearance and having to figure out the music from the handwritten manuscript imposed an obstacle to learning and my visual memory of the score's layout. Thus, three distinct stages of score-based practice sessions can be established: learning with the general handwritten score, which included the piano part along with the orchestral;[4] learning with a handwritten piano part; and learning with a software-notated piano part. Therefore, all annotations had to be copied into different versions of the score. Contrastingly, learning Ben-Amots' piece started with a digital copy of the software-notated score until receiving the published printed score. However, both the notation's appearance and the score's layout remained the same. The implications of these elements are further discussed along with the learning periods later in this chapter.

The second challenge faced regarding expertise was my familiarity with each composer's language. Before these studies, I had CD-recorded and performed multiple times Ben-Amots' solo piece *Akëda* (2000) and received feedback from the composer on my performance.[5] Therefore, I was somewhat familiar with his composition principles and language. Conversely, I had no previous performing experience with Gasull's music. Thus, to an extent, it was easier for me to understand Ben-Amots' style for the commissioned work

[4] This was only for the second movement, which was the first movement delivered, and the composer required some feedback from me.
[5] Masterclass on *Akëda* (2000) with composer Ofer Ben-Amots took place on 24 October 2019 in Colorado College (Colorado Springs).

than Gasull's. However, Ben-Amots' composition principles significantly varied for this commission, as he explored chaos theory, the butterfly effect and the Fibonacci sequence as creative techniques, which determined the piece's pitch organisation, rhythmical patterns, tempo variations and formal structure. This was motivated by this thesis' research aim of testing whether my expertise and training in mathematics would condition my learning and subsequent memorisation. Unexpectedly, they did not, since no strategies emerged during data analysis that explicitly linked to these concepts or used these to enhance my memorisation. Nevertheless, awareness of how Ben-Amots conceived the piece through these mathematical tools informed my performance practice, allowing me to implement Conceptual Simplification to devise coherent theoretical principles, although these did not necessarily match those of the composer. This is further discussed later. But, more importantly, this outcome suggested that the successful implementation of Conceptual Simplification did not depend on my previous experience with a certain musical language or theoretical principles. Consequently, the method was not less effective when approaching a composition without previous useful references, as in Ben-Amots' piece; or an unknown language, as with Gasull's concerto. This might indicate that Conceptual Simplification could eliminate the barrier imposed by lacking expertise in a certain domain for effectively learning and memorising post-tonal music, as discussed in Chapter 2.

Finally, beyond the presence of extended techniques or the instrumentation of the pieces, the speed at which I became acquainted with both works was noticeably influenced by how frequently thematic ideas reappeared. For example, Ben-Amots' piece consists of 13 contrasting sections in terms of tempo, character and thematic material, only presenting a recapitulation of the first theme at the end. Then, within each section, self-referencing switches are encountered. Oppositely, each movement in the concerto has a small number of themes, which reappear multiple times slightly varied. Hence, switches emerge from recurring themes, requiring considerable practice for achieving a confident and fluent performance while removing any hesitations. However, Ben-Amots' piece was harder to integrate, since the contrasting sections challenged keeping track of these switches and developing a coherent storyline that I could use to monitor my performance. Moreover, the concerto's orchestral interludes permitted me anticipating upcoming sections, whereas Ben-Amots' piece barely allowed such thinking, given the sections' brevity or the required attention for anticipating switches, tempo variations, character changes and technical challenges. Consequently, Ben-Amots' piece required considerably more practice than the concerto, despite the latter being significantly longer and written in a more unfamiliar language.

After exposing the main challenges presented by the repertoire itself, the next section discusses the learning periods and the model that emerged from data analysis.

5.3 Learning Periods

For each study, my role as participant involved learning and memorising the corresponding commissioned work and concluded with at least two public performances from memory. During the data analysis of the video-recordings, self-reports and annotated scores, previous models of learning periods were considered, as reviewed in Chapter 2. However, none of them fully adjusted to the patterns identified in the data, the closest being Soares' (2015: 44) and Fonte's (2020: 130-131): the only ones emerging from post-tonal piano music case studies. Concretely, thematic analysis on the data collected from Gasull's Piano Concerto revealed the following themes (Table 5.2):

Table 5.2: Resulting themes from the thematic analysis of the Piano Concerto Self-Case Study.

THEME 1: Initial orientation (score)

Subtheme 1.1 Triage

Code 1.1.1 *Score overview*
Code 1.1.2 *Listening to the computer-generated recording*
Code 1.1.3 *Sight-reading*
Code 1.1.4 *Sight-playing*
Code 1.1.5 *Decision-making on fingerings and hand arrangements*
Code 1.1.6 *Formal analysis*

THEME 2: Sectional (score)

Subtheme 2.1 Triage

Code 2.1.1 *Revision of fingerings and hand arrangements*
Code 2.1.2 *Formal analysis*

Subtheme 2.2 Simplifying Layers of Complexity

Code 2.2.1 *Simplifying Pitch*
Code 2.2.2 *Simplifying Chords*
Code 2.2.3 *Simplifying Extended Techniques*
Code 2.2.4 *Simplifying Structure*
Code 2.2.5 *Simplifying Preceding Structure*

Subtheme 2.3 Conceptual Encoding

Code 2.3.1 *Solkattu Verbalisation and Clapping*
Code 2.3.2 *Rhythm Conceptualisation*
Code 2.3.3 *Pattern Conceptualisation*

THEME 3: Integrational (score)

Subtheme 3.1 Triage

Code 3.1.1 *Revision of fingerings and hand arrangements*
Code 3.1.2 *Formal analysis*

Subtheme 3.2 Simplifying Layers of Complexity

Code 3.2.1 *Simplifying Chords*
Code 3.2.2 *Simplifying Repetition*
Code 3.2.3 *Simplifying Extended Techniques*
Code 3.2.4 *Simplifying Structure*
Code 3.2.5 *Simplifying Preceding Structure*

Subtheme 3.3 Conceptual Encoding

Code 3.3.1 *Chord Conceptualisation*
Code 3.3.2 *Solkattu Verbalisation and Clapping*
Code 3.3.3 *Rhythm Conceptualisation*
Code 3.3.4 *Dynamics Conceptualisation*

THEME 4: Sectional (memory)

Subtheme 4.1 Triage

Code 4.1.1 *Revision of fingerings and hand arrangements*
Code 4.1.2 *Formal analysis*
Code 4.1.3 *Thematic analysis*
Code 4.1.4 *Harmonic analysis*
Code 4.1.5 *Rhythmic analysis*

Subtheme 4.2 Simplifying Layers of Complexity

Code 4.2.1 *Simplifying Octaves*
Code 4.2.2 *Simplifying Voicing*
Code 4.2.3 *Simplifying Chords*
Code 4.2.4 *Simplifying Hands*
Code 4.2.5 *Simplifying Rhythm*
Code 4.2.6 *Simplifying Repetition*
Code 4.2.7 *Simplifying Tempo*
Code 4.2.8 *Simplifying Extended Techniques*
Code 4.2.9 *Simplifying Structure*
Code 4.2.10 *Simplifying Preceding Structure*

Subtheme 4.3 Conceptual Encoding

Code 4.3.1 *Interval Conceptualisation*
Code 4.3.2 *Chord Conceptualisation*
Code 4.3.3 *Solkattu Verbalisation and Clapping*
Code 4.3.4 *Rhythm Conceptualisation*
Code 4.3.5 *Pattern Conceptualisation*
Code 4.3.6 *Switches Conceptualisation*
Code 4.3.7 *Dynamics Conceptualisation*

Subtheme 4.4 Others

Code 4.4.1 *Fingering Trigger Strategy*
Code 4.4.2 *Sensory Learning Styles*

THEME 5: Integrational (memory)

Subtheme 5.1 Simplifying Layers of Complexity

Code 5.1.1 *Simplifying Voicing*
Code 5.1.2 *Simplifying Hands*
Code 5.1.3 *Simplifying Tempo*
Code 5.1.4 *Simplifying Structure*
Code 5.1.5 *Simplifying Preceding Structure*

Subtheme 5.2 Conceptual Encoding

Code 5.2.1 *Solkattu Verbalisation and Clapping*
Code 5.2.2 *Pattern Conceptualisation*
Code 5.2.3 *Switches Conceptualisation*
Code 5.2.4 *Dynamics Conceptualisation*

Subtheme 5.3 Others

Code 5.3.1 *Sensory Learning Styles*
Code 5.3.2 *Mental Practice*

THEME 6: Evaluation (memory)

Subtheme 6.1 Simplifying Layers of Complexity

Code 6.1.1 *Simplifying Tempo*
Code 6.1.2 *Simplifying Structure*
Code 6.1.3 *Simplifying Preceding Structure*

Subtheme 6.2 Conceptual Encoding

Code 6.2.1 *Solkattu Verbalisation and Clapping*
Code 6.2.2 *Switches Conceptualisation*

Subtheme 6.3 Others

Code 6.3.1 *Run-throughs*

THEME 7: Preparation (memory)

Subtheme 7.1 Simplifying Layers of Complexity

Code 7.1.1 *Simplifying Tempo*
Code 7.1.2 *Simplifying Extended Techniques*
Code 7.1.3 *Simplifying Structure*
Code 7.1.4 *Simplifying Preceding Structure*

Subtheme 7.2 Conceptual Encoding

Code 7.2.1 *Interval Conceptualisation*
Code 7.2.2 *Solkattu Verbalisation and Clapping*
Code 7.2.3 *Pattern Conceptualisation*
Code 7.2.4 *Switches Conceptualisation*
Code 7.2.5 *Dynamics Conceptualisation*

Subtheme 7.3 Others

Code 7.3.1 *Run-throughs*
Code 7.3.2 *Practice with the orchestral track*
Code 7.3.3 *Rehearsals with the orchestra, conductor and composer*
Code 7.3.4 *Mental Practice*

THEME 8: Re-evaluation (memory)

Subtheme 8.1 Simplifying Layers of Complexity

Code 8.1.1 *Simplifying Tempo*
Code 8.1.2 *Simplifying Structure*

Subtheme 8.2 Others

Code 8.2.1 *Run-throughs*
Code 8.2.2 *Practice with the orchestral track*
Code 8.2.3 *Mental Practice*

THEME 9: Memory Recall

Subtheme 9.1 Simplifying Layers of Complexity

Code 9.1.1 *Simplifying Structure*

Subtheme 9.2 Others

Code 9.2.1 *Run-throughs*

Similarly, the themes obtained from Ben-Amots' Self-Case Study are presented in Table 5.3:

Table 5.3: Resulting themes from the thematic analysis of the Solo Piano Piece Self-Case Study.

THEME 1: Initial orientation (score)

Subtheme 1.1 Triage

Code 1.1.1 *Score overview*
Code 1.1.2 *Listening to the computer-generated recording*
Code 1.1.3 *Sight-reading*
Code 1.1.4 *Sight-playing*
Code 1.1.5 *Decision-making on fingerings and hand arrangements*
Code 1.1.6 *Formal analysis*

THEME 2: Sectional (score)

Subtheme 2.1 Triage

Code 2.1.1 *Revision of fingerings and hand arrangements*
Code 2.1.2 *Formal analysis*

Subtheme 2.2 Simplifying Layers of Complexity

Code 2.2.1 *Simplifying Octaves*
Code 2.2.2 *Simplifying Hands*
Code 2.2.3 *Simplifying Structure*
Code 2.2.4 *Simplifying Preceding Structure*

Subtheme 2.3 Conceptual Encoding

Code 2.3.1 *Solkattu Verbalisation and Clapping*

THEME 3: Sectional (memory) and Integrational (memory)

Subtheme 3.1 Triage

Code 3.1.1 *Revision of fingerings and hand arrangements*
Code 3.1.2 *Formal analysis*

Subtheme 3.2 Simplifying Layers of Complexity

Code 3.2.1 *Simplifying Voicing*
Code 3.2.2 *Simplifying Chords*
Code 3.2.3 *Simplifying Hands*
Code 3.2.4 *Simplifying Rhythm*
Code 3.2.5 *Simplifying Repetition*
Code 3.2.6 *Simplifying Tempo*
Code 3.2.7 *Simplifying Structure*
Code 3.2.8 *Simplifying Preceding Structure*

Subtheme 3.3 Conceptual Encoding

Code 3.3.1 *Interval Conceptualisation*
Code 3.3.2 *Pattern Conceptualisation*
Code 3.3.3 *Switches Conceptualisation*

Subtheme 3.4 Others

Code 3.4.1 *Run-throughs*

THEME 4: Evaluation (memory) and Integrational (memory)

Subtheme 4.1 Simplifying Layers of Complexity

Code 4.1.1 *Simplifying Hands*
Code 4.1.2 *Simplifying Tempo*
Code 4.1.3 *Simplifying Structure*

Code 4.1.4 *Simplifying Preceding Structure*

Subtheme 4.2 Conceptual Encoding

Code 4.2.1 *Pattern Conceptualisation*
Code 4.2.2 *Dynamics Conceptualisation*

Subtheme 4.3 Others

Code 4.3.1 *Run-throughs*

THEME 5: Preparation (memory)

Subtheme 5.1 Simplifying Layers of Complexity

Code 5.1.1 *Simplifying Tempo*
Code 5.1.2 *Simplifying Structure*

Subtheme 5.2 Others

Code 5.2.1 *Run-throughs*

THEME 6: Sectional (memory) and Integrational (memory)

Subtheme 6.1 Simplifying Layers of Complexity

Code 6.1.1 *Simplifying Voicing*
Code 6.1.2 *Simplifying Hands*
Code 6.1.3 *Simplifying Tempo*
Code 6.1.4 *Simplifying Structure*
Code 6.1.5 *Simplifying Preceding Structure*

Subtheme 6.2 Conceptual Encoding

Code 6.2.1 *Interval Conceptualisation*
Code 6.2.2 *Pattern Conceptualisation*
Code 6.2.3 *Switches Conceptualisation*

Subtheme 6.3 Others

Code 6.3.1 *Run-throughs*
Code 6.3.2 *Mental Practice*

THEME 7: Preparation (memory)

Subtheme 7.1 Simplifying Layers of Complexity

Code 7.1.1 *Simplifying Tempo*
Code 7.1.2 *Simplifying Structure*

Subtheme 7.2 Others

Code 7.2.1 *Run-throughs*
Code 7.2.2 *Mental Practice*

THEME 8: Sectional (memory) and Integrational (memory)

Subtheme 8.1 Simplifying Layers of Complexity

Code 8.1.1 *Simplifying Voicing*
Code 8.1.2 *Simplifying Chords*
Code 8.1.3 *Simplifying Hands*
Code 8.1.4 *Simplifying Rhythm*
Code 8.1.5 *Simplifying Tempo*
Code 8.1.6 *Simplifying Structure*
Code 8.1.7 *Simplifying Preceding Structure*

Subtheme 8.2 Conceptual Encoding

Code 8.2.1 *Interval Conceptualisation*
Code 8.2.2 *Solkattu Verbalisation and Clapping*
Code 8.2.3 *Pattern Conceptualisation*
Code 8.2.4 *Switches Conceptualisation*

Subtheme 8.3 Others

Code 8.3.1 *Sensory Learning Styles*
Code 8.3.2 *Mental Practice*

THEME 9: Evaluation (memory) and Integrational (memory)

Subtheme 9.1 Simplifying Layers of Complexity

Code 9.1.1 *Simplifying Chords*
Code 9.1.2 *Simplifying Hands*
Code 9.1.3 *Simplifying Rhythm*
Code 9.1.4 *Simplifying Repetition*
Code 9.1.5 *Simplifying Tempo*
Code 9.1.6 *Simplifying Structure*
Code 9.1.7 *Simplifying Preceding Structure*

Subtheme 9.2 Conceptual Encoding

Code 9.2.1 *Interval Conceptualisation*
Code 9.2.2 *Solkattu Verbalisation and Clapping*
Code 9.2.3 *Rhythm Conceptualisation*
Code 9.2.4 *Pattern Conceptualisation*
Code 9.2.5 *Switches Conceptualisation*
Code 9.2.6 *Dynamics Conceptualisation*

Subtheme 9.3 Others

Code 9.3.1 *Run-throughs*

THEME 10: Preparation (memory)

Subtheme 10.1 Simplifying Layers of Complexity

Code 10.1.1 *Simplifying Tempo*
Code 10.1.2 *Simplifying Structure*
Code 10.1.3 *Simplifying Preceding Structure*

Subtheme 10.2 Conceptual Encoding

Code 10.2.1 *Pattern Conceptualisation*
Code 10.2.2 *Switches Conceptualisation*

Subtheme 10.3 Others

Code 10.3.1 *Run-throughs*
Code 10.3.2 *Mental Practice*

Therefore, the following learning periods model was obtained:

1) Preliminary work
2) Initial orientation
3) Sectional practice
4) Integrational practice
5) Evaluation of weaknesses
6) Preparation for performance

These periods were not independent and excluding, but frequently overlapped, alternated and complemented each other. Nevertheless, the periods identified coincide with the leading themes and goals observed in the data, which allowed grouping sessions into six main types of performing practice activity.

First, the preliminary stage reflected the impact that collaborating with professional composers and premiering their works had on my acquaintance with the music. Concretely, I had to discuss the project with all parts involved, including the purpose of the commissions; securing performances; reviewing drafts, and providing and receiving feedback until the final performance. Therefore, when starting the study as participant, I was not strictly doing so as a blank canvas, but with a slight idea of the compositions. Thus, both studies reflected a real-world context in which Conceptual Simplification shall be applied, as opposed to a laboratory artificial setting. Hence, prompting the resulting findings to be transferable and generalisable to further engagements and practitioners. Notwithstanding, I also tried to limit my interaction with the pieces until the start of the actual studies, to ensure that data collection was complete and accurate, fully capturing the whole evolution of my learning and memorisation.

Secondly, the initial orientation stage corresponded to Conceptual Simplification's Triage, in which I provided myself with a visual, aural and analytical overview of the pieces, as is later explained in this chapter. This period also included decision-making on fingerings and hand arrangements. Thirdly, sectional practice involved detailed work by sections, in which technical, interpretative and expressive challenges were tackled by combining several simplifying and conceptualisation strategies, along with further formal, harmonic and rhythmic analysis. This work prompted some revision of fingerings and hand arrangements, resulting from further familiarity with the music. Similarly, integrational practice followed an analogous approach, but this time focusing on bigger sections. Also, both sectional and integrational approaches were used for score-based practice and deliberate memorisation. This type of practice aimed at memorising, although this stage also involved different forms of mental practice and physical run-throughs. Then, the evaluation stage consisted in identifying flaws in memory, by challenging it in different ways using simplifying strategies to modify the music's sensory appearance and engaging conceptual memory further. It also consisted in attempting run-throughs at tempo and slower, to spot potential weaknesses; and using mental practice away from the piano or while visualising the keyboard, with and without the score, to spot unnoticed nuances or test my memory's reliability. Finally, the sixth learning period consisted in preparing the performance itself. Hence, similar strategies were used as in the evaluation stage, but this time following a more holistic approach. For example, conceptual memory was tested in bigger sections, rather than locally and on specific details. Concretely, for the concerto, this also involved rehearsing with the provided computer-generated orchestral track, to establish aural cues and stabilise further the tempos and metrical changes. Moreover, rehearsals with the composer, conductor and orchestra provided opportunities to test my memory in different contexts (e.g., pianos, acoustics, environments, external pressure). This secured further my preparation, prompting new ways of practising. Conversely, I did not have many opportunities to reduce the context-dependent memory effect for the solo piece, since Ben-Amots is based in the USA, making it more challenging to work the piece in a similar way. Hence, rehearsals and run-throughs for the solo piece always happened in the same environment.

Having discussed the model in general terms, more details are now provided on how practice was distributed for both works.

5.3.1 Gasull's Practice Sessions

For the concerto, 216 practice sessions were needed for learning, memorising and publicly performing it from memory, from which 55 were for the first movement, 58 for the second, 49 for the third and 54 for the fourth. These include all practice sessions until the world-premiere. After, six additional sessions were needed to prepare for the second performance. Finally, a week later and without further practice, four more sessions, one for each movement, were dedicated to attempting a run-through from memory, to identify which sections were better memorised and work on the troublesome spots. These aimed at preparing for a recording session that was eventually cancelled due to Covid-19. Additionally, between 19 December 2018 and 27 April 2020, four sessions were scheduled for collaborative work with the composer and for planning the performances with the orchestra. Further details on all practice sessions can be found in tables 5.4-5.7.

Table 5.4: Learning periods for the first movement of Gasull's Piano Concerto.

PIANO CONCERTO SELF-CASE STUDY – LEARNING PERIODS			
FIRST MOVEMENT			
Learning Period	**Timeframe**	**Sessions**	**Duration (hr:min:sec)**
Initial orientation (score)	10-16.07.2020	1-3	2:47:11
Sectional (score)	02-19.11.2020	4-12	9:45:02
Integrational (score)	20.11 – 15.12.2020	13-24	12:05:20

Sectional (memory)	16.12.2020 – 12.01.2021	25-35	12:00:24
Integrational (memory)	13-21.01.2021	36-42	7:43:26
Evaluation (memory)	22-25.01.2021	43-44	2:35:27
Preparation (memory)	26.01 – 07.02.2021	45-55	10:16:06[6]
07.02.2021: World-Premiere. Auditori Eduard Toldrà, Vilanova i la Geltrú (Spain).			
Re-evaluation (memory)	10.02.2021	56	1:14:50
11.02.2021: Second performance. Centre Cultural Municipal, Valls (Spain).[7]			
Memory recall	19.02.2021	57	18:22

Table 5.5: Learning periods for the second movement of Gasull's Piano Concerto.

PIANO CONCERTO SELF-CASE STUDY – LEARNING PERIODS			
SECOND MOVEMENT			
Learning Period	**Timeframe**	**Sessions**	**Duration (hr:min:sec)**
Initial orientation (score)	22.04 – 06.05.2020	1-7	5:35:37
Sectional (score)	02-24.11.2020	8-19	11:03:12[8]
Integrational (score)	25.11 – 17.12.2020	20-30	10:42:49
Sectional (memory)	21.12.2020 – 1.01.2021	31-46	18:04:19
Integrational (memory)	22-28.01.2021	47-50	4:36:52
Evaluation (memory)	29.01.2021	51	1:11:59
Preparation (memory)	30.01 – 06.02.2021	52-58	8:41:46
07.02.2021: World-Premiere. Auditori Eduard Toldrà, Vilanova i la Geltrú (Spain).			
Re-evaluation (memory)	09-10.02.2021	59-60	2:44:34
11.02.2021: Second performance. Centre Cultural Municipal, Valls (Spain).			
Memory recall	19.02.2021	61	25:03

[6] Practice sessions on 5 and 7 of February 2021 could not be recorded. The latter exclusively consisted of mental practice with the score while conducting myself, imagining the conductor's moves. During this work, I took a nap in between.
[7] In both concerts, I also performed from memory solo works by Catalan composer Robert Gerhard.
[8] Incomplete video-recording for the session on 19 November of 2020.

Table 5.6: Learning periods for the third movement of Gasull's Piano Concerto.

PIANO CONCERTO SELF-CASE STUDY – LEARNING PERIODS			
THIRD MOVEMENT			
Learning Period	**Timeframe**	**Sessions**	**Duration (hr:min:sec)**
Initial orientation (score)	11-30.06 – 01.07.2020	1-4	3:40:50
Sectional (score)	02-18.11.2020	5-11	5:25:47
Integrational (score)	20.11 – 14.12.2020	12-22	9:18:15
Sectional (memory)	15.12.2020 – 12.01.2021	23-32	10:23:45
Integrational (memory)	13-21.01.2021	33-39	6:13:21
Evaluation (memory)	22.01.2021	40	1:00:10
Preparation (memory)	26.01 – 06.02.2021	41-49	8:51:56
07.02.2021: World-Premiere. Auditori Eduard Toldrà, Vilanova i la Geltrú (Spain).			
Re-evaluation (memory)	09-11.02.2021	50-52	1:35:49
11.02.2021: Second performance. Centre Cultural Municipal, Valls (Spain).			
Memory recall	19.02.2021	53	6:02

Table 5.7: Learning periods for the fourth movement of Gasull's Piano Concerto.

PIANO CONCERTO SELF-CASE STUDY – LEARNING PERIODS			
FOURTH MOVEMENT			
Learning Period	**Timeframe**	**Sessions**	**Duration (hr:min:sec)**
Initial orientation (score)	18.11 – 02.12.2020	1-6	4:08:46
Sectional (score)	07-23.12.2020	7-14	5:44:58
Sectional (memory)	04-22.01.2021	15-39	24:07:02
Integrational (memory) + Evaluation (memory)	24-28.01.2021	40-47	13:21:56
Preparation (memory)	29.01 – 06.02.2021	48-54	6:09:59[9]
07.02.2021: World-Premiere. Auditori Eduard Toldrà, Vilanova i la Geltrú (Spain).			

[9] Incomplete video-recordings for sessions on 3, 4 and 6 February of 2021.

Re-evaluation (memory)	10.02.2021	55	1:23:12.
11.02.2021: Second performance. Centre Cultural Municipal, Valls (Spain).			
Memory recall	19.02.2021	56	29:55.

Beyond the individual practice sessions detailed in tables 5.4-5.7, the preparation period also included:

- Two 2-hour rehearsals in which I performed a run-through of all movements and worked on several details. The first rehearsal took place both with the conductor and composer, whereas the second was only with the composer.

- Four rehearsals with the orchestra before the premiere, and a dress rehearsal before the second performance with a totalling time of 8 hours and 34 minutes.

- Two extra rehearsals with the conductor and the orchestra's concertinos, with a totalling time of 1 hour and 15 minutes.

Analysis of the performances verified that all divergences from the score were due to a lack of coordination between me and the orchestra, or clarity in my playing. Altogether, these sum up to four for the world-premiere and one for the second performance.

5.3.2 Ben-Amots' Practice Sessions

For the solo piece, 124 practice sessions were dedicated to learning, memorising and publicly performing it from memory. Additionally, a 2-hour Zoom meeting was scheduled on 3 October 2021 with Ben-Amots to discuss the work and exchange feedback. This meeting happened once I had developed an overview of the piece and had started sectional practice with the score. During the study, further written consultations happened, and some typos were amended. Table 5.8 details how these practice sessions were distributed.

Table 5.8: Learning periods for Ben-Amots' Solo Piano Piece.

SOLO PIANO PIECE SELF-CASE STUDY – LEARNING PERIODS			
Learning Period	**Timeframe**	**Sessions**	**Duration (hr:min:sec)**
Initial orientation (score)	30.06 – 28.07.2021	1-9	7:51:49
Sectional (score)	30.09 – 12.10.2021	10-17	12:14:35
Sectional (memory) + Integrational (memory)	08-24.11.2021	18-33	47:50:32[10]
Evaluation (memory) + Integrational (memory)	25-30.11.2021	34-37	12:31:09
Preparation (memory)	01-02.12.2021	38-39	3:04:02
03.12.2021: World-Premiere. Centre Cívic Matas i Ramis, Barcelona (Spain).			
Sectional (memory) + Integrational (memory)	06.12.2021 – 02.02.2022	40-53	23:49:32
Preparation (memory)	02-03.02.2022	54-56	2:27:33
04.02.2022: Second performance. Centre Cívic Casa Golferichs, Barcelona (Spain).[11]			
Sectional (memory) + Integrational (memory)	13.04 – 02.09.2022	57-102	21:54:41[12]

[10] Incomplete video-recordings for sessions on 8, 9 and 18 November of 2021.
[11] In the December and February recitals, I also performed from memory solo works by Olivier Messiaen, Tōru Takemitsu, Unsuk Chin, Josep Maria Guix and Maurice Ravel.
[12] Several technical issues impeded recording the following sessions: 13, 14, 18, 19, 20, 22, 26 and 29 April 2022; 9, 10, 11, 12, 13, 16, 18, 19 and 20 May 2022; 23 and 24 June 2022.

Evaluation (memory) + Integrational (memory)	29.08 – 10.09.2022[13]	103-120	8:17:39[14]
Preparation (memory)	12-14.09.2022	121-124	5:13:55[15]
15.09.2022: Third performance. Civivox Condestable, Pamplona-Iruña (Spain).[16]			

Some accidental notes were identified in the performances, more likely due to a slip of the finger than a memory lapse, along with some lack of rhythmical precision in difficult sections or transitions. Altogether, there were seven for the world-premiere, four for the second performance and twelve for the third performance. The latter also included a slight confusion with a switch in the left hand in bars 89-90. This increase in mistakes between the second and third performances can be partly attributed to significantly shorter practice sessions in preparation for the last performance, which did not allow much time for combining detailed work with run-throughs, although mental practice happened more extensively. More important, though, was the long travel to the concert venue, and performing a more difficult programme in the same recital.[17]

Despite both Self-Case Studies satisfying the same learning periods model, two main variants were identified in the fourth movement of Gasull's concerto and Ben-Amots' piece. This result was anticipated in the above tables and is now further explained.

[13] This period overlapped with the previous one. At this stage, I was scheduling practice sessions both in the morning and the afternoon, and so, different work was completed in parallel on the same day.
[14] Several technical issues impeded recording the afternoon sessions on the following days: 29, 30 and 31 August 2022; 1, 2, 3, 5, 6, 7, 8 and 9 September 2022.
[15] The practice session on 14 September 2022 fully consisted of mental practice and was not recorded.
[16] In this recital I also performed from memory solo works by Pierre Jodlowski, Unsuk Chin, Josep Maria Guix, Philippe Manoury, David Lang, Dai Fujikura, Yixuan Zhao and Tōru Takemitsu.
[17] Links to the video-recordings of the actual performances can be found in Chapter 4.

5.4 Conditioning Parameters for Learning and Memorisation

The commissioned works were substantially different, but Conceptual Simplification's implemented strategies were generally the same for all pieces. Furthermore, the method's effectiveness was not conditioned by my expertise with the composers' musical language. However, beyond these similarities, some divergences emerged for the learning periods, prompting a flexible implementation of the method, along with several metacognitive strategies.

First, amongst the biggest challenges of learning the concerto, there were securing switches, and internalising both rhythm and certain hand-arrangements that were not idiomatic for the instrument or frequent in its repertoire. Acknowledging all these factors, the most efficient approach for memorising the concerto was to first learn each movement with the score until accomplishing run-throughs without stopping, to then start memorising. This decision was successful, especially for the first movement which was particularly challenging in terms of rhythm, allowing to progressively internalise and build a fluent performance. Furthermore, it also permitted memorising in bigger chunks much earlier. However, this work plan could not be implemented with the fourth movement at not receiving a proper score for it with sufficient notice. Consequently, after completing sectional work with the score, I opted for memorising by sections, without attempting to integrate the whole movement with the score first. This resulted in the observed divergence from the learning periods model.

Secondly, Ben-Amots' piece was particularly challenging for memorising pitches, internalising tempos and integrating all sections together. Concretely, mastering transitions that involved contrasting tempos was considerably difficult since these were changing almost in every section, but also within a section, making it hard to establish a main temporal reference. Identifying rhythmical equivalences for securing such tempo changes was not applicable in this case, as tempo changes followed the Fibonacci sequence. Hence, the proportions between the different tempos did not satisfy a standard temporal equivalence that could be useful. This is an important finding, providing evidence that my mathematical expertise was not an advantage in this case when memorising a piece based on a mathematical sequence. Therefore, being familiar with Ben-Amots' composition principle for this work was not useful for me when memorising, as opposed to other mathematical principles (e.g., symmetry, permutations). Similarly, pitch organisation was also informed by the Fibonacci sequence, but this was not useful for memorising either: the patterns identified were either tonal or followed alternative theoretical principles that reflected my understanding of the piece. Nonetheless, such principles were different from those of the composer. Furthermore, the piece involved 13 contrasting sections that required different piano-playing techniques, prompted by unrelated passages that mostly involved new material, different musical textures and patterns, which were barely traceable across the piece. This feature was determinant in the amount of time needed for integrating the whole work and mastering successful run-throughs. However, such distinctiveness in tempo markings also positively contributed to faster retention of tempo changing. Finally, Ben-Amots' piece involved some switches too, but these were not the main issue for memorising this composition.

Considering all this, the most efficient approach for memorising Ben-Amots' piece, while ensuring that no mistakes were encoded during score-based learning, was to start memorising at an early stage. Hence, memorisation started with sectional practice. This decision was made when noticing performing mistakes in fast challenging passages or disconnected elements across the keyboard, which I would rapidly internalise if I kept relying on the score. Consequently, the resulting learning periods for Ben-Amots' piece reflect that after score-based sectional work, I skipped integration of the whole piece and started memorising by sections, to then unify all these sections from memory.

Furthermore, the process of unifying several contrasting sections in terms of themes, texture, tempo and technique required a much longer practice timeframe, including being able to perform the whole piece from memory accurately. Thus, the completion of Ben-Amots' study took much longer than expected, although this was also prompted by further performing opportunities that permitted developing a stronger interpretation. This is reflected within the repetition of the memory-related learning periods (i.e., Sectional, Integration, Evaluation, Preparation). Such extra work was focused on the second half of the piece (b.82-137), which is harder than the first half, both musically and technically. Also, unlike the concerto, I could not run Ben-Amots' piece with a familiar audience before the public performances (e.g., friends, composer). Hence, that might also explain needing more time to achieve a full performance that I was satisfied with and was good enough for the conclusion of this study.

The next section covers how Conceptual Simplification was implemented for both pieces.

5.5 Memorisation Strategies

The strategies used for learning and memorising both works are here presented according to Conceptual Simplification's steps: Triage, Simplifying Layers of Complexity and Conceptual Encoding. These are detailed in Chapter 3.

5.5.1 Triage

This first step permitted gaining an overview of the commissioned works, anticipating challenging sections and identifying what problem-solving strategies could work best. During the Triage, I also designed a work plan for the upcoming weeks, and the composers provided mock audios of the works. For the solo piece, this was a computer-generated piano track.

For the concerto, it consisted of three different computer-generated versions: (1) Orchestra with piano, (2) Orchestra with piano and metronome, and (3) Orchestra without piano and with metronome. For the third movement, only audio without a metronome was provided since this consists of a solo piano part with a joint final cadence with the orchestra at the end. Before any physical practice started, the relevant mock audios without metronome (i.e., solo piano or piano with orchestra) were heard twice: once without any visual reference, to provide a first impression of the music; and a second time following the score, to enhance an initial sight-reading preview. This general picture was further developed with formal analysis. For Ben-Amots' piece, this was provided by the composer with rehearsal letters, whereas, for the concerto, I established the macrostructure, which was further segmented into subsections as practice and familiarity with the piece evolved. Other forms of analysis were completed as needed for fulfilling physical and mental practice, especially toward successful memorisation. Inevitably, sight-reading the score for identifying similar sections, making performing decisions, updating the work plan and deciding on further strategies was repeated throughout learning and memorisation. Once all these initial steps were completed, I reviewed the piece in more detail, by drafting a first version of fingerings and hand arrangements on the score, that were later refined with prolonged practice. This process provided physical feedback on the music that enhanced and refined even more decision-making on potential strategies.

5.5.2 Simplifying Layers of Complexity

Mostly, sight-playing did not assist my technical learning due to the pieces' difficulty. Therefore, I opted to segment my practice into feasible passages. From there, I kept combining Simplifying Structure with other suitable simplifying strategies, depending on the challenges faced. Whenever a passage was too difficult to attempt in forward motion, that is playing it the usual way, from beginning to end, I would do so in backward motion (i.e., from end to beginning), by focusing practice on the latest biggest cell I could play without hesitation. Once completed all exercises for that segment, I repeated this procedure by recursively adding the previous cell that satisfied the same principle. This implementation of Simplifying Preceding Structure was repeated as many times as needed, until reaching the beginning of the passage. However, I avoided segmenting extensively when using backward motion to prevent time-consuming practice. Simplifying Preceding Structure provided the certainty of always running into a cell that I knew better than the previous one, which progressively boosted my confidence when performing. This approach was followed during most learning periods that involved memorisation, each time focusing on larger sections, to ensure that no hesitations were internalised at any point, contributing to progressively building successful run-throughs. When necessary, these steps were combined with Simplifying Tempo.

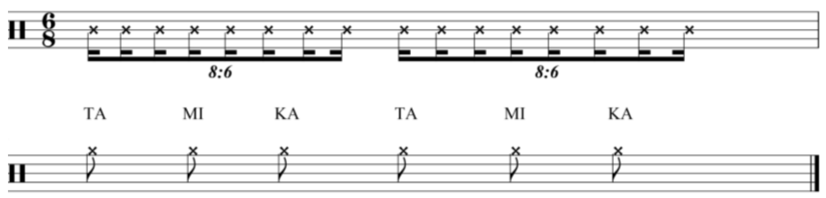
Other simplifying strategies were used for removing layers of pitch, octaves, voicing, chords, hands, rhythm, repetition and extended techniques. These are now discussed in that same order, focusing on how their implementation enhanced memorisation. Notwithstanding, these strategies were also useful for score-based practice.

Simplifying Pitch

Gasull's concerto presented multiple challenging metrical changes, which needed to be tackled independently. Hence, Simplifying Pitch was used when pitch organisation was more straightforward, was previously solved, or was not the leading parameter, as in Example 5.3:

Example 5.3: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 150-151, to exemplify Simplifying Pitch.

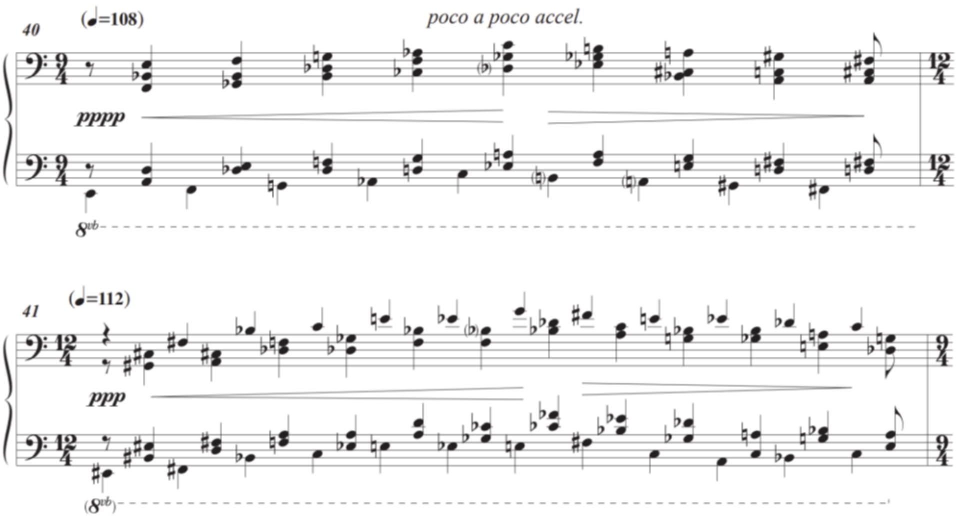
Bar 151 of Example 5.3 presents a rhythm consisting in fitting eight semiquavers within a ternary metric of quavers, while the pitches can be easier encoded within a repeating five-note pattern, plus a B-natural. Hence, pitches were temporally removed to tackle the rhythmical pattern first with *solkattu*, as Example 5.4 shows:



Example 5.4: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bar 151, after implementing Simplifying Pitch.

<u>Simplifying Octaves</u>

The encoding of certain passages and patterns was enhanced by transposing these within the same octave, range or register. For instance, playing sections such as Ben-Amots' Example 5.5 at a higher octave helped in hearing better the harmony, the individual notes and the resulting melody; but also, in recognising the underlying patterns of the chords.



Example 5.5: Ofer Ben-Amots, *The Butterfly Effect* (2021), bars 40-41, to exemplify Simplifying Octaves.

Similarly, this strategy was also useful for transposing all notes from a disjointed motif into the same octave to see what the resulting melody was, or how the notes fell into a chromaticism. This is shown in Example 5.6:

Example 5.6: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bar 152, to exemplify Simplifying Octaves.
On the left, bar 152 in its original form. On the right, the same excerpt after implementing Simplifying Octaves.

Playing at a lower register and within the same octave a passage that was to be played in a high register and across more than one octave, allowed me to internalise better the notes and the resulting melody. Once this was clear, I memorised it again in its original form and register (see Example 5.7).

Example 5.7: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 127-128, to exemplify Simplifying Octaves. On the left, bars 127-128 in its original form. On the right, bar 128 of the same excerpt after implementing Simplifying Octaves.

<u>Simplifying Voicing</u>

This strategy permitted understanding and encoding a passage or pattern that involved polyphony, by working with all possible combinations of the voices, including one-by-one.

Example 5.8: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 137-139, to exemplify Simplifying Voicing.

When using Simplifying Voicing in Example 5.8, each of the four voices was first memorised separately, and then, in all its possible combinations: 1+2, 1+3, 1+4, 2+3, 2+4, 3+4, 1+2+3, 1+2+4, 1+3+4, 2+3+4 and 1+2+3+4. Note that left-hand's voices 1 and 2 are in unison until the octave passage starts in bar 138. Therefore, learning them separately consisted in internalising both resolutions of this unison.

Simplifying Chords

This strategy was used to simplify chord sequences in different ways, but also to assist conceptual encoding. For the latter, two different versions of this strategy were implemented. The first one was to arpeggiate a chord sequence (e.g., Example 5.13), to internalise each note of the chords further, or to ease the difficulty of playing all notes at once while actively thinking of the patterns. This was done hands separately or together, depending on the context and challenges faced. The second version was to adapt Simplifying Voicing within a chordal texture. This was particularly useful in passages in which chords were only one element of the texture, and special attention was needed on a certain voice. That was the case for passages like Example 5.9, where attention focused first on the right-hand's top melody, ignoring the rest of notes of the chords, to then these be progressively restored.

Example 5.9: Ofer Ben-Amots, *The Butterfly Effect* (2021), bar 104, to exemplify Simplifying Chords.

Simplifying Chords was also useful for tackling passages such as Example 5.10, in which I combined both strategies mentioned above: each of the three layers of chords was memorised separately, reinforcing individual notes using the arpeggiating technique. Then, following the same principle of Simplifying Voicing, these were combined in all possible ways: 1+2, 1+3, 2+3 and 1+2+3.

Example 5.10: Ofer Ben-Amots, *The Butterfly Effect* (2021), bar 130, to exemplify Simplifying Chords.

Simplifying Hands

This strategy was implemented when understanding and encoding benefitted from removing either hand or simplifying some of its layering. This was particularly relevant when tackling multi-layered textures in which unifying the leading voice was essential (see Example 5.11).

Example 5.11: Ofer Ben-Amots, *The Butterfly Effect* (2021), bars 116-118, to exemplify Simplifying Hands. The leading voice of the passage is highlighted in green.

Using Simplifying Hands in Example 5.11 consisted in memorising first the leading voice highlighted in green, regardless of the hand with which this was played, to then do the same with the accompaniment, which consists of fragments that follow the main theme when the leading voice exchanges hands. Once this work was completed, additional layers were restored, such as the secondary voices that accompany the leading voice.

Simplifying Rhythm

This strategy was implemented for simplifying rhythm in several steps to internalise it; or for removing rhythm to gain greater insight into pitch organisation, as shown in Example 5.12.

Example 5.12: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 83-88, to exemplify Simplifying Rhythm.

Simplifying Rhythm is illustrated with bars 84-87 from Example 5.12. This passage consists of a sequence of uniform arpeggios in both hands. Hence, since the rhythm has an ornamental role, this was temporally removed, obtaining a chordal texture instead (see Example 5.13):

Example 5.13: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 84-85, after implementing Simplifying Rhythm.

Then, conceptualisation strategies were used to encode each chord sequence. These were first memorised hands separately, and then, together.

Simplifying Repetition

This strategy removes unnecessary repetitions, thus, making underlying patterns such as harmonic sequences clearer. For instance, given Example 5.14:

Example 5.14: Ofer Ben-Amots, *The Butterfly Effect* (2021), bars 13-15, to exemplify Simplifying Repetition.

Example 5.14 was simplified into a sequence of chords, only maintaining the resulting harmonic rhythm. Thus, by removing the sextuplet repetition, it became easier to encode the corresponding chords (Example 5.15), following strategies described in this chapter.

Example 5.15: Ofer Ben-Amots, *The Butterfly Effect* (2021), bars 13-15, after implementing Simplifying Repetition.

This procedure was implemented to other textures that were similarly adorned with repetition such as tremolos (e.g., bars 64-68 of Ben-Amots' piece); but, also to facilitate learning a certain passage. This is the case of Example 5.16, in which trills were temporally removed to focus on the overall rhythmical precision of that passage.

Example 5.16: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 49-55, to exemplify Simplifying Repetition.

Simplifying Extended Techniques

This strategy was particularly important for Gasull's concerto since extended techniques did not remain invariable but changed during the collaborative process with the composer. Most notably, whistling was substituted for plucking the corresponding strings instead. Hence, Simplifying Extended Techniques (see Chapter 3) permitted that such changes did not significantly affect my preparation: the actual movements to perform such techniques were incorporated once the rest of information was well-learned and memorised. Therefore, it simply became a matter of adding an extra layer of movement on top of that: whistling could be carried out without standing but plucking required locating the strings and plucking them accordingly, in combination with the actions that had to be taken on the keyboard. Example 5.17 illustrates how some of these techniques were combined.

Example 5.17: Feliu Gasull, *La flor de l'atzavara* (2020), 'Racons', bars 41-45, to exemplify Simplifying Extended Techniques. The Catalan word "xiulant" means "whistling".

The next section discusses the conceptual encoding strategies that emerged from the analysis.

5.5.3 Conceptual Encoding

This section details general procedures followed for conceptually encoding those patterns unveiled with simplifying strategies. The order followed is Interval Conceptualisation, Chord Conceptualisation, *Solkattu* Verbalisation and Clapping, Rhythm Conceptualisation, Pattern Conceptualisation, Switches Conceptualisation and Dynamics Conceptualisation.

Interval Conceptualisation

This strategy permitted identifying and understanding the relationships amongst a series of intervals within a passage. Generally, traditional harmony was used to encode sequences of simple harmonic intervals (i.e., notes played simultaneously); and melodic intervals (i.e., notes played sequentially). Nonetheless, for groups of notes that combined both types of intervals and fell within the same hand position, I implemented Blocking to turn these intervals into chords, by respecting the original arrangement while Simplifying Rhythm.[18] Then, I chunked the resulting interval relationships with traditional harmony or as an idiosyncratic conglomerate of intervals, finding a coherent theoretical framework when possible. To strengthen memory further, this was combined with visual memory of the resulting black-and-white patterns of the keyboard. Taking, for instance, Example 5.18:

Example 5.18: Ofer Ben-Amots, *The Butterfly Effect* (2021), bars 88-89, to exemplify Interval Conceptualisation.

[18] Blocking is further discussed in Chapter 3.

Following this procedure, Example 5.18 was transformed into Example 5.19:

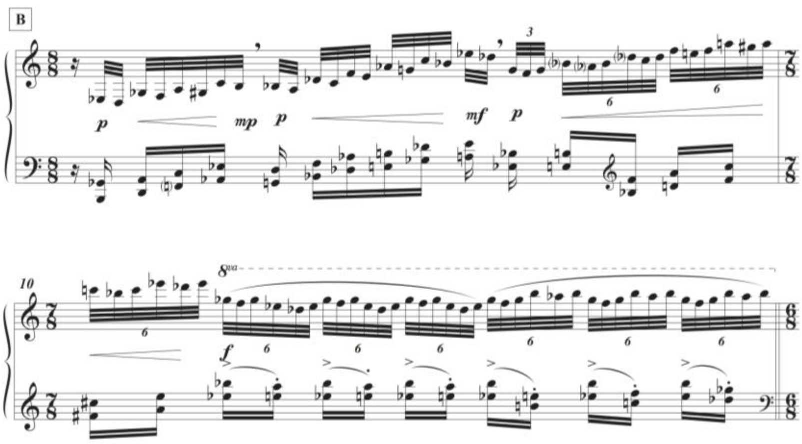
Example 5.19: Ofer Ben-Amots, *The Butterfly Effect* (2021), bars 88-89, after implementing Interval Conceptualisation.

Memory was further strengthened using the contrary motion of the octaves, and the rotational symmetry of order 2 present in the first half of each bar.[19] This is highlighted in Example 5.20 with matching colours for the equivalent octaves.

Example 5.20: Ofer Ben-Amots, *The Butterfly Effect* (2021), bars 88-89, after implementing Interval Conceptualisation. The two rotational symmetries of order 2, one per bar, are highlighted with different colours.

Combining Interval Conceptualisation with coding the ascending or descending direction of a melodic sequence was more strictly used when grouping into hand positions the right hand in Example 5.21.

[19] Rotational symmetry and other types of symmetries are thoroughly discussed in Chapter 3.

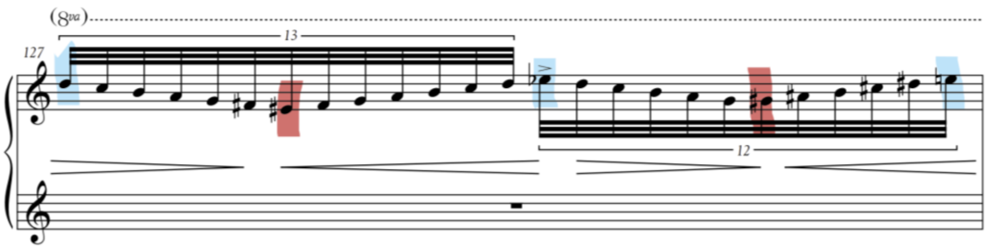


Example 5.21: Ofer Ben-Amots, *The Butterfly Effect* (2021), bars 9-10, to exemplify Interval Conceptualisation.

Therefore, by grouping the melodic sequence into 2-note and 3-note chords, the right-hand virtuosic progressions became clearer, and it was easier to chunk its patterns and hand positions. This was done first hands separately, and then, the left hand was restored.

Example 5.22: Ofer Ben-Amots, *The Butterfly Effect* (2021), bar 9, right hand after implementing Interval Conceptualisation. Notes were grouped according to their either descending or ascending direction.

Finally, there were other cases in which a sequence was encoded only using its boundaries. Typically, these corresponded to the highest and the lowest note in the sequence since the rest between these two could be chunked within a standard pattern (e.g., a scale). Thus, it only required retrieving the bottom and top note boundaries of the sequence, along with the scale pattern that filled the rest of the notes in between. This was the procedure followed for passages such as Example 5.23.



Example 5.23: Feliu Gasull, *La flor de l'atzavara* (2020), 'Passeig', bar 127, to exemplify Interval Conceptualisation. The corresponding note-boundaries were highlighted in blue (top) and red (bottom).

Furthermore, when dealing with such passages, I also thought of the fingering, to trigger the corresponding motor sequences accurately. Hence, chunking such passages according to standard scales and its boundaries made this fingering trigger strategy even more successful. This was also used with switches.

Chord Conceptualisation

Related to Interval Conceptualisation, this strategy was implemented within two contexts. The first one consisted in breaking down a chord, for which traditional harmony was not applicable, into intervals. This was the inverse of Blocking, which groups into a chord those notes falling within the same hand position. Such procedure is illustrated with the left-hand chord in Example 5.24, which was encoded as a minor third plus a perfect fourth.

Example 5.24: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 68-69, to exemplify Chord Conceptualisation.

The second context involved finding a pattern that encoded a sequence of chords or clusters. For instance, the left hand for the first two bars of Example 5.25 can be thought of as a series of 4-note clusters rooted on an A-F natural scale. Or, alternatively, a D-B melodic minor scale, if analysed from the top melody instead.

Example 5.25: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 65-66, to exemplify Chord Conceptualisation.

Solkattu Verbalisation and Clapping

This strategy was used when understanding and internalising a rhythm was challenging, and required ensuring that I was memorising the right information. Following the same set of syllables presented in Chapter 3, Example 5.26 illustrates how this strategy was implemented in the concerto. Concretely, this consists of two consecutive septuplets for the 14-note pattern; a sextuplet plus a septuplet, for the 13-note pattern; and two consecutive quintuplets for the 10-note pattern. Using *solkattu*, I encoded the passage below with the word sequence:

ta-ke-di-mi ta-ki-da, ta-ke-di-mi ta-ki-da

ta-di-na ta-jha-nu, ta-ke-di-mi ta-ki-da

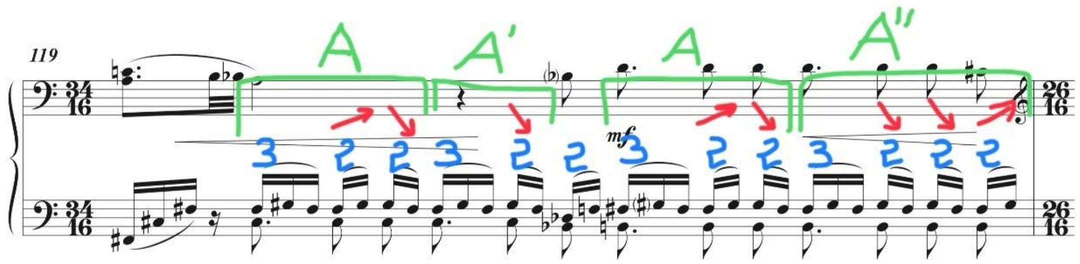
ta-di-ghi-na-ton, ta-di-ghi-na-ton

Example 5.26: Feliu Gasull, *La flor de l'atzavara* (2020), 'Passeig', bar 124, to exemplify *Solkattu* Verbalisation and Clapping.

Moreover, to internalise further passages like this, I practised the music before and after the corresponding excerpt at tempo, but at a slower tempo the passage itself, to verify the proportion of each rhythmic unit with *solkattu*. This provided me with extra confidence and accuracy when performing at tempo such sequences.

<u>Rhythm Conceptualisation</u>

This strategy was used when encoding a passage or pattern required developing a theoretical framework for monitoring the performance. This was the case of sections built on a self-referencing pattern, and whose variations depended on different parameters. Example 5.27 illustrates a section in which there is an apparently arbitrary variation of two parameters: the rhythm's metrical measure, which ranges between ternary and binary; and the ascending or descending direction of the semiquaver-units. Thus, to memorise this bidimensional variation, I encoded independently the metrical sequence (3-2-2)-(3-2)-(2)-(3-2-2)-(3-2-2-2) and the sequence of relevant directions ↑↓-↓(↑)-↑↓-↓↓↑. The combination of both produced the structure A-A'-A-A". Therefore, I only needed to memorise pattern A and rationalise all its variations. Accordingly, this misleading section could be easily performed and monitored by triggering the corresponding pattern, according to the structure identified.



Example 5.27: Ofer Ben-Amots, *The Butterfly Effect* (2021), bar 119, after implementing Rhythm Conceptualisation.

A similar strategy was used to encode the metric of those waiting bars in the concerto, between one soloist entrance and another. Example 5.28 illustrates the 6/8 + 3/4 pattern that repeats identically until bar 36, and slightly varied further on. Memorising according to this structure facilitated synchronisation with the conductor and orchestra, even when lacking visual cues, since it became a framework from where the rest of information was retrieved.

Example 5.28: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 1-20, to exemplify Rhythm Conceptualisation.

Pattern Conceptualisation

This strategy was implemented to develop a theoretical framework that combined several parameters at once (e.g., harmony, rhythm, dynamics, repetition, octaves, voicing). One of the contexts in which this was most useful was when having a shifting ostinato in one hand that was not necessarily changing with the pace of the other hand (see Example 5.29).

Example 5.29: Ofer Ben-Amots, *The Butterfly Effect* (2021), bars 101-102, to exemplify Pattern Conceptualisation.

In this context, Pattern Conceptualisation implied encoding all the different patterns within the ostinato, in terms of pitches, dynamics, number of repetitions for each tetrachord, and how the latter rhythmically interacts with the right hand. This required combining simplifying strategies for rhythm, repetition, chords and hands; and conceptualisation strategies for chords and dynamics, along with *solkattu*. Hence, the procedure for memorising the section illustrated in Example 5.29 was to focus first on the left hand to identify all turning points in the ostinato. This allowed removing unnecessary repetitions when the tetrachord remained the same, blocking into chords, and obtaining the structural rhythm of the resulting sequence. Once these chords were encoded, I could practise the sequence first with the simplified rhythm (i.e., without the semiquaver articulation); then, play for each beat the corresponding chord, regardless of whether this was a new chord or a repetition of the previous one. Finally, the original ostinato rhythm was restored. In this final stage, I monitored the performance using a numerical pattern that summarised the number of repetitions of each tetrachord, correlating these sequences with the corresponding dynamics. This process was completed with the left hand first, and then hands together. Additionally, the chords in the right hand were practised in a separate process previously described in this chapter, which allowed to develop a multidimensional mental map of the whole section. Likewise, a similar procedure was implemented for the ostinato in bars 123-126 of the concerto's first movement, although what varied were not the pitches, but the rhythm instead.[20]

Another context in which Pattern Conceptualisation was helpful was in rationalising how each hand's intervention related to the other. This could be as simple as fixing specific pitch cues for one hand from the other. For example, given a passage, each bar satisfies that the bottom note of the left-hand chord is always the first note of a sequence in the right hand, following Li's (2007) suggested mnemonics.[21] Alternatively, a more elaborate procedure could be encoding a passage with a mathematical concept that defined how both hands interacted: e.g., a symmetry within the movement or the pitches that each hand plays.[22]

Finally, a more abstract approach was to find a general rule that summarised a passage, and that could be later used to retrieve it and monitor the performance (see Example 5.30).

[20] The piano part can be retrieved from Appendix K.
[21] Several examples of this can be found in bars 75-80 of Ben-Amots' piece. Li's (2007) mnemonics are discussed in Chapter 2.
[22] Several examples of this can be found in bars 83-90 and 134-137 of Ben-Amots' piece, and across the fourth movement of Gasull's Piano Concerto.

Example 5.30: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 93-94, to exemplify Pattern Conceptualisation.

In Example 5.30, a pitch organisation pattern can be found. After transposing each arpeggiating unit to the same octave and simplifying repetitions, both hands terminate their arpeggio on the same note. Furthermore, the first note of each right-hand arpeggio is always a semitone lower (-1/2) than its corresponding in the left hand; and the second note of the right-hand arpeggio starts being one tone higher (+1) than the one in the left hand, and one semitone higher (+1/2) for the rest. Therefore, the right hand can be deduced from the left hand. Consequently, memorising this passage only requires remembering three trichords for the left hand, and Figure 5.1 from which the right hand can be reconstructed:

$$\begin{pmatrix} 0 \\ +1 \\ -1/2 \end{pmatrix} \text{x2} \quad + \quad \begin{pmatrix} 0 \\ +1/2 \\ -1/2 \end{pmatrix} \text{x3}$$

Figure 5.1: Summary of Example 5.30, after implementing Pattern Conceptualisation.

<u>Switches Conceptualisation</u>

Amongst all memorisation challenges reported during the Self-Case Studies, switches were the hardest to secure in memory. The most problematic ones were those of the concerto, unfolding in the context of a recurring theme. These consisted of multiple places in all movements that resolved differently or presented a different arrangement. Concretely, for the first movement, these were in bars 20(3rd beat)-25(1st beat), bars 33-36, bars 136(3rd beat)-140 and bars 149-152. For the second movement, these switches were in bars 12-24, bars 41(2nd beat)-46, bars 124-125, bars 126(2nd beat)-128 and bars 152-163. Similarly, the third movement involved switches in bar 1, bars 9-14, bars 15-16, bars 37-38 and bars 73-78. However, this movement was less problematic since the piano is alone until the last cadence. Finally, switches in the fourth movement were placed in bars 1-8, bar 34, bars 37(2nd beat)-45, bar 86, bars 93-96, bars 97-99, bars 100-104, bars 105-117, bars 132-136 and bars 137-148.[23] Switches did not cause any issues during public performances but required significant effort to achieve a fluent and secure performance.

The first step to approach switches was to identify them during the Triage, before practising them individually with physical and mental practice. Following the guidelines provided in Chapter 3, I avoided mixing related switches at an early stage. Accordingly, during sectional work, I did not practise or memorise two or more related switches in a single session, to avoid cross-referencing. Once switches were individually learned or memorised, the second step was to compare them by spotting the differences. Normally, it sufficed in identifying the exact point in which it diverged from the model (i.e., the theme's first appearance), and in which ways. These differences were practised again both physically and mentally. This is now illustrated with Example 5.31:

[23] All piano parts can be retrieved from Appendix K.

Example 5.31: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 20-24 and 136-140, to exemplify Switches Conceptualisation. On the left, the model switch in bars 20(3rd beat)-24; on the right, a second switch on the same theme in bars 136(3rd beat)-140.

Example 5.31 illustrates side-by-side two related switches from the concerto. In this case, the overall metrical structure is the same, but in the theme's second beat, a rearrangement in all voices and the rhythm occurs. This goes on for the rest of the passage, only preserving the structural rhythm and most pitches in the top melody. When practising and performing excerpts like this, I mentally visualised the conduction of the voices, either with my eyes closed or while looking at the keyboard. By being aware and paying attention to those slight variations that could mislead me, I became fluent at anticipating each of these switches beforehand. This was a successful performance strategy, even when feeling under pressure.

Furthermore, additional memorisation challenges were caused by uniformity, entangled polyphony and difficulty to synchronise with the orchestra, resulting from metrical changes and progressive accelerando. These were identified in all movements of the concerto. For the first movement, these were in bars 30-32, bars 38-39, bar 43, bars 70-71, bar 100 and the entrance in bar 131. For the second movement, these were bars 26-40, bars 47-79, bar 102 and bars 109-135. Finally, for the third movement, this only happened in bars 59-72; and for the fourth movement, in bars 93-148.

Alternatively, switches in Ben-Amots' piece resulted from self-referencing. Hence, the same approach was implemented but focusing instead on identifying the smallest piece of information that could serve as a model for the rest of the passage. According to this basic unit, the rest of the section was segmented into cells according to their resemblance or divergence from that model. This process provided a structure that I used for retrieval.[24]

Dynamics Conceptualisation

This strategy was used to conceptualise dynamics according to the formal structure. It was particularly useful for passages or patterns with substantial repetition or self-referencing, in which explicitly encoding dynamics made a difference for confident memorisation. Example 5.32 illustrates a bidimensional pattern, which is highlighted by noting the correlation between the changes in the corresponding rhythmic and dynamics patterns.

[24] Further details and examples of how to implement Switches Conceptualisation are given in Chapter 3.

Example 5.32: Feliu Gasull, *La flor de l'atzavara* (2020), 'Impromptu', bars 145-148, after implementing Dynamics Conceptualisation.

An equivalent example can be found in bars 40-49 of Ben-Amots' piece although, in that case, instead of cross-encoding rhythm and dynamics, I did so with blocks of chords and dynamics.[25]

After detailing how Conceptual Simplification was implemented for both commissioned works, the following section provides a summary of the findings.

[25] The full score can be retrieved from Appendix K.

5.6 Summary

These Self-Case Studies were far more substantial in terms of repertoire, data collection and time dedication than any study I could undertake with recruited pianists. Hence, several important conclusions result from the findings. First, evidence suggested that Conceptual Simplification could be an effective tool for learning and memorising post-tonal piano music, despite not possessing previous expert knowledge of a particular musical language. This is significant since the literature reported that experts are more effective than novices in chunking according to pre-existing knowledge, but in the context of post-tonal music, experts might not always be effective at identifying patterns or finding these useful to memorise.[26] Hence, Conceptual Simplification's pool of strategies to simplify post-tonal complexity may remove such barrier. Similarly, results also illustrated how complexity can influence learning and memorisation of contrasting content without repetition, and switches.

Regarding influential parameters from the repertoire itself, the concerto particularly stood out for the rhythm's difficulty and the presence of extended techniques in all movements. These required making a series of decisions that influenced my learning and memorisation, as described in this chapter. Learning and integrating the first three movements of the concerto, first with the score, and then from memory, allowed me to memorise in bigger chunks. However, this approach was counterproductive for Ben-Amots' piece, which was more conceptually complex and technically difficult. Such complexity spanned across several parameters, including pitch, tempo, structure and technique. Beyond that I needed more time than usual to fully commit the piece to memory, these challenges also required that most of my attention was paid to the keyboard, rather than the score, to ensure accuracy when

[26] Brewer (1987), Chaffin and Imreh (1997a: 316), Chaffin and Logan (2006), Chaffin et al. (2002), Chueke and Chaffin (2016), Ericsson and Charness (1994), Ericsson et al. (2017), Fonte (2020: 106-108; 134; 293; 298; 318-319; 439-450; 452), Gobet (2015), Gordon (2006: 84), Hallam (1997), Halpern and Bower (1982), Li (2007), Miklaszewski (1995), Mishra (2005), Nuki (1984), Ockelford (2011: 237), Oura and Hatano (1988), Sloboda et al. (1985), Soares (2015: 75; 148-149; 194), Tsintzou and Theodorakis (2008: 8).

playing, especially for pitches. Otherwise, there was a significant risk of mislearning the music. Furthermore, the differences between the contexts of solo and soloist with orchestra implied a longer learning process to incorporate both aural and the conductor's cues to my playing and develop the ability to perform the concerto accompanied. Nonetheless, the orchestral interludes allowed me to anticipate the next entrance, while in the solo piece, I repeatedly experienced cognitive overload due to the piece's incessant activity. Finally, in both works the nature and format of the scores that I had at my disposal also played a role. For example, working with manuscripts and then switching to computer-notated scores disrupted to some extent my visual memory. Similarly, Gasull's handwritten notation and non-idiomatic language made me prefer sight-reading to sight-playing when developing an overview of the music. Likewise, technical challenges in Ben-Amots' piece made preferable early attempts of deliberate memorisation, to avoid wrong incidental memorisation. Lastly, Gasull's late delivery of the fourth movement also conditioned how Conceptual Simplification was implemented for memorising. Consequently, one of the most unexpected results was that the piece's length was not necessarily a parameter that indicated its difficulty. This was exemplified when comparing the number of sessions needed for the 10-minute solo piece, with those needed for the 28-minute concerto.

Moreover, the commissioned pieces were significantly different, conditioning my learning and memorisation, but the strategies used were essentially the same. This suggests Conceptual Simplification's flexibility within different contexts and its systematic approach, regardless of the idiosyncratic features of the compositions. The identified strategies satisfied the method's three stages: Triage, Simplifying Layers of Complexity and Conceptual Encoding. Hence, the studies contributed to further experimenting with these within different contexts, enriching their possibilities.

Finally, results from both studies suggest that Conceptual Simplification was an effective learning and memorisation method for me as a practitioner with the commissioned repertoire. This argument is supported by the evidence presented in this chapter in terms of the implemented and newly developed strategies; but also, on the success of the world-premieres and subsequent performances. The next section provides an overview of Conceptual Simplification's evolution from its first prototype provided in my Master's thesis Farré Rozada (2018)[27] to the resulting version of this thesis.

5.7 Evolution of Conceptual Simplification

As previously discussed in Chapter 2 and Chapter 3, in my Master's thesis Farré Rozada (2018) I provided an initial version of Conceptual Simplification. This consisted of a pool of memorisation strategies that permitted simplifying complexity in different ways and scaffolding the memorisation of the post-tonal piano work *Makrokosmos I* (1972) by George Crumb. Concretely, the five proposed strategies, which are further discussed in Appendix A, were:

1) Simplifying Complex Chords
2) Identifying Interval Relationships
3) Simplifying Layers of Complexity
4) Switch Conceptualisation
5) Structural Dynamic Map

As a result of this doctoral research, and particularly after completing the Self-Case Studies discussed in this chapter, the strategies above were further refined and extended, allowing to

[27] See further details in Appendix A.

formalise a new version of Conceptual Simplification consisting of three main stages: Triage, Simplifying Layers of Complexity and Conceptual Encoding. Consequently, the potential applications of the method could also be reframed to scaffold the analysis, learning and memorisation of post-tonal piano music. Furthermore, beyond testing this improved approach with further repertoire and other practitioners, this thesis also thoroughly discusses the theoretical background of Conceptual Simplification, informed by mathematics and computer science. Particularly, how group theory, number theory, geometry and the paradigms of divide-and-conquer, decrease-and-conquer and transform-and-conquer can be implemented within the context of musical cognition, memory and performance. Therefore, making explicit the underlying rationale that originally triggered the strategies proposed in Farré Rozada (2018). To further compare the differences between both versions of the method, Figure 5.2 summarises its main features:

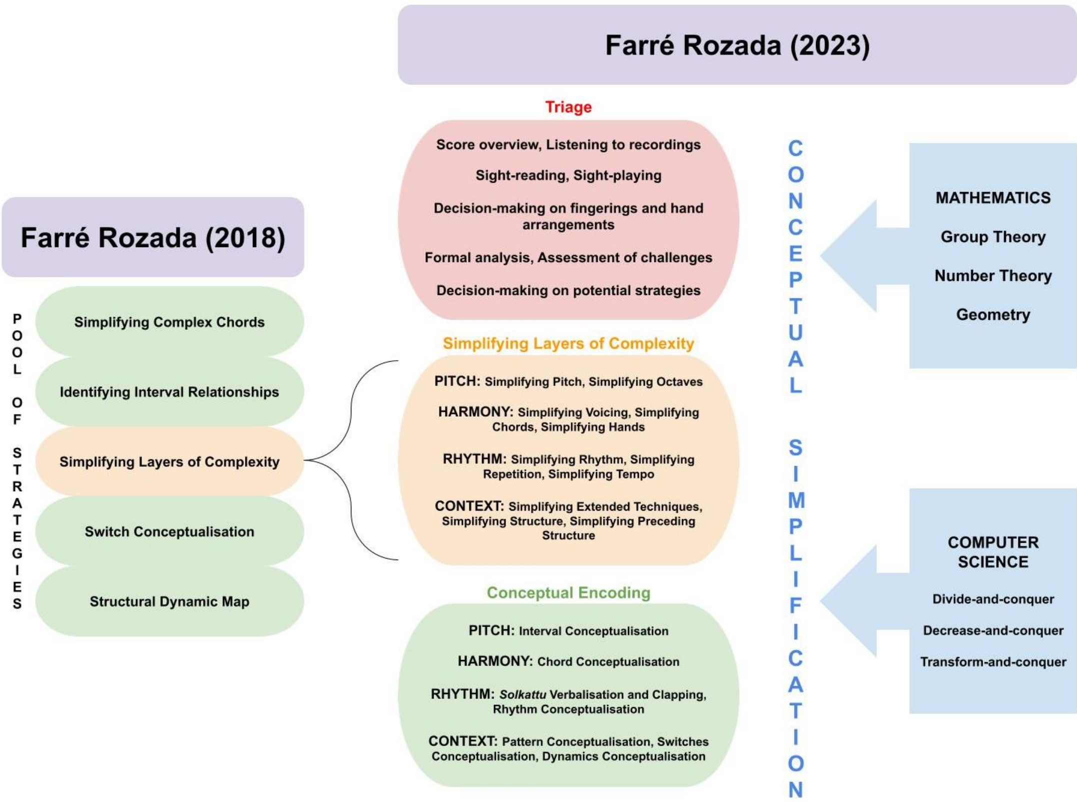


Figure 5.2: Summary of how the method Conceptual Simplification evolved from the Master's thesis Farré Rozada (2018) to this PhD thesis Farré Rozada (2023).

Thus, this doctoral research formalised an extended version of Conceptual Simplification, which involves eight strategies for the Triage; eleven strategies for Simplifying Layers of Complexity, organised according to pitch, harmony, rhythm and context; and seven strategies for Conceptual Encoding, also following those same categories. All these strategies were discussed in Chapter 3 and the present chapter, and are summarised below in Table 5.9:

Table 5.9: This thesis' resulting version of Conceptual Simplification.

TRIAGE	SIMPLIFYING LAYERS OF COMPLEXITY	CONCEPTUAL ENCODING
Score overview Listening to recordings Sight-reading, sight-playing Deciding on fingerings and hand arrangements Formal analysis Assessment of challenges Deciding on potential effective strategies	**Pitch** Simplifying Pitch Simplifying Octaves **Harmony** Simplifying Voicing Simplifying Chords Simplifying Hands **Rhythm** Simplifying Rhythm Simplifying Repetition Simplifying Tempo **Context** Simplifying Extended Techniques Simplifying Structure Simplifying Preceding Structure	**Pitch** Interval Conceptualisation **Harmony** Chord Conceptualisation **Rhythm** *Solkattu* Verbalisation and Clapping Rhythm Conceptualisation **Context** Pattern Conceptualisation Switches Conceptualisation Dynamics Conceptualisation

The next chapter presents the findings from the interviews with professional soloists.

Chapter 6: Findings from the Interviews

6.1 Introduction

This chapter presents the results from three semi-structured interviews with pianists Hayk Melikyan, Ermis Theodorakis and Jason Hardink.[1] These aimed at identifying which strategies use specialised professional soloists for memorising post-tonal piano works, what the reasons are for performing from memory or with the score, and which parameters influence the memorisation process of this repertoire. Also, to compare the interviewees' memorisation approaches with Conceptual Simplification, and those of the recruited participants with lesser experience in post-tonal music, and closer to the conservatoire's educational methods, which still lack specific training on memorisation. The main findings were:

1) Memorisation enhances learning when done deliberately to develop understanding. Learning and memorisation should happen simultaneously and develop progressively during the learning process of a piece.

2) Two main types of post-tonal music complexity were identified: highly detailed scores with contrasting sections lacking repetition and self-referencing pieces.

3) Effective memorisation requires engaging conceptual memory, which can be prompted with analysis. When post-tonal music lacks coherence, it can be useful to fit the material into any theoretical frameworks available, including composition principles, and familiar or unfamiliar identified patterns. However, the composer's

[1] As stated in Chapter 4, all three interviewees granted permission for not being anonymised.

principles might not always be helpful for memorising or monitoring the performance: the best possible analysis is the one that makes sense to the performer.

4) Conceptual memory should lead memorisation, complemented by the Sensory Learning Styles.[2] Memory should be regarded as a muscle that needs to be challenged in different ways, establishing a parallelism with how athletes train.

5) Memorisation can be a double-edged sword. Deliberate memorisation can be used as a coping strategy for performance anxiety. However, performing from memory also implies the risk of potential memory lapses and constitutes a trigger of performance anxiety.

6) Mental practice complements physical practice toward memorisation, and it can also be a coping mechanism for performance anxiety.

This chapter discusses these findings as follows. First, I present the interviewees' general memorisation approaches. Secondly, the identified main types of complexity for post-tonal piano music are detailed. Thirdly, the interviewees' memorisation strategies are explained by categories: strategies for memorising pitch, rhythm and dynamics; practice strategies and performance strategies. Finally, influential parameters to memorisation are discussed, to then conclude with a summary of the findings. Table 6.1 below presents the main themes obtained from the thematic analysis of the written transcriptions of the interviews.

[2] These are properly defined and discussed in Chapter 2.

Table 6.1: Resulting themes from the thematic analysis of the Interviews.

THEME 1: Memorisation approach conditioned by the repertoire

Subtheme 1.1 Depends on the context

Code 1.1.1 *Solo music*
Code 1.1.2 *Chamber or ensemble music*
Code 1.1.3 *Orchestral music*

Subtheme 1.2 Complexity of the music

Code 1.2.1 *Style (Classical, Contemporary)*
Code 1.2.2 *Presence of multiples switches or self-referencing*
Code 1.2.3 *Lack of repetition*
Code 1.2.4 *Technical difficulty*

THEME 2: Memorisation approach conditioned by the learning styles

Subtheme 2.1 Musical skills

Code 2.1.1 *Perfect pitch*
Code 2.1.2 *Sight-reading*
Code 2.1.3 *Sight-playing*
Code 2.1.4 *Internal hearing/Mental imagery*
Code 2.1.5 *Memorisation strategies*

Subtheme 2.2 Learning Styles

Code 2.2.1 *Sensory Learning Styles (aural memory, visual memory, kinaesthetic memory)*
Code 2.2.2 *Analytical Learning Styles (conceptual memory, analysis)*
Code 2.2.3 *Mental practice*
Code 2.2.4 *Non-musical approaches (photographic memory, sleep)*

Subtheme 2.3 Interaction between learning and memorisation

Code 2.3.1 *Memorisation as part of the learning process*
Code 2.3.2 *Memorisation as an outcome of learning*

THEME 3: Memorisation approach conditioned by other factors

Subtheme 3.1 Amount and quality of practice

Code 3.1.1 *Length of practice session*
Code 3.1.2 *Performing schedule*
Code 3.1.3 *Deliberate practice vs. Practice based on repetition*
Code 3.1.4 *Distributed practice vs. Massed practice*

Subtheme 3.2 Previous experience

Code 3.2.1 *Familiarity*
Code 3.2.2 *Performing experience*
Code 3.2.3 *Propensity to performance anxiety*

Subtheme 3.3 Mental health

Code 3.3.1 *Ability to focus*
Code 3.3.2 *Attitude and general well-being*
Code 3.3.3 *Stress management and positive self-talk*

THEME 4: Memorisation strategies

Subtheme 4.1 Strategies for Memorising Pitch

Code 4.1.1 *Analysis (formal, harmonic, thematic, pitch organisation)*
Code 4.1.2 *Segmentation (formal structure, phrases, cells)*
Code 4.1.3 *Chunking (tonal patterns, identified rules, composition principles)*

Code 4.1.4 *Combining aural and kinaesthetic memory*
Code 4.1.5 *Visual memory (encoding geometrical shapes on the keyboard)*

Subtheme 4.2 Strategies for Memorising Rhythm

Code 4.2.1 *Mapping rhythmical equivalences*
Code 4.2.2 *Practising by altering certain parameters (tempo)*

Subtheme 4.3 Strategies for Memorising Dynamics

Code 4.3.1 *Kinaesthetic memory*
Code 4.3.2 *Identifying dynamical patterns*
Code 4.3.3 *Combining mental and physical practice*

Subtheme 4.4 Practice Strategies

Code 4.4.1 *Metacognitive strategies (distributed practice, segmentation, challenging memory from different perspectives)*
Code 4.4.2 *Mapping relationships on the score*
Code 4.4.3 *Playing on different registers of the keyboard*
Code 4.4.4 *Playing on different instruments*
Code 4.4.5 *Combining different repertoire*
Code 4.4.6 *Sight-reading*
Code 4.4.7 *Mental practice*
Code 4.4.8 *Physical and mental run-throughs*
Code 4.4.9 *Repetition as an overlearning strategy*

Subtheme 4.5 Performance Strategies

Code 4.5.1 *Positive self-talk*
Code 4.5.2 *Mental practice*
Code 4.5.3 *Monitoring performance with conceptual memory*
Code 4.5.4 *Using rests and fermatas to anticipate upcoming material*

THEME 5: Disadvantages of performing from memory

Subtheme 5.1 Risk of forgetting

Code 5.1.1 *Performing from memory can trigger performance anxiety*
Code 5.1.2 *Lacking confidence can hinder the performance*
Code 5.1.3 *Requires conceptual memorisation*

Subtheme 5.2 Main obstacles

Code 5.2.1 *Slowness of the process (lack of contrast, lack of repetition)*
Code 5.2.2 *Memory's volatility (potential forgetting is unpredictable)*

THEME 6: Benefits of performing from memory

Subtheme 6.1 Performing from memory is useful

Code 6.1.1 *Helpful for practising*
Code 6.1.2 *Performing from the score can be dangerous (unreliable page-turners, interaction between keyboard and score)*
Code 6.1.3 *Memorisation deepens understanding and prompts learning*
Code 6.1.4 *Memorisation engages conceptual memory*

Subtheme 6.2 Performing from memory enhances performance

Code 6.2.1 *Performing from memory prompts accuracy*
Code 6.2.2 *Memorisation prompts confidence*
Code 6.2.3 *Deepens the emotional connection to the music*
Code 6.2.4 *Provides a greater sense of freedom when performing*
Code 6.2.5 *The performance is more fluent*
Code 6.2.6 *Enhances spontaneity and theatricality*
Code 6.2.7 *Enhances the connection with the audience*

Subtheme 6.3 Performing from memory as a standard

Code 6.3.1 *Memorisation is a requirement*
Code 6.3.2 *Memorisation as a professional standard*
Code 6.3.3 *Depends on the repertoire*
Code 6.3.4 *Depends on the occasion and context*

The next section discusses the memorisation approaches identified by the interviewees.

6.2 Memorisation Approaches

According to the interviewees, learning and memorisation should not be sequential, but two processes that develop simultaneously. Theodorakis summarised this approach with the sentence 'to learn is to memorise', with which Hardink fully concurred. They explained that memorisation should start early and assist learning in producing a deep understanding of the music; and it should be deliberate and progressive, as opposed to incidental and resulting from sheer repetition. In Hardink's words:

> if I really wanted to learn my music thoroughly, the best way to do it would be to not just read through it, over and over, until it sorts of sinks in by osmosis. But from the moment of learning the first measure, would be to memorise it right away.

However, for chamber music, this approach varied depending on each pianist's learning style. Theodorakis reported using memorisation for learning more thoroughly his part and those of the other instrumentalists, especially for enhancing coordination, or facilitating challenging page turns. Alternatively, Hardink's approach for solo and chamber music are different. For the latter, he learns how to perform the music from the score instead. Nonetheless, regardless of the genre, Hardink emphasised the importance of practising the piece in the same way as it should be performed. Thus, he practises how to interact with the score during performance or plans to memorise with enough time, accordingly:

> the worst thing I can think I can possibly do is, memorise a piece and get to within a week or two of the performance, and feel like it's not quite solid enough. And then put the music up in front of me. And then play it from the music. Because I didn't spend those early months with the music, like playing the music while looking at it, right? So, it actually becomes a completely different experience that often leads me to… just play less accurately… Because I've actually grown unaccustomed to looking at the music, and then there's certain gestures that I've internalised that, on the page… I'm not as intimate with the way it looks, as the way it sounds and feels, and the way I experienced that with the keyboard… the lesson I've learned is, I either have to learn it with a score, with the intention of performing it from the score. Or just learn it from memory and be fully committed, and not allow myself to get to any situation where I feel uncomfortable in the late stages, and suddenly put the music out.

Both Hardink and Theodorakis emphasised memorisation as essential for learning, which forces one 'to understand it by finding patterns', in Theodorakis' words. Furthermore, he noted that he 'cannot easily distinguish the memorisation process from the analytical one'. Hence, for Theodorakis, analysis is the best trigger for engaging conceptual memory:

> The analysis that I do myself on the pieces is the key for memorising them… sometimes the algorithm or the system behind pitches, dynamics, articulations… might be so complex that you cannot follow it in real time when playing. So, I have, again, to apply strategies of my own that do not have to do with the structure of a piece.

This process was also reported by Melikyan, who applies 'some sort of calculation' to the pieces he memorises (e.g., counting the number of phrases, pulses, pauses), to rationalise the music.

Furthermore, all three interviewees agreed that playing solo music from memory positively impacts their performances. For Melikyan, it becomes easier to focus on the creative aspects of the performance rather than on technical aspects, as he would when performing from the score, since the latter leads him to focusing more on the composition principles, rather than on the performance itself. Other challenges of using the score were noted by Theodorakis, such as turning pages or page-turners' potential unreliability. However, for Theodorakis, performing from memory has the greater advantage of having 'a better overview', which allows one to 'anticipate the whole form of the piece while being in a certain moment of it'. He described this feeling as being freer on stage as if he 'had much more absorbed and assimilated the music'. According to him, 'it's indeed a different feeling that you perceive as well by being in the audience; it does make a difference whether the performer is reading the piece on stage or really knows what's going to happen'.[3] When relating this effect to other performing arts (e.g., dance, theatre), Hardink summarised it as:

> the difference between reciting a piece of poetry with the text in front of you or having it memorised. I'm sure it is certainly possible to give an amazing and vivid reading of a poem, reading it from the text. But it's just the same as an actor reading their lines or having internalised them and memorised them.

Similarly, Theodorakis added that since the late nineteenth century, performing from memory 'has been a part of the virtuosity' of the soloist, just like memorising has been an essential part of theatre and dance. However, this ended with contemporary music that was 'more complex' or contained 'more information'. Highlighting that this extra difficulty should not compromise the benefits of performing from memory this repertoire, he states:

> I don't know what happens with modern theatre when actors have to recite texts in different languages or nonsense texts. I mean, it's always a help if there is direction and a kind of meaning in the text in order to memorise it. Or that you understand the language. So, what

[3] To get a sense of the phenomenon that Theodorakis is describing here, I suggest watching on YouTube the performances of Jade Simmons (https://youtu.be/5lt0kORNEn8) and Adam Kent (https://youtu.be/f-1mw_V_mTk) of the piano work *Tumbao* (2005) by Cuban composer Tania León.

> happens if you don't understand the language, and you just memorise sounds? Or you just memorise syllables or words that don't have to do anything with each other? Yes, it's also a challenge, but yet, modern actors tackle this challenge. Nobody discusses if they're going to participate in a play with their notes, with their book.

Essentially, both Theodorakis and Hardink emphasise the process of internalising the music up to a point that becomes 'intuitive'. This does not quite 'feel in the same way' when referring to the score, even if there is still the intention 'to provide that same narrative structure', that Hardink again compares to 'whether you're reading a poem, or have it committed to memory, and are really living the words that you're saying'.

Finally, Hardink concludes that playing without the score contributes to the accuracy of his performances, although this might seem 'counterintuitive': committing a piece to memory involves 'a different learning process' in which 'playing the right notes is more inevitable' since the score cannot be used during performance as a memory aid. He remarks that this is 'especially' true 'in very physical, visceral, athletic types of pieces', where your eyes are constantly disputed between the keyboard, the score, 'and sort of everywhere all at the same time'. Having these sorts of pieces in mind, he admits: 'I could put a recording side-by-side of me playing with the music and without, and I'm telling you that there are so many mistakes in my performances with the music'. However, he also recognises that this lack of accuracy can start during the learning process:

> …as I memorised it, I realised that in my reading of the score, at the climax, I played the left hand in the wrong clef… I had just never noticed it when I was reading the piece. But as soon as I started to memorise it… I was looking at things differently, because I guess, when I'm about to commit something to memory, I like to check all the boxes, and I carefully scrutinise everything… How is that even possible, that I would make a mistake like that with

> the music in front of me? But as soon as I start to commit it to memory, I realised the mistake?

Ensuring accuracy is one of the main reasons why pianists like Hardink consider that it is important to make an extra effort to also perform post-tonal music from memory. The additional dedication and commitment that is needed to be able to 'feel artistically free' when playing this repertoire without the score also implies a 'more committed and engaging' physical relationship with the instrument. Hence, 'if that feeling is so strong' when performing from memory, Hardink believes that 'it has to be different for the audience too'.

The interviewees expressed a predilection for performing solo post-tonal piano music from memory. This option enhances a vivid performance, promoting spontaneity and creativity on stage and facilitating the theatricality needed for delivering a convincing performance. According to Theodorakis, by conveying 'security and freedom' to the audience, the performance is not seen as 'a struggle', but that is 'under control'. This way, communication is preserved. Additionally, memorisation can assist in ensuring accuracy during the learning and internalisation processes. Thus, it eventually contributes to the best possible preparation for performance, which can influence the likeability of a general audience for this repertoire. The next section discusses the different kinds of complexity identified by the interviewees for post-tonal piano music.

6.3 Types of Complexity

Interviewees identified two main kinds of complexity for post-tonal piano music. The first kind was described as highly detailed scores featuring puzzling rhythms and disconnected melodic cells, with unpredictable dynamics, contrasting sections and lacking repetition (e.g., see Example 6.1). This was illustrated with composers Iannis Xenakis, Karlheinz Stockhausen, Brian Ferneyhough and Jason Eckardt.

Example 6.1: Jason Eckardt, *Echoes' White Veil* (1996), end of page 17, to exemplify the first kind of complexity.[4]

The second kind corresponded to scores based on repetition with slight variations and/or long phrases without pauses (e.g., see Example 6.2). This was illustrated with minimalist and post-minimalist pieces by John Adams and Morton Feldman; but also, specific works by Claus-Steffen Mahnkopf and Stefan Beyer.[5] Additionally, Messiaen's music was described as a mix of these two kinds of complexity.

[4] A videorecording of Hardink performing Eckardt's *Echoes White Veil* (1996) from memory is available here: https://youtu.be/kYdK0s3dN1U

[5] As an example of this second kind of complexity, Theodorakis also went through Xenakis' chamber music piece *Komboï* (1981). A videorecording of his performance of this piece is available here: https://youtu.be/Y5x7nqDjqPE

Example 6.2: Morton Feldman, *Piano Piece* (1952), beginning, to exemplify the second kind of complexity.

For Hardink, the difficulty of the first kind of complexity resides in figuring out the score and internalising all the information. Consequently, both learning and memorisation can be 'very slow':

> I feel like when I'm learning the most difficult music and memorising it as I learn it, that I'm reduced to the same state of a 10-year-old trying to learn a Clementi Sonata… if I'm learning something by Xenakis, or Eckardt, or Ferneyhough… if I commit a bar of music to memory in a given day, that might feel like a huge victory.

One of the main differences that Hardink highlighted between learning these sorts of pieces with the standard classical repertoire is that, with the latter, there is a certain familiarity with the 'language', hence internalisation is 'greatly streamlined'. Therefore, his learning process is the same for both styles of music, only that in standard classical repertoire some steps are 'instantaneous' and the same strategies 'manifest themselves differently'.

Although memorising the first kind of complexity requires extra time and effort, Theodorakis agreed with Hardink in that it is easier to memorise when there is always ‘new material, and a lot of information going on’ than ‘when there are slightly varied repetitions of the same thing’: i.e., switches within a self-referencing context.[6] According to Theodorakis, encoding ‘extreme polyphony’ and ‘rhythmical overlaying’ is more manageable than devising a system for memorising self-referencing patterns, although the latter might seem more straightforward at first. Hence, for dealing with similarity and self-referencing textures, Theodorakis uses extramusical strategies that involve ‘auxiliary types of memory’ to retain certain features of the score (e.g., systems or page breaks), while focusing on kinaesthetic memory. This was the case when he memorised Beyer’s *Hain* (Example 6.3), in which a melodic pattern is repeated in fragments of different lengths and played at a fast tempo.

Example 6.3: Stefan Beyer, *Hain* (2010), bars 1-48, to exemplify a self-referencing texture.[7]

While Theodorakis did not struggle with ‘technical clarity’, he reported a time-consuming process: ‘getting it correct memorising and presenting it with no mistakes, and being absolutely concentrated on stage… This was really an extra effort to do… photographic memory saved me and helped me with such situations’. He structured practice by segmenting the piece into different sections, according to how the main melodic pattern is presented and

[6] Switches are properly defined and discussed in Chapter 2 and Chapter 3.
[7] In the full score, the composer provides these bar numbers for this section.

the piece's structure. He also used fermatas and rests 'to anticipate' and 'think' about what was coming next, as another performance mental strategy to deal with switches.

Another kind of switches that interviewees related to this second kind of complexity was when the same rhythmical pattern repeats, transposed to different pitches each time. An example is Mahnkopf's *Beethoven-Kommentar* (bars 2-4), illustrated with Example 6.4:

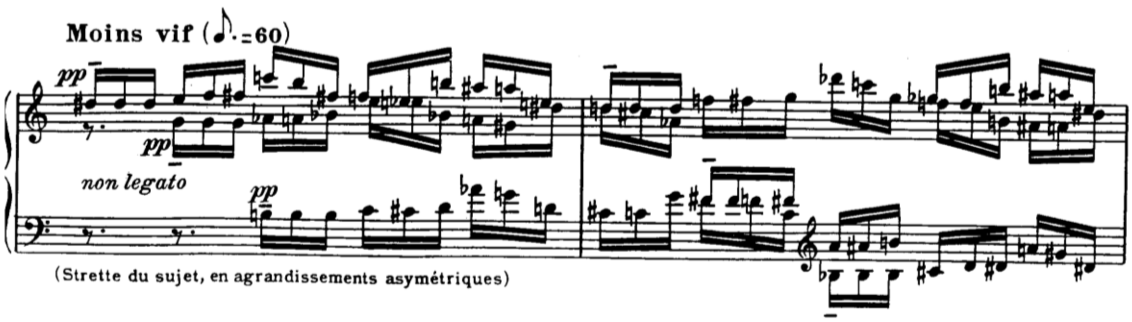
Example 6.4: Claus-Steffen Mahnkopf, *Beethoven-Kommentar* (2004), bars 1-4, to exemplify another context of self-referencing texture.[8] Here, the composer imitates the structure and initial motif from the 33rd variation of Beethoven's *Diabelli Variations Op. 120* (1819-1823). According to Theodorakis, by using 'repetitions and sequences' of 'complex rhythms', arranged 'in a motivic way'.

Theodorakis explained that Mahnkopf's *Beethoven-Kommentar* is a 12-tone piece based on the chromatic scale (see Example 6.4, bar 1), in which the pitches are orderly presented between both hands. Given that pitch organisation follows a standard musical scale, Theodorakis emphasised a challenge: the cells are predominantly based on 'major sevenths or minor

[8] An audio-recording of Theodorakis performing Mahnkopf's *Beethoven-Kommentar* (2004) is available here: https://youtu.be/WCdPtiE5Bns

seconds, and their transpositions', making it difficult to find different sonorities that can aurally enhance memorisation.

This repetition of a motif with slight harmonical differences is also the core of Messiaen's technique *agrandissements asymétriques*. This is a pitch-organisation algorithm that, every time a given musical theme is repeated, each of the pitches is either transposed a half-step higher or lower, or left the same. Again, these are switches within a self-referencing context. Theodorakis detailed the challenge that this technique poses for memory with the following canon in Messiaen's *Vingt Regards sur l'Enfant-Jésus*.



Example 6.5: Olivier Messiaen, *Vingt Regards sur l'Enfant-Jésus* (1944), 'Par Lui tout a été fait', bars 130-131, beginning of the three-part canon based on *agrandissements asymétriques*.

Example 6.5 presents a musical theme in the upper voice that is subsequently imitated by the other voices. Then, in the second bar, the same musical theme reappears in the upper voice, but slightly modified with *agrandissements asymétriques*. When comparing both bars, the D# in bar 1 goes one semitone lower to D♮, while the next eight notes are transposed one semitone higher and the last four notes are left the same. The other two voices are similarly transformed but with different arrangements. This section comprises 12 bars, and within each bar, all voices are transformed differently each time, following this algorithm.

During Theodorakis' interview, it was discussed that this canon might remind of a fugue, hence suggesting memorising all voices individually first, and then, all their possible combinations. However, as Theodorakis stated, in a fugue, 'the independency of the voices leads always to new results,' which is not what happens in this case. Hence, Example 6.5 is another instance of the second kind of complexity due to the presence of multiple switches. Concretely, Theodorakis recalled how difficult it was for him to memorise this section, precisely for the implicit risk of mixing the bars when playing:

> Here you have partly new results, but… they are slightly the same. So, what I did was not just to learn the music by heart, like fingerings and how it sounds, and telling the names of the notes in my head when doing a mental run-through of the piece. But also, I focused for instance, on the course of the harmonies that come out of the process… through this asymmetrical transposition, you've got always different vertical combinations of intervals. So, the melodies sound always quite the same… for me, it was really important to know: 'I am now in the first bar of the second system'. So, like really photographically, really having this completely unmusical way of memorising and perceiving music, assisting me in order not to get lost. Because just musical memory might not be always enough for this kind of stuff. Fingerings could be similar for every part of the sequence, or identical. So, just emphasising on the harmonies and the counterpoint, and the photographic place of every bar… it was of great help.

Finally, another example provided by the interviewees of how Messiaen's music relates to both kinds of complexity was illustrated with the work *Des canyons aux étoiles* (1974),[9] which combines rhythmical and melodic difficulty with the presence of several switches. According to Hardink, the 'stylised version of birdsong' that Messiaen uses to illustrate each bird can

[9] Hardink's CD recording of this work is available on Hyperion: https://www.hyperion-records.co.uk/dw.asp?dc=W24075_68316.
See also The Guardian's review: https://www.theguardian.com/music/2023/apr/06/messiaen-des-canyons-aux-etoiles-review-epic-score-soars-in-utahs-superb-recording

have similar gestures but resolve in different ways. This makes it challenging when playing to 'keep all those iterations straight' since you can easily mix one with the other.[10]

The next section presents the interviewees' memorisation strategies for post-tonal music and for dealing with different kinds of musical complexity.

6.4 Strategies for Memorising Post-Tonal Piano Music

Interviewees also shared their memorisation strategies, from which this chapter highlights Theodorakis' procedures for memorising pitch, rhythm and dynamics; and Hardink's metacognitive strategies for challenging memory. Finally, despite being beyond the scope of this thesis, an unexpected finding was how memorisation can condition performance anxiety and vice versa. This was reflected in their coping strategies, like using mental practice. Therefore, this section starts presenting the interviewees' memorisation strategies for different parameters, followed by practice and performance strategies, and their views and experiences with performance anxiety.

6.4.1 Strategies for Memorising Pitch

Theodorakis explained several memorisation strategies, mostly for pitch. Concretely, he described his analytical approach focused on fitting the music into a tonal framework, or any theoretical knowledge available. For example, chunking the information using known tonal patterns (e.g., chords, scales, arpeggios); but also, other familiar patterns, not necessarily tonal. He explained how he trained himself to analyse, encode and think post-tonal music 'in

[10] A videorecording of Hardink explaining Messiaen's birdsongs in the context of the piece *Des canyons aux étoiles* (1971) is available here: https://youtu.be/mC_6XmgAbw0

groups of pitches', although these 'don't necessarily have to be tonal triads', but can also be 'other types of triads or trichords' and 'tetrachords'. He also combines this principle with Forte's (1973) Set Theory,[11] to 'classify triad chords, tetrachords and hexachords by intervals', and how these can be altered with 'octave transportations and inversions'. This allows him to 'define the character of every unit by the content of the intervals': e.g., a unit with several consonant intervals implies a more consonant sound, while a unit with a combination of dissonant intervals leads to a more dissonant sound. Accordingly, Theodorakis uses these 'autonomous units' as flexible models for encoding 'very different styles of music'. Among these, he can either implement it to a composition with a pre-established system (e.g., a 12-tone row); or 'invent' his own system to memorise a piece based on stochastic distributions with 'no pitch organisation'. An example of the first kind is illustrated with Schoenberg's piano pieces (Example 6.6):

Example 6.6: Arnold Schoenberg, *Piano Piece Op. 23 No. 5* (1923), bars 1-4, to exemplify Theodorakis' memorisation strategies for pitch.

In Example 6.6, the 12-tone row is presented in the right hand, which Theodorakis uses as a model to encode the rest of the pitches. Similarly, the tetrachord technique can also be illustrated in Example 6.7:

[11] In the musical context, Set Theory is used to provide concepts for categorising certain musical objects, and describe how they relate to each other. The theoretical basis for analysing tonal music was first developed by Hanson (1960), although Forte (1973) extended this theory for the atonal repertoire.

Example 6.7: Arnold Schoenberg, *Piano Piece Op. 33 No. 1* (1929), bars 1-4, to exemplify Theodorakis' memorisation strategies for pitch.

The first two bars of Example 6.7 consist of six tetrachords, each regarded as a four-pitch unit, followed by a melodic version and a polyphonic arrangement of some of these in the next two bars. For example, the fourth tetrachord can be identified as a melody spread out in the right hand of bar 3 since both elements are built with the pitches F#–A–B–F♮, or its enharmonic equivalent.[12] Hence, once these relationships between the same groups of pitches are established, encoding simplifies to learning how the intervals generated by the four pitches in each tetrachord are combined each time. From this perspective, this piano piece could be regarded as a Theme and Variations form, in which each tetrachord (i.e., a theme) is presented in different ways.[13] However, in this case, the tetrachords do not always appear in the same order.

Finally, Theodorakis uses Webern's Piano Variations (Example 6.8) to illustrate how he combines both strategies described above to encode pitches (i.e., identifying the 12-tone row and grouping these notes into trichords or tetrachords), with recognising the implementation of symmetry.

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[12] A similar correspondence can be traced between the third tetrachord and the left hand in bar 3; the fifth tetrachord and the right hand in bar 4; and the sixth tetrachord and the left hand, also in bar 4.

[13] A Theme and Variations form is a canonical musical composition that consists in initially presenting a simple melody, that is then repeated several times with different melodic, rhythmic and harmonic variations.

Example 6.8: Anton Webern, *Piano Variations Op. 27* (1936), 'Variation I', bars 1-10, to exemplify Theodorakis' memorisation strategies for pitch.

For instance, the first seven bars of Example 6.8 form a vertical symmetry, with its axis of symmetry in the second beat of bar 4. Hence, the first three bars and a half are the vertical projection of the following three bars and a half.[14] In this work, Theodorakis mentioned that Webern provides an important indication by beaming together each trichord and tetrachord: 'this is how he wants you as a performer to understand the music' and 'is also the key for encoding and memorising the piece'.

Theodorakis used these examples to illustrate how 'knowing the rules', such as how the dodecaphonic method works or identifying a symmetrical arrangement, can be useful for memorising, since it provides a model for 'understanding' and 'organising' atonal music. However, as mentioned earlier, there might be pieces in which it is not useful to know the composition principles, because 'the processes are hard to follow, or there is no system'. Theodorakis illustrated this with Xenakis' *Eonta* (Example 6.9), in which the notes are distributed stochastically (i.e., using a random process), and that Theodorakis describes as an

[14] A similar analysis can be done for the rest of the piece, with different kinds of symmetries: e.g., vertical, horizontal, rotational.

'extreme example of absence of any logic between the pitches':

> This is typical stochastic music by Xenakis… [At the beginning] you've got the sign *sigma* (Σ). This represents the pitch group that contains all the 88 keys of the piano… [He works] with random numbers from 1 to 88. So, these pitches are completely random, and octaves do not play any role… He consciously ignores the octaves. So, the 1st key of the piano is the first A, and the 13th key of the piano is another A, but for Xenakis… they are just two different numbers.

Example 6.9: Iannis Xenakis, *Eonta* (1964), bars 1-4, to exemplify Theodorakis' memorisation strategies for pitch.[15]

According to Theodorakis, one of the most challenging aspects of memorising a piece generated with a stochastic distribution is the lack of restriction in the material used. This is important since any exclusion or avoidance of material in a composition can be potentially used as a rule for memorising, while establishing principles that permit identifying the

[15] A videorecording of Theodorakis performing Xenakis' *Eonta* (1964) from memory is available here: https://youtu.be/IzUPAMY2A8k

corresponding patterns.[16] For example, pitch organisation in dodecaphonic and serial music is determined by an ordered 12-tone row of pitches and 'a consequent avoidance of octaves'. Therefore, any groups of pitches that can be found in these sorts of compositions follow the rule that 'you almost never find octaviated things'.

Nonetheless, despite this lack of constraints in *Eonta*'s pitch organisation, Theodorakis proceeded to memorise the pitches following a similar set of rules, as described in the previous pieces. However, although he encoded the music using pitch groups, this time he needed to switch and adapt the patterns used for chunking. For example, he encoded the first half of bar 1 using a tonal framework: an 'A-flat major chord first inversion, with minor six', followed by some 'chromatic contractions [as] dissonances' on A♮ and G♮, and a B-minor chord. However, he chunked the second half of that bar using a 'chromatic tetrachord with some octaviations' and another tetrachord based on the whole-tone scale, followed by a 'D major-minor, first inversion with an F on the bass' and a D-minor first inversion. This 'very detailed process' allowed him to spot that there is a point in the piece in which Xenakis 'starts to recycle his material by retrograding it'. According to Theodorakis:

> I easily found this out because I knew the beginning by heart, and then I figured out the same intervals in the same pitches that were repeating, but in another constellation, so I quickly figured out, from some point, that he uses the retrograde of this stochastic material.

This is an example of the importance of spending time understanding the music, and how consciously engaging conceptual memory also enabled Theodorakis to become more aware of the material being used, while optimising his learning, even in a stochastic musical work with no apparent coherence. Additionally, reaching such deep knowledge of Xenakis'

[16] This also happens in Manoury's Piano Toccata, in which octaves are avoided and the rest of pitches follow a horizontal symmetry.

composition principles, or any other composer, provided a shortcut for learning and memorising, since these were used as newly established patterns for chunking. This is what Theodorakis did, for instance, with Xenakis' *Mists* (Example 6.10):

Example 6.10: Iannis Xenakis, *Mists* (1980), bars 32-37, to exemplify Theodorakis' memorisation strategies for pitch.[17]

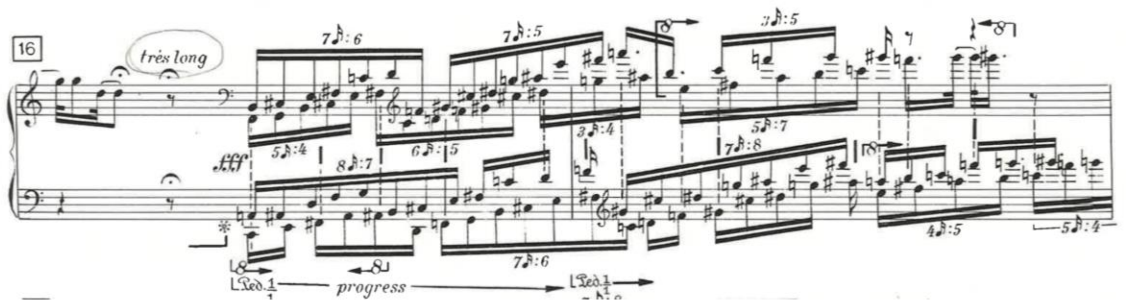
For *Mists*, Theodorakis stated that pitch organisation is clearer since this follows certain scales with 'a specific harmonic profile', resulting from applying a particular sieve.[18] Consequently, each passage is based on a determined 'harmonic surface' that Theodorakis described as 'the piano had no other keys than those'. This restriction of material to 'limited intervallic possibilities' makes it 'simpler to memorise'. Furthermore, Xenakis recycled this material in *à r. (Hommage à Ravel)* (1987), his third Piano Concerto *Keqrops* (1986) and *Naama* (1984). Therefore, internalising these sieve-made patterns consists of extending the range of patterns to which the music of this composer can be chunked and encoded.

[17] A videorecording of Theodorakis performing Xenakis' *Mists* (1980) from memory is available here: https://youtu.be/nC6DQy-aDPc

[18] In 1963, Xenakis conceived one of the main elements of his musical language: Sieve Theory. This was used as a method for creating scales by filtering elements. Sieves are closely related to the concepts of symmetry and periodicity, and can be used for pitches and rhythm. For further details see Exarchos (2007).

6.4.2 Strategies for Memorising Rhythm

Theodorakis' strategies for identifying the principles of a score were not restrained to pitches. He also illustrated how he deals with complicated rhythms. For instance, in Xenakis' *Mists* he highlighted that 'at least one of the four [voices of the polyphony] has always a simpler rhythm'. This is observed in bar 16 (Example 6.11), in which the bass starts in semiquavers. Then, this rhythmical figure moves to the tenor, and again to the bass. Finding these sorts of threads allowed him to build the rest of the polyrhythms. Theodorakis also highlighted how Xenakis simplifies the score by reflecting the proportion of these rhythms with 'good spacing', which makes clearer how the voices interact rhythmically. Then, it is a matter of not just playing the notes 'somewhere in between', but to 'try to listen and check the regularity of every line'.

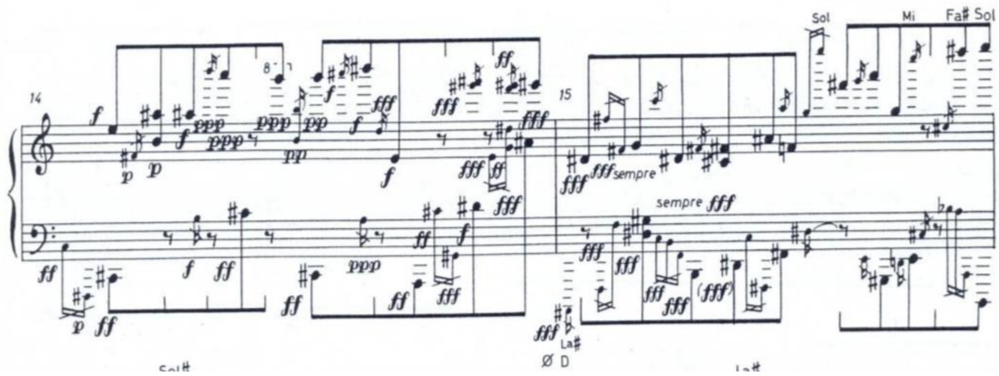


Example 6.11: Iannis Xenakis, *Mists* (1980), bars 16-17, to exemplify Theodorakis' memorisation strategies for rhythm.

6.4.3 Strategies for Memorising Dynamics

Finally, another parameter that Theodorakis exemplified how to explicitly encode was dynamics. For *Eonta* (Example 6.12), he described that there is 'a logic' behind 'the level of dynamics', because Xenakis works with them in 'statistical' terms:

> When you do a *crescendo*, you start from piano… your goal is *fortissimo*, and you go through different stages. In Xenakis' case here [*Eonta*], it is a statistical *crescendo*: you go from 100% *pianissimo* to, for instance, 80% *pianissimo* and 20% *mezzoforte*; or 10%, or 15% *piano* and 5% *mezzoforte*. And then, the 65% *pianissimo*, 20% *piano*, then 5% *mezzoforte* and 10% *forte*… as you move towards the louder dynamics, at some point you reach the goal of 100% *fortissimo*… So, it is a stochastical or statistical *crescendo*, and not a linear one as in a romantic piece… it is difficult to have the accuracy of dynamics. But understanding the logic is something that definitely helps.



Example 6.12: Iannis Xenakis, *Eonta* (1964), bars 14-15, to exemplify Theodorakis' memorisation strategies for dynamics.

Theodorakis used this logic to reinforce the implicit 'motoric feeling' of performing contrasting dynamics, since the physical action involved in playing *forte* is different from playing different degrees of *piano*, and kinaesthetic memory seemed more effective for him to retain all this information. After repeating these contrasts many times, he also internalised the sound with aural memory. However, he admitted that mainly relying on kinaesthetic memory requires that this is 'regularly refreshed', since it demands 'to go more often back to the score and verify things and information'.

6.4.4 Practice Strategies

All interviewees described several practice strategies for consciously engaging conceptual memory. However, they specified that performing a musical work also involves physical gestures, listening and reacting to the sound, and attending to visual cues. Hence, advocating for combining the Sensory Learning Styles with a conceptual understanding of the piece.[19] Concretely, Theodorakis and Hardink use these to complement and secure further deliberate memorisation, since every kind of memory provides an additional layer for developing a safety net for performance. Similarly, Theodorakis also reported using photographic memory (i.e., visual memory of the score) as an extramusical mental strategy for securing further challenging passages (e.g., switches), by visually capturing the score's layout and organisation.

Another issue regarding effective memorisation was the importance of metacognitive strategies for time management and assisting learning.[20] For example, Hardink's first rule is to not overload a practice session with an overly ambitious task. In his own words: 'holding myself to a standard… of really not proceeding past a measure, or a phrase, or a gesture of music until I really know it'. Thus, he aims at committing 'one note at a time' to his 'brain and body', while encoding it within 'a larger structure or gesture'. This helps him in developing an understanding of the piece, both on a larger and smaller scale, without risking overlooking any detail.

[19] The Sensory Learning Styles are defined and reviewed in Chapter 2.
[20] Metacognitive strategies are discussed in Chapter 2.

Once learning is focused on integrating the piece's sections, Hardink proceeds to challenge his memory in different ways, since he believes that every memory lapse 'is a chance to learn it better'. Consequently, this is his strategy for anticipating any potential memory lapses and keeping these 'from even happening' when performing. For this purpose, he tests whether he really knows a passage by changing certain parameters of it, such as the register of the piano in which he plays it:

> If I have a phrase of music that is easily transferable from one register of the keyboard to another… I practise it somewhere else on the piano… [if] my memory is just dependent on the sound of the register in which I learned it and the way it feels there, and if I take it to the bass register and try to play, it completely falls apart. Well, then I don't really know the passage.

This exemplifies how Hardink strengthens memorisation 'by finding ways in which to upset the predictability of just playing it as written'. He compared this strategy to the training that athletes do by combining 'different exercises' to challenge their muscles: 'if you're trying to build muscle in a certain area of your body… doing the same exercise over and over, day after day, is not the best way to get stronger'. According to Hardink, this principle also applies to the brain, and how this can get 'complacent' if a passage is always learned and practised in the same way. However, Hardink's strategies for testing his memory and preventing potential memory flaws are not limited to practising in different registers of the piano, but also in different instruments, especially those in poor condition:

> another way of challenging your memory and your knowledge of a piece is to sit down at an instrument that's completely out of tune and has some broken strings. And can you still play it? Or do those factors actually completely disrupt your knowledge of the piece in a certain way? So, I think part of what I'm trying to do, with even just like taking a passage that's written in the upper register… and play it in the low register, is just to recreate that jarring

> experience of like: 'Oh, I know it really well. But as soon as you change one factor in the music, it falls apart'. So again, I think the more you can find ways to create those experiences early on in your learning of a piece, then, if I happen to play on a piano that I don't like in a concert, I'm less likely to be just completely thrown off by it.

Hardink's descriptions of these metacognitive strategies aim at mitigating the context-dependent memory effect,[21] which he complements with distributed practice and the implicit implementation of the desirable difficulty hypothesis to boost the spacing effect.[22] Consequently, he avoids long practice sessions based on sheer repetition, without 'really paying attention'. Instead, he follows an elaborative rehearsal approach,[23] since he believes that kinaesthetic memory is more effectively used as an overlearning strategy.[24] Furthermore, he combines different repertoire during practice, to avoid rehearsing on the same for a long time:

> the worst thing I could do is play it 300 times in a row, and then walk away. The best thing to do would be to play it 10 times this afternoon, and then 10 times tonight, because when I come back to it, after having not seen it for a while, I'm actually engaged in the process of almost relearning it again… the more times I go through that, the more times I sort of struggle with remembering it, the more I'm actually solidifying it.

Hardink's approach of deliberately strengthening memory contrasts with Melikyan's, which consists in 'systematic rehearsals both with score and without', so memorisation is incidental and 'happens automatically' after prolonged practice. Melikyan's approach also differs from Hardink's in challenging memory by performing run-throughs with small audiences, and without using mental practice. Furthermore, Melikyan's memorisation align with that of a

[21] See Chapter 2, section 2.2.2.3.
[22] See Chapter 2, section 2.4.2.
[23] See Chapter 2, section 2.2.2.1.
[24] See Chapter 2, section 2.4.2.

visual and an aural learner:[25] he described 'drawing imaginary lines' based on his hand positions on the keyboard and rationalising it. Accordingly, he memorises a musical work as a 'set of geometric shapes and mathematical calculations' (see Figure 6.1). However, with time, he started relying more on aural memory, describing the phenomenon known as associative chaining.[26]

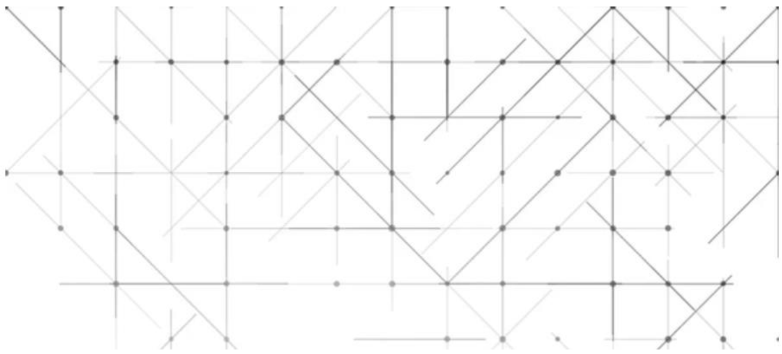


Figure 6.1: Drawing provided by Melikyan to illustrate the geometrical shapes on the keyboard described above.

Therefore, Melikyan's memorisation approach does not rely on a single parameter, but his focus constantly shifts from basic issues (e.g., fingering, articulation), to his theoretical understanding of the piece, and the expression he wants to convey. Again, his descriptions align with the literature on musical memorisation, and concretely, Performance Cue Theory.

6.4.5 Performance Strategies

Interviewees suggested that for them memorisation is a double-edged sword. Memorising solo repertoire provides extra value to the performance: there is deeper involvement with the music during practice, avoiding depending on the score even when this is present on the music stand. Nevertheless, they admitted that memorisation requires further dedication,

[25] These types of learners established by Svard and Mack (2002) are discussed in Chapter 2, section 2.4.2.
[26] See Chapter 2, section 2.3.

potentially triggering performance anxiety. Concretely, Melikyan experiences performance anxiety, which intensifies when performing from memory, as he is 'always worried about forgetting the text', despite his confidence in his 'memorisation skills'. Hence, using the score is his most effective strategy for preventing such anxiety. Hardink aligned with this view, recognising that there is 'a whole level of anxiety' that disappears when using the score and playing chamber music. However, in solo contexts, his 'level of fear' before going out on stage is comparable to that of having 'to jump out of an airplane', especially when performing something for the first time. Similarly, Theodorakis mentioned that pianists can sometimes use 'pills and other medications' for preventing performance anxiety, which can occasionally lead to suffering 'nervous breakdowns'. Nevertheless, Theodorakis reported not using those since his practice methods and memorisation strategies tested over the years through his experience provided him 'with confidence', enabling him to keep performance anxiety 'under control'.

Hardink's metacognitive strategies suggested that his memorisation approach is determined by his performance anxiety. Concretely, seeking effective ways of preparing himself as thoroughly as possible is his coping mechanism for effectively confronting it on stage. Hence, memorising early on, challenging his practice in different ways, and explicitly testing his understanding and conceptual memory are essential performance strategies that he deliberately implements much in advance of the performance. In his own words:

> memorisation and performing from memory seem to be one of the main factors in what makes being a pianist so neurotic and anxious… I think for pianists, especially, you're just responsible for so much information, especially when it's committed to memory. It sometimes seems like on the verge of what is reasonable to ask a person, a student, a human to deliver… So, the more comfortable you can get with that process, and the more committed and solid you can feel in performance, then you can sort of mitigate that anxiety.

Moreover, performance strategies for coping with performance anxiety were further emphasised by Hardink through his implementation of mental practice:

> No one wants to hear stories about their Carnegie Hall debut [laughs]. But certainly, I played a solo recital there for the first time, just a couple of years ago. And so, I obviously planned a kind of long-term process, to get ready for that event. And knew my music cold and all of that. But there was nothing that could prepare me for trying to fall asleep in my hotel room in New York City, the night before that concert. And I just couldn't sleep… I just laid there, and I played through my pieces… I think I probably fell asleep by like four in the morning… Certainly, I was using that mental practice as an anxiety coping mechanism.

Hardink emphasised experiencing performance anxiety with different levels of intensity depending on the performance's context and repertoire: whether it is a premiere or the first time performing a piece, who is present in the audience, the venue's prestige, how challenging the pieces are, etc. This previous statement also suggested that mental practice can be an effective performance strategy for effectively delivering one's previous preparation during practice. Accordingly, deliberate practice and effective memorisation strategies might not suffice for successfully performing from memory. Beyond this, one's self-regulation strategies, such as an appropriate use of mental practice, might be required. Moreover, Hardink recognised that the nature of self-talk before performing hugely impacts him:

> I think [what] we all dislike the most, it's: you're ready to walk out on stage, and then someone starts to make an announcement, or the conductor decides to introduce the composer or whatever it is, and you suddenly went from feeling like I'm about to walk out. And now I have four minutes to pace back here and think about all the ways in which I can mess up this piece.

In situations like this, Hardink triggers positive self-talk and mental practice, which provides him with the certainty that if he 'can play through every note' in his mind, then 'there's no amount of nerves or distractions' that can 'disrupt' his preparation. Thus, knowing that his mind has 'the music fully committed' and not only his 'fingers' is what makes him confident:

> strengthening the memorisation of a passage is the same thing as being ready for anything that goes wrong in a performance. So, I'm constantly telling myself that anything that strengthens my understanding, and relationship, and knowledge of a certain passage of music is going to make the performance better.

In a way, Hardink's views advocate for Conceptual Simplification's approach, in which the music is simplified or modified in different ways until full understanding is achieved.

All interviewees reported mental practice as an effective strategy for complementing physical practice with the instrument. Hardink described it as an essential 'Zen-like ritual' to locate flaws in memory and develop an understanding of the piece, while providing him with confidence to tackle performance anxiety, helping him to focus. Similarly, Melikyan's routine involves imagining himself performing the piece before going to sleep, although he does not regularly perform from memory since he frequently changes his repertoire. Thus, his most frequent strategy for securing memory further is to play for a small audience, relying more on physical than mental run-throughs. Finally, for Theodorakis, mental practice had a more central role and implied memorisation. As a student, he had limited time to physically practise on a piano, hence he mentally rehearsed for many hours first, to then check specific details on the instrument. Despite Theodorakis rehearsing now more on the piano from the beginning, he reported still using mental practice to recall a memorised piece in different moments and situations of the day.

6.5 Influential Parameters

Interviewees conveyed that complexity is an influential parameter for memorisation. Additionally, they were also asked about their experience with sight-reading, perfect pitch, synaesthesia, emotions and sleep, and how these influence their memorisation. For them, synaesthesia and emotions do not play a conscious role when memorising. However, sight-reading and perfect pitch were described as two skills that contribute to creating the first impression of a piece, helping in internalising, and even memorising, the music early on.

Focusing first on sight-reading, Melikyan confirmed that feeling confident with this skill is important for memorising, which for him starts when sight-reading for the first time, since 'lots of things become very clear' then. According to him, this is 'directly related to the level of professionalism and experience'. Similarly, Theodorakis noted that for being a fluent sight-reader, you need to prompt 'a quick understanding of the style' and 'compositional principles', which allows you to 'anticipate' the upcoming bars. Hence, 'memorising and sight-reading' are procedures 'that sharpen the ability of understanding the music'. Nevertheless, Theodorakis stated that sight-reading is not 'relevant' to his memorising technique. Similarly, for Hardink, sight-reading can lead to 'a sort of extreme intellectualisation of hearing the music before you even play it', and so 'process what you're seeing into music'.

Certainly, this visual approach can be linked to an aural one. However, is it essential to have perfect pitch to experience this? Hardink has relative pitch, but he can still read a score and imagine how it sounds, which is a procedure that, according to him, can be even easier when having perfect pitch, as Theodorakis confirmed. Conversely, Melikyan did not regard perfect pitch as an advantage for memorising. This argument was contrasted by Theodorakis, advocating that perfect pitch can be useful, though not essential, when recalling independent pitches that are not related harmonically, such as 'pointillistic textures'. Also, frequently performing atonal music can be 'a good training' for sharpening perfect pitch, even when not having one. Nonetheless, given the small size of the sample, these results were inconclusive.

Finally, the last parameter discussed was sleep. Melikyan did not report any significant experiences related to memorisation and sleep. Alternatively, Theodorakis regarded sleep as a strategy for 're-approaching' problems that may arise during practice, since stepping back and relaxing 'might lead quicker to the solution'.[27] Additionally, whenever attempting mental recalls of pieces he is learning, he can be more successful in the morning, after a good night's sleep. Lastly, Hardink extended sleep's potential for memory to 'the act of resting a piece', as an effective method for deepening understanding:

> you could work really hard at something, get a great night's sleep, and come back the next day, and have something click. I find that that process can also be extended over a piece that you work on for a year, and don't play for a year, and then bring it back. And somehow the piece has developed inside of you, when you weren't consciously working on it… the process is to actually let go of the music for a while: whether it's to sleep at night, or to just give it a break, and… something positive happens, and you don't just like, forget it and can't play the piece anymore. Certainly, there's a period of like building it back up.

[27] Theodorakis also mentioned that he tries to have an afternoon nap whenever possible.

6.6 Summary

According to the interviewees, there are more reasons for performing post-tonal piano music from memory than from the score. Especially, for developing understanding, and prompting more accurate and vivid performances. Also, for enhancing communication with the audience, promoting its interest in the lesser-known repertoire. Furthermore, learning and memorisation should not be distinguished one from the other, since combining them leads to confident performances.

Memorisation strategies develop with each pianist's personality and learning style, according to their needs, but also the repertoire and context of the performance: two different pianists could use the same strategies, but these might be implemented differently. For instance, Theodorakis advocated for a 'multi-tasking' approach, in which he practises all the score's indications at once. Additionally, he does not simplify complexity by layers but rather focuses on the most difficult sections first. Alternatively, Hardink reported practising strategies that challenge his learning process, instead of repeatedly following the same approach,[28] since he considers that efficiency is inversely proportional to the length of practice. Hence, whenever he feels distracted or inefficient, he either stops or changes his practice routine, only using repetition as an overlearning strategy. However, both Theodorakis and Hardink memorise as they learn and rely on mental practice as an important strategy for consolidating memory, although Theodorakis also combines this with perfect pitch.

Nevertheless, this approach requires time, especially for challenging pieces. For Melikyan, memorising is mostly not possible due to his busy performing agenda, which also involves learning different programmes in a short timeframe. This presents a different paradigm of a

[28] Some of these strategies would involve transposing things to different registers of the piano, playing them in different groupings, different tempos and even different dynamics. Also, in different instruments.

performer, without enough time for memorising thoroughly. Therefore, his performance preparation combines good sight-reading skills and incidental memorisation, reason for which he feels less confident performing from memory, despite having memorised the music. Thus, he often uses the score as a memory aid to boost his confidence.

Another issue discussed was collaborative work with composers and whether this was an advantage when memorising. According to Theodorakis, knowing a piece's composition principles is only helpful for memorising if simple enough: the most useful analyses and memorisation strategies are the ones developed by the performer itself. Nevertheless, all three pianists identified two main kinds or extremes of complexity in post-tonal piano music: the most detailed and the simplest. For the latter, they highlighted the implicit difficulty of switches, requiring efficient strategies to deal with self-referencing pieces. For Theodorakis, the most effective was relying on extramusical resources (e.g., photographic memory) and mentally monitoring the score when performing while relating it to the structure. Also, to use rests and fermatas to anticipate what comes next.

Nonetheless, it was conveyed that memorising post-tonal piano music demands a flexible approach, including using tonal music strategies. However, with atonal music, new patterns might be needed for encoding and memorising. Also, it can help to identify the material's restrictions and use these as a rule for identifying patterns. Similarly, complex rhythms can be memorised by discerning the simplest components to build the remaining rhythmical structure, whereas dynamics memorisation tends to combine conceptual and kinaesthetic memories, using the Sensory Learning Styles as an additional safety net.

Beyond memorisation strategies, it was also discussed effective ways for structuring practice. Concretely, Hardink carefully portions the amount of music to learn and memorise in a single day, prioritising quality rather than quantity. Also, he regards mistakes as tools for identifying flaws in memory and learning better a passage. Accordingly, Hardink practises and recalls a piece in different ways and times, prompting relearning to strengthen memory.

It was also suggested that performance anxiety is commonly triggered by the fear of forgetting when performing from memory, which increases according to the performance context. However, deliberate memorisation could significantly mitigate this anxiety, in combination with mental practice and positive self-talk. Another effective strategy for reducing such anxiety was using the score, even if barely used when performing. Since none of the interviewees received any training on how to memorise better, this might explain why Melikyan and Hardink still experience performance anxiety, and that all three developed different strategies to tackle it. For instance, Theodorakis relies on his memorisation strategies and analytical approach, while Hardink practises in all possible ways to foresee potential memory lapses and strengthen his memory accordingly. Alternatively, Melikyan prefers to perform with the score on the piano stand, and not worry about memory.

Finally, in terms of influential parameters, sight-reading was considered useful for familiarising oneself with a new piece, along with perfect pitch, the latter not essential. They also mentioned the benefits of gaining perspective on a musical work, either in the shorter-term using sleep or in the longer-term by resting the piece for a while. Both processes were identified as helpful for enhancing understanding at many levels.

The next chapter presents the findings from the Study with Participants.

Chapter 7: Findings from the Study with Participants

7.1 Introduction

This chapter presents the findings of testing with other practitioners some Conceptual Simplification strategies described in Chapter 3, while identifying other successful strategies for memorising post-tonal piano music. Participants memorised four excerpts,[1] either using their own strategies (Group X: control group) or following a series of instructions (Group Y: experimental group), which recreated my own implementation of Conceptual Simplification for these excerpts. Participants in Group X were PB-X, PC-X, PH-X and PK-X; and for Group Y were PA-Y, PD-Y, PE-Y, PF-Y, PG-Y, PJ-Y and PL-Y. Additionally, the study evaluated whether the suggested strategies could be useful for the participants' daily performance practice, either as a brand-new approach or mixed with their regular working methods. Finally, it also aimed at testing:

1) In what ways the given instructions influenced Group Y's results in comparison to Group X's.

2) Given that participants completed a Morning Memorisation Test (MMT), an Afternoon Recall (AR) on that same day, and a Next-Day Recall (NDR) on the following morning: in what ways did a night's sleep influence the NDR results, as opposed to the AR.

Inevitably, each test's limited timing might have influenced the participants' responses. Thus, they were also asked about whether the suggested strategies could have been useful, having had more time during the test, or in a longer term.

[1] Participants in the Pilot Study were only asked to memorise three excerpts. Once the design and method were validated with participants PA-Y, PB-X and PC-X, it was considered that an additional atonal excerpt (i.e., Excerpt 4) was needed, to fill a gap in the spectrum of repertoire covered with this study.

The key findings of this study were:

1) Participants reacted differently, conditioned by experience, background, abilities and learning style. Unexpectedly, perfect-pitch possessors and kinaesthetic learners found Conceptual Simplification useful.

2) No scientific background is required to effectively implement Conceptual Simplification, as shown in the results of the Logical Reasoning Test and the Memorisation Test. Nonetheless, Group Y did not implement Conceptual Simplification's three-step procedure on their own (see Chapter 3), but only followed the given instructions that guided them through the process.

3) The most successful participants in control Group X were those implementing Conceptual Simplification strategies on their own. This suggests that this method is the most effective for memorising the excerpts. However, since these participants had no instructions on how to memorise using Conceptual Simplification, they were more successful than their group peers, but less than those participants in Group Y following the method.

4) Conceptual Simplification strategies worked well in combination with the participants' usual memorisation strategies. The most efficient Conceptual Simplification strategies were those based on conceptual memory. Amongst these, *solkattu* could be an effective strategy for memorising complex rhythms.

5) Most participants found it easier to recall the excerpts after sleeping.

These findings are presented as follows. First, a summary of the participants' memorisation approaches is provided. Since their profiles were detailed in Chapter 4, only some features are summarised. Secondly, the different types of complexity identified by the participants are exposed. Thirdly, all strategies implemented by the participants, including those suggested, are discussed. Finally, the roles of sight-reading, perfect pitch, synaesthesia, mental practice, sleep, emotions and scientific background are analysed, concluding with a summary of the findings.

7.2 Memorisation Approaches

The recruited sample was quite varied. Participants were originally from the UK, USA, Canada, Singapore, Oman, Greece, Cyprus and Russia. However, except for PG-Y, they had all studied piano performance in England. Participants included one amateur with 15 years of piano-playing experience, two 2nd-year BMus students, one bachelor's graduate, three master's graduates and postgraduate students, one PhD student, and three professional pianists. From the total sample of 11 participants, only two scored less than 50% in the Logical Reasoning Test (LRT) and another two scored more than 80%. Most participants correctly answered at least 60% of the questions. The LRT was a timed test, expected to be completed in 18 minutes. Nevertheless, PF-Y needed 40 minutes, while PK-X only needed 14 minutes and 50 seconds. The LRT's easiest question was the fifth one, which was correctly answered by all participants; and the most difficult was the first one, which was only guessed by PB-X and PK-X.[2]

[2] Further details on the participants' profiles can be found in Chapter 4.

According to Svard and Mack's (2002) classification of types of learners and Mishra's (2004) learning styles,[3] participants were classified as follows (see Table 7.1), highlighting further the sample's heterogeneity. Despite the diversity of profiles, a tendency was observed toward preferring an Analytical Learning Style with PB-X, PC-X, PG-Y and PH-X; and toward relying on the Sensory Learning Styles with PD-Y, PE-Y, PF-Y and PL-Y. Finally, PA-Y, PJ-Y and PK-X fell in between.

Table 7.1: Individual learning preferences of participants.

Participant	Visual learner	Aural learner	Kinaesthetic learner	Analytical/conceptual learner
PA-Y	X			X
PB-X				X
PC-X				X
PD-Y		X		
PE-Y		X	X	
PF-Y	X		X	
PG-Y				X
PH-X				X
PJ-Y		X		X
PK-X	X	X		X
PL-Y	X	X	X	

PE-Y, PF-Y and PL-Y admitted that their confidence in the memorised excerpts could have been higher if they had engaged more with the instructions' analytical approach. These participants rarely analyse music when memorising, hence the suggested strategies collided with their usual procedures. PE-Y also highlighted the importance of always using the same score when learning and memorising, since changing its visual appearance can seriously

[3] See Chapter 2.

disrupt cognition. Finally, PJ-Y tends to control the right hand with the ears and the left hand with the eyes, arguing that the sound of the right hand is usually more distinct than that of the left hand, which also requires deeper knowledge of harmony.

Another important issue was understanding why participants find memorisation useful, and pursue this performance option, even when not compulsory. Amateur PG-Y highlighted how memorisation forces understanding, develops a comprehensive view of the music and avoids exclusively relying on kinaesthetic memory. This participant also uses memorisation as a coping strategy for performance anxiety, to ensure delivering the closest possible performance to the one practised. Also, PG-Y claimed that playing from the score, even when using this as a memory aid, can be distracting. PA-Y and PH-X coincided with PG-Y in that memorisation enhances understanding, and should be planned and developed well in advance, so this is useful for focusing on the performance. Similarly, both made clear that performing from memory and performing from the score should be regarded as 'two completely different mindsets', in PH-X's words, and practice should unfold accordingly, while conceptual memory should be engaged regardless.

Thematic analysis on the Questionnaire revealed the participants' following approaches to memorisation, as summarised in Table 7.2:

Table 7.2: Resulting themes from the thematic analysis on the Questionnaire.

THEME 1: Memorisation approach conditioned by the repertoire
Subtheme 1.1 Depends on the musical genre
Code 1.1.1 *Solo vs. chamber* ***Code 1.1.2*** *Style (Baroque, Classical, Impressionistic, Contemporary)* ***Code 1.1.3*** *Harmony's complexity* ***Code 1.1.4*** *Amount of detail or information*
Subtheme 1.2 Depends on the musical texture
Code 1.2.1 *Melody with accompaniment vs. Polyphonic texture* ***Code 1.2.2*** *Presence of switches* ***Code 1.2.3*** *Lack of repetition*

Code 1.2.4 *Technical difficulty*

THEME 2: Memorisation approach conditioned by the learning styles

Subtheme 2.1 Sensory Learning Styles

Code 2.1.1 *Visual memory*
Code 2.1.2 *Aural memory*
Code 2.1.3 *Kinaesthetic memory*

Subtheme 2.2 Analytical Learning Styles

Code 2.2.1 *Conceptual memory*
Code 2.2.2 *Segmented Processing Strategy*
Code 2.2.3 *Mental practice*

Subtheme 2.3 Interaction between learning and memorisation

Code 2.3.1 *Memorisation as part of the learning process*
Code 2.3.2 *Memorisation as an outcome of learning*

THEME 3: Memorisation approach conditioned by other factors

Subtheme 3.1 Amount and quality of practice

Code 3.1.1 *Length of practice session*
Code 3.1.2 *Deadline to performance*
Code 3.1.3 *Deliberate practice vs. Practice based on repetition*

Subtheme 3.2 Previous experience

Code 3.2.1 *Familiarity*
Code 3.2.2 *Performing experience*
Code 3.2.3 *Propensity to performance anxiety*

Subtheme 3.3 Mental health

Code 3.3.1 *Ability to focus*
Code 3.3.2 *Attitude and general well-being*
Code 3.3.3 *Stress management*

THEME 4: Memorisation strategies

Subtheme 4.1 No strategies

Subtheme 4.2 Written Strategies

Code 4.2.1 *Analysis (formal, harmonic, thematic)*
Code 4.2.2 *Segmentation (formal structure, phrases, cells)*
Code 4.2.3 *Numbering*
Code 4.2.4 *Mapping relationships*
Code 4.2.5 *Chunking (identifying patterns)*
Code 4.2.6 *Written recalls*

Subtheme 4.3 Physical Strategies

Code 4.3.1 *Sight-playing*
Code 4.3.2 *Verbalisation and Singing*
Code 4.3.3 *Segmentation (formal structure, phrases, cells)*
Code 4.3.4 *Blocking*
Code 4.3.5 *Practising by altering certain parameters (tempo, register, switching hands)*
Code 4.3.6 *Practising transitions*
Code 4.3.7 *Practising backwards*
Code 4.3.8 *Repetition of challenging sections*
Code 4.3.9 *Run-throughs*

Subtheme 4.4 Mental Strategies

Code 4.4.1 *Sight-reading*
Code 4.4.2 *Visualising the keyboard*
Code 4.4.3 *Combining mental and physical practice*
Code 4.4.4 *Mental practice or run-throughs*

Subtheme 4.5 Aural Strategies

Code 4.5.1 *Listening to recordings*
Code 4.5.2 *Perfect pitch*
Code 4.5.3 *Linking sound to movement*

Subtheme 4.6 Visual Strategies

Code 4.6.1 *Mnemonics or Memory cues*
Code 4.6.2 *Identifying black-and-white patterns*

Subtheme 4.7 Emotional Strategies

Code 4.7.1 *Emotions as meaningful encoding*
Code 4.7.2 *Emotions as a well-learned retrieval structure*

Subtheme 4.8 Metacognitive Strategies

Code 4.8.1 *Planning practice goals*
Code 4.8.2 *Listening to recorded run-throughs to refine the performance*
Code 4.8.3 *Resting the piece*
Code 4.8.4 *Training non-musical memory and rational thinking*
Code 4.8.5 *Enhancing physical and mental well-being*
Code 4.8.6 *Sleeping*
Code 4.8.7 *Exercising*

THEME 5: Disadvantages of performing from memory

Subtheme 5.1 Risk of forgetting

Code 5.1.1 *Performing from memory can trigger performance anxiety*
Code 5.1.2 *Lacking confidence can hinder the performance*
Code 5.1.3 *Requires conceptual memorisation*

Subtheme 5.2 Potential obstacles

Code 5.2.1 *Lack of memorisation training or effective methods*
Code 5.2.2 *Requires more time and work*
Code 5.2.3 *Good sight-reading skills limit memorisation ability*

THEME 6: Benefits of performing from memory

Subtheme 6.1 Performing from memory is useful

Code 6.1.1 *Helpful for practising*
Code 6.1.2 *Performing from the score can be dangerous*
Code 6.1.3 *Memorisation deepens understanding*
Code 6.1.4 *Memorisation engages conceptual memory*

Subtheme 6.2 Performing from memory enhances performance

Code 6.2.1 *Memorisation facilitates focus*
Code 6.2.2 *Memorisation prompts confidence*
Code 6.2.3 *Deepens the emotional connection to the music*
Code 6.2.4 *Provides a greater sense of freedom when performing*
Code 6.2.5 *The performance is more fluent*
Code 6.2.6 *Performing from memory enhances communication, spontaneity and theatricality*
Code 6.2.7 *Can be a strategy for coping with performance anxiety*

Subtheme 6.3 Performing from memory as a standard

Code 6.3.1 *Memorisation is a requirement*
Code 6.3.2 *Memorisation as a professional standard*
Code 6.3.3 *Depends on the repertoire*
Code 6.3.4 *Depends on the occasion and context*

Participants described their memorisation process to be shaped by the repertoire, with their strategies varying according to the musical genre,[4] texture,[5] and harmony's complexity; and their learning styles, depending on whether memorisation was an essential part of learning, or an outcome of practice. For those participants who considered memorisation essential for prompting internalisation, they reported that this enhanced their understanding, was useful for practising, deepened their emotional connection to the music, and provided a greater sense of freedom when performing. However, their memorisation process was conditioned by the length of practice sessions, performances' deadlines and previous experience; but also, cognition and mental health (e.g., attitude, concentration, ability to focus, level of stress, feeling well-rested). All these determined the main disadvantages and benefits of performing from memory. Amongst the disadvantages, there was the fear of forgetting and the additional time required for memorising. PC-X also noted that good sight-reading skills could limit this memorisation ability. Conversely, the identified benefits were deepening understanding; enhancing performance by feeling more focused, confident and spontaneous; and meeting the professional standard for solo pianists of performing from memory, excluding chamber, collaborative and post-tonal music with complex scores.[6]

For participants, memorising implied two main challenges. First, internalising effectively the music, which cannot be rushed and requires discipline. Consequently, they reported using

[4] i.e., baroque, classical, romanticism, impressionism or contemporary.
[5] e.g., polyphony, melody with accompaniment.
[6] The examples provided by the participants for complex music were compositions with graphic scores, or more conventional works with lots of detail, difficult rhythmical patterns and structures, and daunting musical textures in which the music seems random. These could involve multi-layered or self-referencing textures, and scores with multiple switches or with a lack of repetition.

deliberate practice such as working at different tempos, using mnemonics,[7] focusing on voicing and switching hands when practising. Secondly, consciously combining different types of memory for preparing a bulletproof performance. Concretely, the Memorisation Test provided plenty of evidence on memory's volatility and how unreliable kinaesthetic memory was on its own. Therefore, to overcome such challenges, participants reported using written, physical, mental, aural and visual strategies.[8] Written strategies included different forms of analysis; numbering; chunking, including according to a tonal framework; mapping relationships on the score, such as a structural dynamic map or for differentiating switches; and written recalls. Physical strategies involved verbalisation and singing; segmentation according to the formal structure, sections, numbered phrases or cells; Blocking,[9] practising transitions and using backwards motion;[10] switching hands, focusing on a specific hand or practise swapping from one to the other; run-throughs and performing the piece in different ways, to spot flaws in memory.[11] Mental strategies were reported by either using the piano to visualise the keyboard, and combining mental and physical practice; or without the piano, monitoring different types of memory when attempting mental run-throughs. Similarly, aural strategies included listening to recordings, perfect pitch, and linking sound to movement when practising mentally. Finally, visual strategies involved developing memory cues, including mnemonics or emotions. Participants also mentioned metacognitive strategies such as planning, recording and noting mistakes, leaving the piece for a while, training non-musical memory and rational thinking, enhancing physical and mental health, sleeping and exercising.

[7] These could be personal associations such as a list of words, pictures or colours.
[8] PK-X and PL-Y claimed not using any strategies to memorise, although they reported some during the interviews.
[9] Nellons (1974: 27-46).
[10] PF-Y also reported the following order for memorising challenging passages: 1) notes 2) fingering 3) rhythm 4) articulation 5) phrasing 6) dynamics 7) tempo, etc. In a way, PF-Y reports an implementation of Simplifying Layers of Complexity, where the layers are the musical parameters.
[11] For those participants with a tendency on relying solely on kinaesthetic memory, these physical strategies would also include memorising by repetition.

However, only PA-Y, PB-X, PD-Y and PH-X reported specific memorisation strategies. Furthermore, participants detailed their learning periods as follows:

1) Preliminary Work and Understanding: musicological research, listening to recordings, reviewing the score, sight-reading, writing fingerings, analysis and mental practice.

2) Sectional Practice: segmentation, chunking, mapping, problem-solving and deliberate practice.

3) Integrational Practice: progressive learning and improvement of technical mastery.

4) Evaluation

5) Preparation for Performance

PA-Y and PH-X also described repetition as an overlearning strategy: PH-X repeats 'certain patches' many times that are 'particularly challenging', while PA-Y strengthens memory from different perspectives, preventing cognitive overload by not memorising 'too much at a time'. Other overlearning strategies were attempting mental and physical run-throughs privately and in different tempos, or in front of others. Generally, those participants that usually memorise analytically reported feeling more confident when performing under stressful situations. Also, participants highlighted the importance of good improvising skills for overcoming memory lapses and having a hierarchical retrieval structure to tackle switches or jump to the next section, if necessary. Figure 7.1 summarises the participants' levels of confidence, depending on the context of the performance.

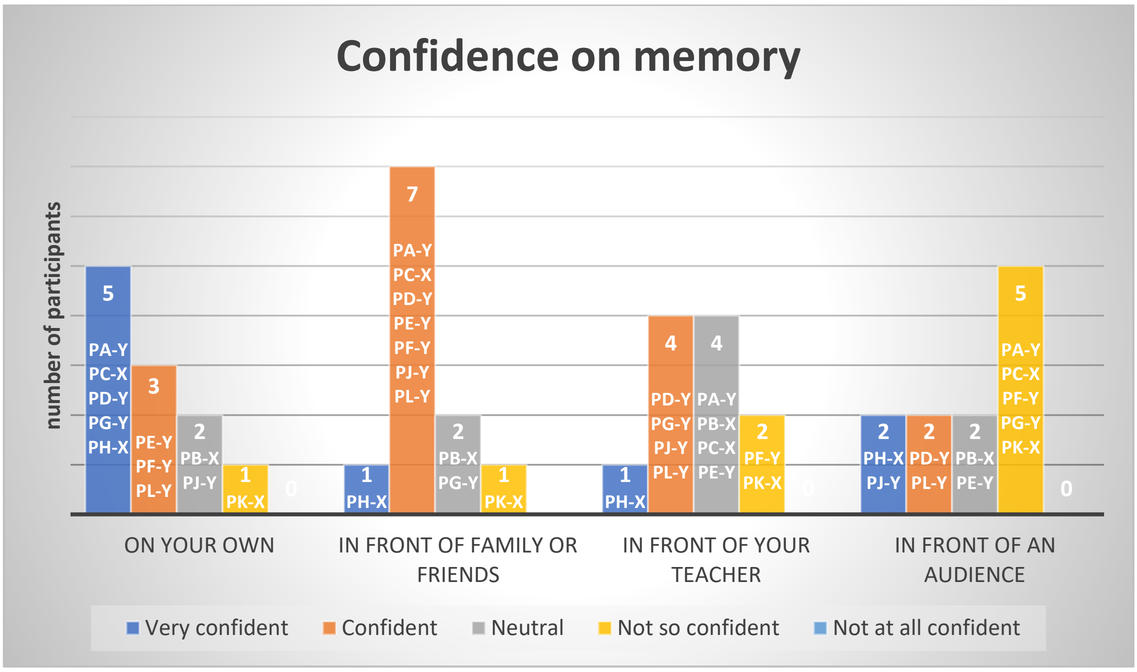


Figure 7.1: Participants' confidence on their memory, once they have memorised a piece of music, assessed within different contexts.

The next section presents the identified challenges of the excerpts.

7.3 Types of Complexity

Participants were asked which excerpts they found most difficult and the easiest. As show figures 7.2-7.3, the most challenging excerpts were 1 and 3, which were found easier after sleeping between the AR and NDR, and equally or even more difficult between the MMT and AR. Conversely, excerpts 2 and 4 were the easiest ones. Excerpt 2 had traces of tonality and a memorable tune, while Excerpt 4 was quite short.

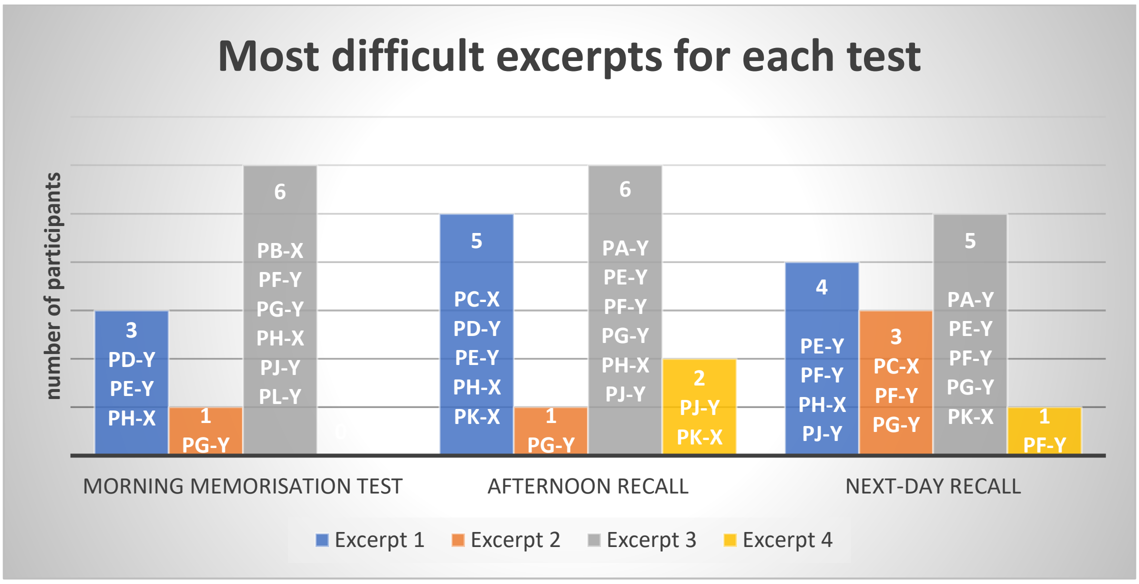


Figure 7.2: Excerpts that were found the most difficult by participants for each test.

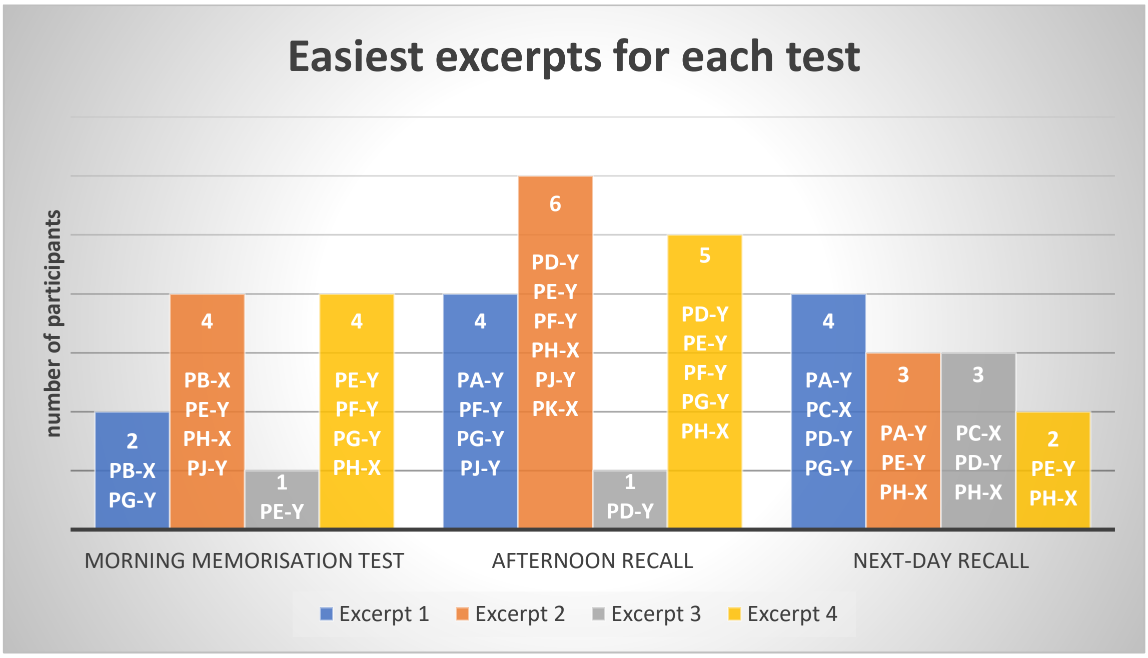


Figure 7.3: Excerpts that were found the easiest by participants for each test.

Excerpt 1 was difficult for participants who rarely analyse harmonically (e.g., PD-Y); or by those who did not identify a pattern within the chords (e.g., PH-X). For all of them, this difficulty increased in the AR. PD-Y could remember the patterns and was able to follow the suggested steps from memory, but it felt like practically re-learning the excerpt, since this participant usually memorises using perfect pitch. PD-Y also found that 'the left hand was trickier'. Similarly, participants regarded as kinaesthetic learners (e.g., PE-Y); or those that deliberately seek for coherence but did not find any in these chords (e.g., PH-X), struggled more in the AR. PE-Y could only remember the top line and some of the chords, thus trying to follow the right hand, while PH-X could only remember the first half of the excerpt and forgot in which octave it should be played. Their memory deteriorated even more during the NDR, when PE-Y claimed playing, along with the top line, 'random notes' with 'both hands', while PH-X felt 'a bit more inaccurate'. Furthermore, those Group X's participants who analysed harmonically also struggled in the AR. For instance, PC-X found it harder because this excerpt 'had more notes' and needed to get 'used' to the chords. Similarly, PK-X 'spent 11 minutes, literally, just figuring out the first note' and 'starting on different inversions', although PK-X knew 'they were a tritone apart, and… they were both minors'. Thus, not conceptualising the chromatic sequences eventually became an obstacle for this participant.

All participants struggled the most with Excerpt 3 which, in many cases, forced them to exceed the indicative timing. This was extended from 30 minutes (Pilot Study) to 45 minutes (Main Study). Nonetheless, PB-X, PF-Y and PH-X needed to take a break, and PG-Y did not complete it. Also, PL-Y mentioned struggling to 'hear it' using perfect pitch in the same way as for the rest of the excerpts, partly attributing this to a lack of expertise in recent post-tonal music. Additionally, during the AR, PA-Y could remember the pattern by recalling the symmetrical pitch organisation, but struggled with the rhythm and knowing where each note or chord came in. Such difficulty with rhythm was experienced by all participants, regardless of their group or expertise.

For Excerpt 2, PG-Y's major difficulty was hand coordination and counting, instead of memorisation. However, PC-X claimed that excessively relying on kinaesthetic memory for this excerpt caused some memory slips during the NDR. Finally, Excerpt 4 was easy for most participants. However, not paying attention to pitch organisation forced PJ-Y and PK-X to do some 'guesswork'. An exclusive reliance on kinaesthetic memory also trapped PF-Y during the NDR, who realised that the visual strategy of remembering white-and-black combinations was not so reliable in the longer term.

Additionally, the level of difficulty experienced by the participants was also conditioned by their familiarity and expertise with the excerpts: PC-X and PK-X could name the author and even the work from where Excerpt 1 was selected;[12] PK-X recognised Excerpt 3,[13] and PJ-Y had heard it before. Similarly, PH-X had previously heard Excerpt 2 on multiple occasions,[14] and had it 'already' in the ear, despite not recognising the piece. Also, PB-X never 'played anything quite like' Excerpt 3 but was familiar with the style of excerpts 1 and 2, for which PD-Y had a vestigial aural memory. Therefore, any previous knowledge of the excerpts might have posed an advantage over other participants. Additionally, all participants except for PE-Y, PK-X and PL-Y printed the scores, only some of them making annotations (see Figure 7.4). Most of these involved indications regarding pitch, harmony and structure, along with any patterns identified.

[12] PC-X had heard the piece before and PK-X guessed it from the typeface, which is quite characteristic for being Crumb's own handwriting.
[13] Concretely, PK-X had previously looked at the score of Manoury's *Passacaille pour Tokyo* (1994), from which the composer arranged the *Toccata pour piano* (1998). The latter is from which I selected Excerpt 3.
[14] PH-X attended a masterclass with David Lang in which I performed the original piece from where Excerpt 2 was selected.

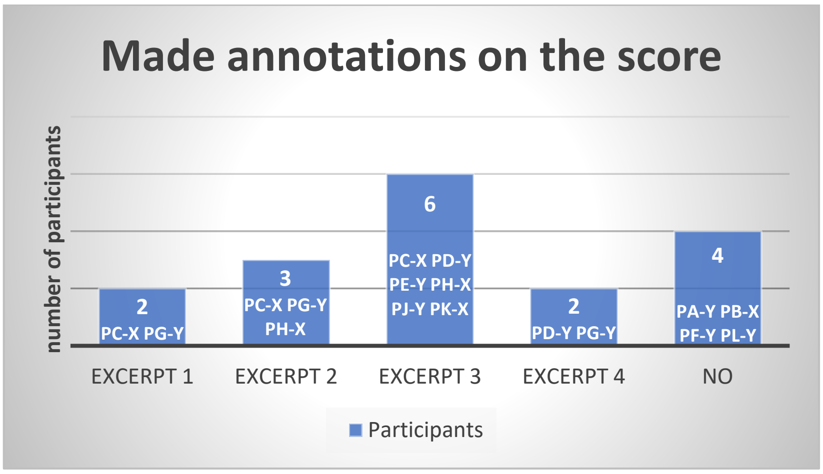


Figure 7.4: Participants' annotations made on the scores of the excerpts.

Participants completed all tests scheduled,[15] and reported recording several times their performances and uploading their best. When more than one recording was submitted, these were analysed, but only the first one was included in the comparative analysis.[16] This research decision distorted the results since it was not clear which recording was more representative in each case. Furthermore, access was only granted to those recordings uploaded on the form. Despite this limitation, certain tendencies could be observed in the data provided. The results of the Memorisation Test for Excerpt 1 are summarised in Table 7.3 (Pilot Study) and Table 7.4 (Main Study); and Figure 7.5 (Group X) and Figure 7.6 (Group Y).

[15] i.e., the Questionnaire, the Logical Reasoning Test (LRT), and the Memorisation Test, formed by the Morning Memorisation Test (MMT), the Afternoon Recall (AR) and the Next-Day Recall (NDR). Additionally, those participants in the Pilot Study voluntarily attempted a Written Recall (WR) of excerpts 1-3, some days after completing the study.

[16] For example, PB-X submitted many versions of the same performance. This was a sign that this participant was being transparent during the Memorisation Test, which allowed me to see what the learning process was. However, it also provided me with unrequested data that distorted PB-X's results with the rest of participants. Consequently, for the Main Study, only one performance recording and one voice-note per excerpt and test were allowed. I also took the research decision that the first performance submitted by PB-X would be used for comparing it with the rest, although all submissions were properly analysed.

Table 7.3: Pilot Study. Results of the Memorisation Test for Excerpt 1. Expected Timing: 15 min. Max Score: (42, 13).

	MMT		AR		NDR		WR	
ID-Group	**Timing**	**Score**	**Timing**	**Score**	**Timing**	**Score**	**Timing**	**Score**
PA-Y	22:47	(42, 11)	3:15	(42, 12)	1:25	(42, 13)	5-day gap	(42, 13)
PB-X	8:00	**Version I:** **(39, 13)** Version II: 1st (33, 11) 2nd (4, 7) 3rd (42, 13)	5:00	(41, 13)	4:00	**Version I:** **(42, 12)** Version II: (42, 13)	20-day gap	(42, 12)
PC-X	21:00	(42, 13)	4:00	(42, 12)	0:57	(42, 13)	5-day gap	(42, 13)

Table 7.4: Main Study. Results of the Memorisation Test for Excerpt 1. Expected Timing: 15 min. Max Score: (42, 13).

	MMT		AR		NDR	
ID-Group	**Timing**	**Score**	**Timing**	**Score**	**Timing**	**Score**
PD-Y	17:00	(42, 12)	14:00	(33, 9)	4:00	(32, 9)
PE-Y	22:55	(38, 9)	5:00	(35, 8)	3:00	(29, 12)
PF-Y	33:11	(40, 10)	2:40	(30, 8)	1:54	(40, 9)
PG-Y	30:00	(39, 0)	8:00	(34, 0)	7:00	(37, 11)
PH-X	15:00	(42, 13)	5:00	(35, 10)	2:00	(34, 11)
PJ-Y	14:00	(42, 13)	8:00	(41, 7)	7:00	(42, 10)
PK-X	11:30	(42, 10)	11:00	(36, 8)	2:30	(42, 11)
PL-Y	25:00	(36, 0)	7:00	(0, 0)	4:00	(0, 0)

The timings needed for memorising the excerpts (MMT) decreased substantially during the AR, becoming briefer during the NDR. In comparison, Group X needed less time than Group Y to memorise the excerpts during the MMT. Notwithstanding, this could be due to the experimental group having to follow the instructions, therefore needing more time to complete the test. This explanation is further supported by observing that the timings needed for the AR and NDR are quite similar between both groups. When calculating the average scores,[17] two outliers were identified: PG-Y was inaccurate with the rhythm; and PL-Y, for both pitches and rhythm. Respectively, these participants are the amateur pianist and the postgraduate student who struggled the most with the suggested strategies.[18] Therefore, if their results are excluded from the mean's calculation, since these negatively biased Group Y's average performance, both groups' average scores become more similar (see Table 7.5). Also, while Group Y had to follow an unusual memorisation method which was occasionally not useful in the short term, during the interviews, participants highlighted its potential, including their willingness to incorporate such strategies in their performance practice. This contrasts with Group X, who were not imposed any guidelines on how to proceed.

In any case, a decay in the scores was observed in both groups between the MMT and AR, and a slight improvement of these in the NDR, after a night's sleep. This suggests that, generally, participants recalled better the excerpts after sleeping, than on the same day they memorised these. Furthermore, for those participants attempting written recalls, their memory was preserved for up to a 20-day gap without practice.

Table 7.5: Comparison of Group X's and Group Y's average results for Excerpt 1.

	MMT		**AR**		**NDR**	
Group	**Average Timing**	**Average Score**	**Average Timing**	**Average Score**	**Average Timing**	**Average Score**
X	13:53	(41, 12)	6:15	(39, 11)	2:08	(40, 11)
Y	23:33	(40, 8)	6:51	(31, 6)	4:03	(32, 9)
Y (without PL-Y)	23:19	(41, 9)	6:49	(36, 7)	4:03	(37, 11)
Y (without PG-Y and PL-Y)	21:59	(41, 11)	6:35	(36, 9)	3:28	(37, 11)

[17] When calculating the average for pitches and rhythm, decimals were used to round the scores up, if equal or bigger than 5; or down, if smaller than 5.

[18] In his recordings for Excerpt 1, PG-Y did not respect the rhythm. This participant was performing at a much slower tempo to thoroughly think of each chord, as PG-Y explained during the MMT interview. Therefore, PG-Y remembered the rhythm, but was not able to perform accordingly. During the NDR, this participant was able to play faster, which indicates that PG-Y's thinking might have also been faster. Additionally, PL-Y reported usually working differently from the strategies suggested, reason for which this participant struggled during the Memorisation Test.

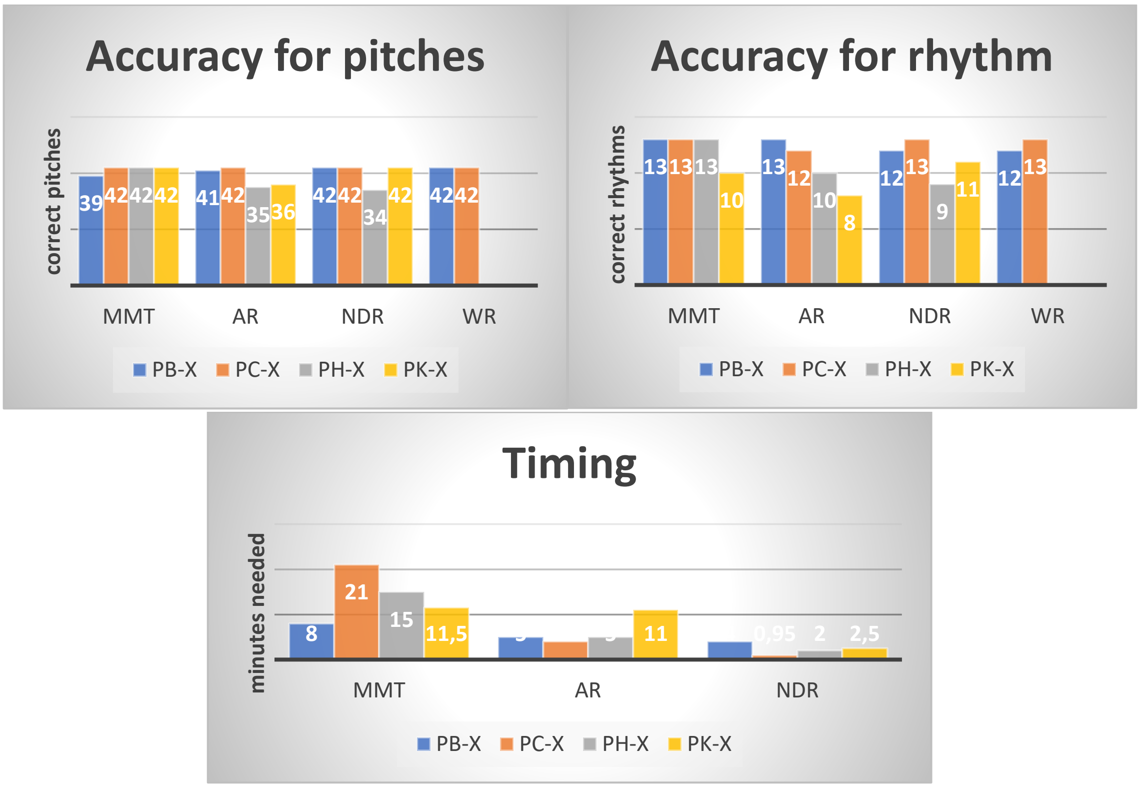
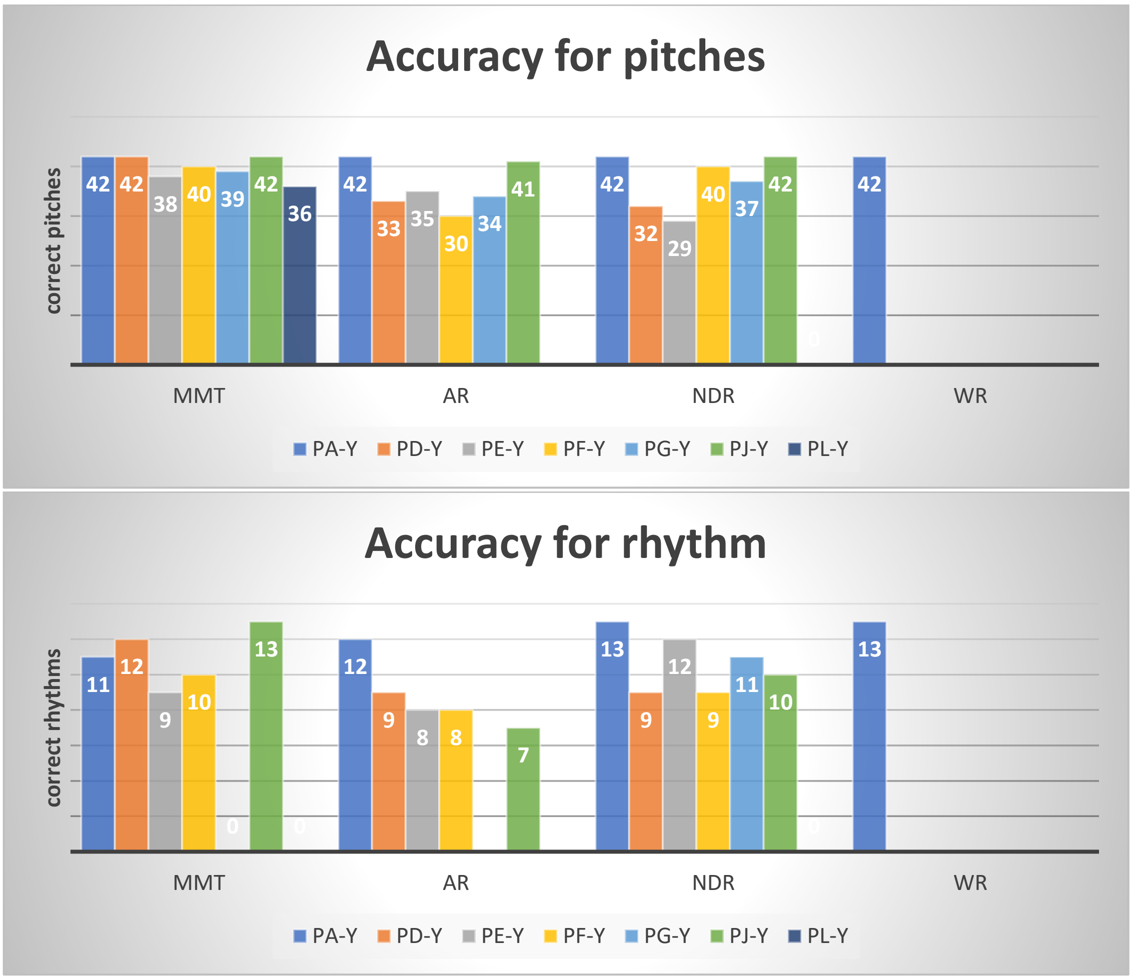


Figure 7.5: Group X's results for Excerpt 1.



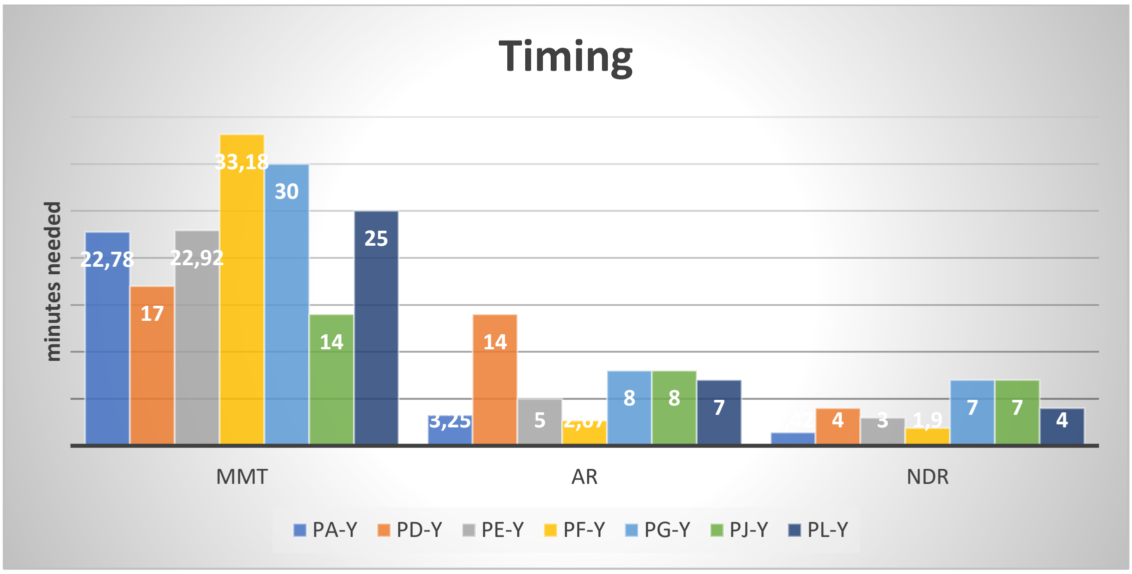


Figure 7.6: Group Y's results for Excerpt 1.

The results of the Memorisation Test for Excerpt 2 are summarised in Table 7.6 (Pilot Study) and Table 7.7 (Main Study); and Figure 7.7 (Group X) and Figure 7.8 (Group Y):

Table 7.6: Pilot Study. Results of the Memorisation Test for Excerpt 2. <u>Expected Timing:</u> 30 min. <u>Max Score:</u> (19 + 269, 18).

	MMT		AR		NDR		WR	
ID-Group	**Timing**	**Score**	**Timing**	**Score**	**Timing**	**Score**	**Timing**	**Score**
PA-Y	35:36	(19 + 265, 18)	3:14	(19 + 265, 17)	1:15	(19 + 266, 17)	5-day gap	(17 + 269, 17)
PB-X	19:00	**<u>Version I:</u>** **(14 + 194, 11)** <u>Version II:</u> (19 + 268, 14)	4:00	(19 + 269, 12)	4:00	(19 + 269, 13)	20-day gap	$(19 + \frac{269}{2}, 17)$
PC-X	23:00	(19 + 269, 11)	2:00	(19 + 263, 9)	0:45	**<u>Version I:</u>** **(17 + 237, 9)** <u>Version II:</u> (19 + 256, 8)	5-day gap	(19 + 269, 18)

Table 7.7: Main Study. Results of the Memorisation Test for Excerpt 2. <u>Expected Timing:</u> 30 min. <u>Max Score:</u> (19 + 269, 18).

	MMT		AR		NDR	
ID-Group	**Timing**	**Score**	**Timing**	**Score**	**Timing**	**Score**
PD-Y	22:00	(19 + 269, 18)	5:00	(19 + 269, 17)	2:00	(19 + 268, 17)
PE-Y	14:20	(19 + 259, 11)	5:00	(19 + 212, 11)	11:30	(16 + 259, 12)
PF-Y	25:00	(19 + 268, 18)	0:45	(19 + 267, 17)	0:47	(16 + 253, 17)
PG-Y	70:00	(15 + 232, 9)	23:00	(17 + 267, 13)	14:00	(19 + 267, 12)
PH-X	30:00	(19 + 269, 11)	5:00	(18 + 269, 12)	4:00	(19 + 269, 13)

PJ-Y	16:00	(18 + 247, 11)	2:00	(19 + 269, 11)	2:50	(18 + 265, 15)
PK-X	14:30	(19 + 265, 13)	0:40	(18 + 246, 13)	1:00	(19 + 261, 13)
PL-Y	17:00	(18 + 247, 13)	5:00	(10 + 137, 7)	3:00	(11 + 147, 1)

Again, a similar tendency was observed: the timings decay drastically during the AR and slightly during the NDR; while the scores tend to improve after sleeping, thus, recovering from a worse result in the AR. The written recalls also showed that memory was preserved, and even improved, providing a snapshot of the participants' memory in the longer term. Once again, PG-Y and PL-Y biased Group Y's average result: PG-Y provided a 70-minute timing outlier, while PL-Y's accuracy for Excerpt 2 is generally much lower than the rest. Therefore, if the averages are calculated ignoring these two participants, Group Y provides a better performance than Group X, with similar timings, as shown in Table 7.8:

Table 7.8: Comparison of Group X's and Group Y's average results for Excerpt 2.

	MMT		**AR**		**NDR**	
Group	**Average Timing**	**Average Score**	**Average Timing**	**Average Score**	**Average Timing**	**Average Score**
X	21:38	(18 + 249, 12)	2:55	(19 + 262, 12)	2:26	(19 + 259, 12)
Y	28:34	(18 + 255, 14)	6:17	(17 + 241, 13)	5:03	(17 + 246, 13)
Y (without PL-Y)	30:29	(18 + 257, 14)	6:30	(19 + 258, 14)	5:24	(18 + 263, 15)
Y (without PG-Y and PL-Y)	22:35	(19 + 262, 15)	3:12	(19 + 256, 15)	3:40	(18 + 262, 16)

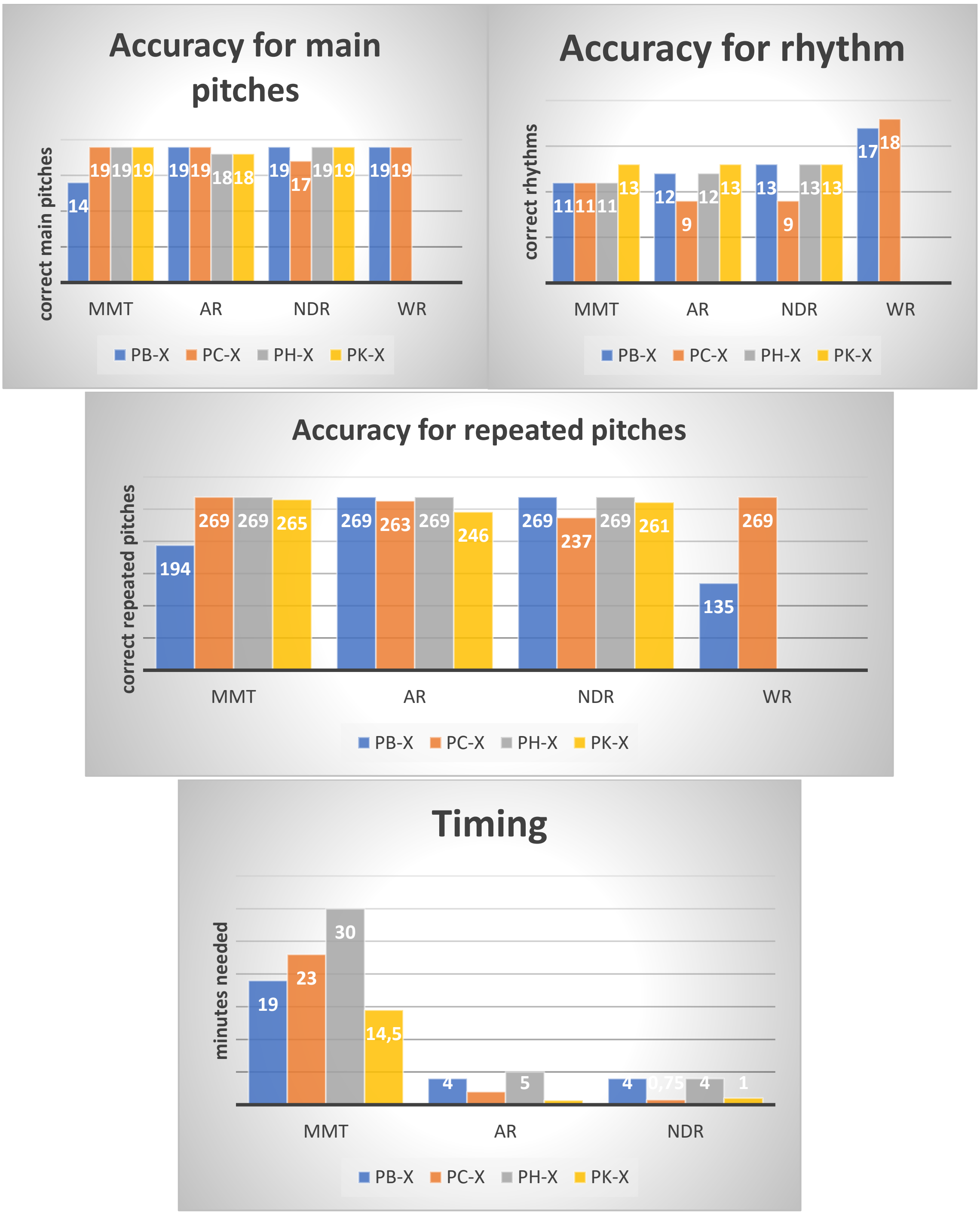
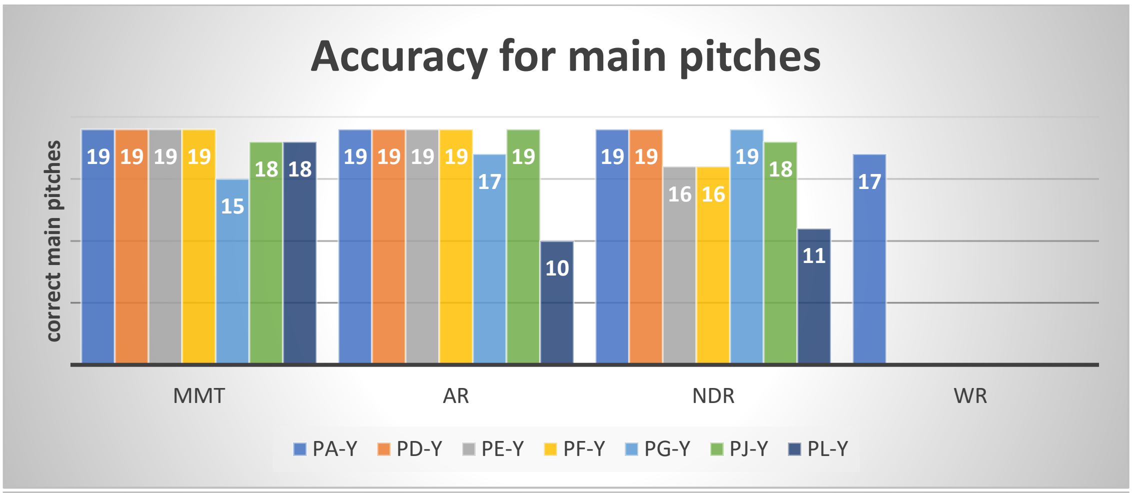
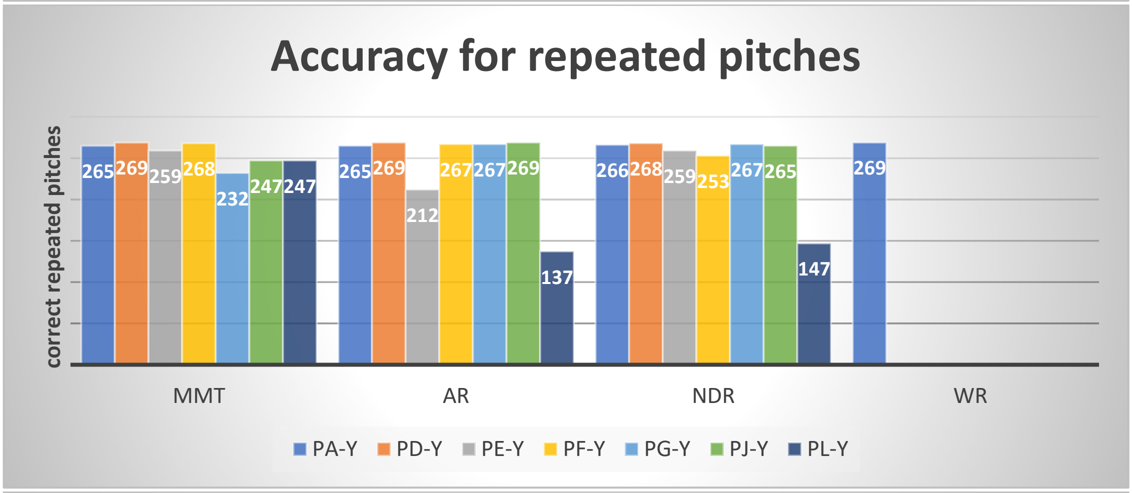
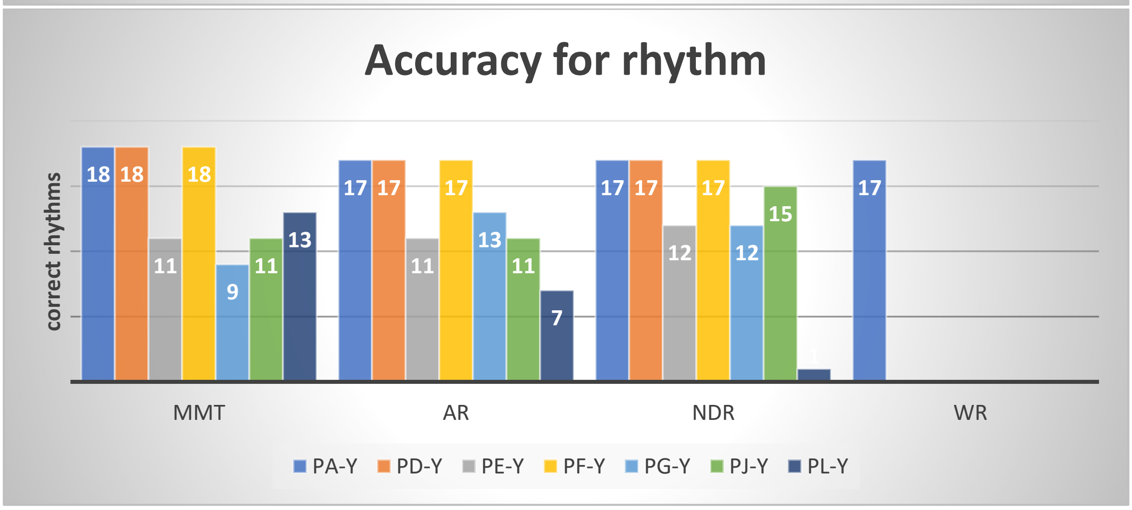


Figure 7.7: Group X's results for Excerpt 2.


Accuracy for main pitches
correct main pitches
19 19 19 19 15 18 18
19 19 19 19 17 19 10
19 19 16 16 19 18 11
17
MMT
AR
NDR
WR
PA-Y PD-Y PE-Y PF-Y PG-Y PJ-Y PL-Y


Accuracy for repeated pitches
correct repeated pitches
265 269 259 268 232 247 247
265 269 212 267 267 269 137
266 268 259 253 267 265 147
269
MMT
AR
NDR
WR
PA-Y PD-Y PE-Y PF-Y PG-Y PJ-Y PL-Y


Accuracy for rhythm
correct rhythms
18 18 11 18 9 11 13
17 17 11 17 13 11 7
17 17 12 17 12 15
17
MMT
AR
NDR
WR
PA-Y PD-Y PE-Y PF-Y PG-Y PJ-Y PL-Y

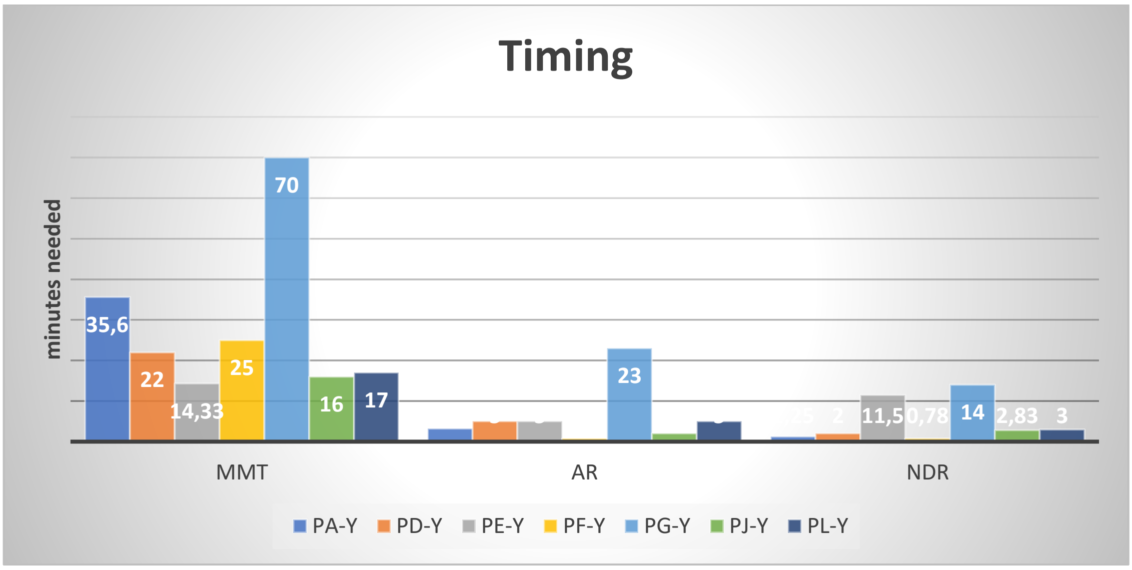


Figure 7.8: Group Y's results for Excerpt 2.

The results of Excerpt 3 for the Memorisation Test are now summarised in Table 7.9 (Pilot Study) and Table 7.10 (Main Study); and Figure 7.9 (Group X) and Figure 7.10 (Group Y):

Table 7.9: Pilot Study. Results of the Memorisation Test for Excerpt 3. <u>Expected Timing:</u> 30 min. <u>Max Score:</u> (146 + 28, 20).

	MMT		**AR**		**NDR**		**WR**	
ID-Group	**Timing**	**Score**	**Timing**	**Score**	**Timing**	**Score**	**Timing**	**Score**
PA-Y	45:34	(146 + 27, 16)	8:39	(114 + 26, 13)	2:29	(114 + 25, 15)	5-day gap	(145 + 19, 12)
PB-X	66:00, including a 5-min break.	**<u>Version I:</u>** **(146 + 26, 16)** <u>Version XI:</u> (146 + 28, 19)	14:00	(146 + 28, 17)	4:00	**<u>Version I:</u>** **(49 + 6, 15)** <u>Version II:</u> (146 + 26, 12) <u>Version III:</u> (146 + 28, 12) <u>Version IV:</u> (146 + 28, 11)	20-day gap	(114 + 3, 4)
PC-X	42:00	(138 + 28, 18)	2:00	**<u>Version I:</u>** **(110 + 20, 16)** <u>Version II:</u> (144 + 27, 15)	0:52	(137 + 26, 19)	5-day gap	(146 + 28, 20)

Table 7.10: Main Study. Results of the Memorisation Test for Excerpt 3. Expected Timing: 45 min. Max Score: (146 + 28, 20).

	MMT		AR		NDR	
ID-Group	**Timing**	**Score**	**Timing**	**Score**	**Timing**	**Score**
PD-Y	37:00	(145 + 25, 19)	6:00	(131 + 24, 16)	4:00	(146 + 26, 17)
PE-Y	54:00	(141 + 25, 10)	9:00	(146 + 25, 9)	6:30	(146 + 21, 12)
PF-Y	77:00	(144 + 28, 15)	7:00	(146 + 28, 15)	9:15	(146 + 27, 19)
PG-Y	20:00	(0, 0)	-	(0, 0)	-	(0, 0)
PH-X	50:00	(146 + 22, 16)	4:00	(130 + 21, 12)	3:00	(146 + 21, 10)
PJ-Y	36:00	(132 + 24, 15)	2:00	(140 + 25, 14)	3:00	(143 + 25, 13)
PK-X	41:30	(144 + 27, 15)	9:00	(143 + 7, 10)	3:30	(144 + 6, 7)
PL-Y	90:00	(145 + 24, 14)	5:00	(111 + 10, 9)	10:00	(112 + 6, 11)

Once more, the same evolution appears in both timings and scores. Beyond the previous comparisons, with Excerpt 3, Group Y did better in the NDR than Group X. This suggests that, even without practice, those participants that followed my indications when memorising this excerpt consolidated their conceptual memory. Since PG-Y attempted to memorise Excerpt 3 for 20 minutes, but desisted without submitting any recordings, his results were omitted when calculating Group Y's average (see Table 7.11). Moreover, amongst the multiple versions that PB-X provided during the MMT for this excerpt, only Versions I and XI were analysed in depth, since these represent the first attempt and last, after many versions that could be regarded as "practice".[19] However, this quirk in PB-X's data indicates a persistent struggle with Excerpt 3, which was also experienced by the other participants. In a voice-note, PL-Y emphasised the difficulty of the rhythm. Despite having instructions to memorise this excerpt, PL-Y found that, unlike older music, there were no 'understandable'

[19] Since I was not present when participants recorded the excerpts, I am only aware of the materials that they submitted, having no control on how many times they recorded, although this information was requested during the interviews. Therefore, in PB-X's case, and when occasionally others did something similar (e.g., PC-X), all recordings were analysed, and the first version was selected to compare it with the others. Therefore, the results of this study should be considered noting that PB-X submitted more recordings that others kept private, which inevitably biases the results and subsequent conclusions.

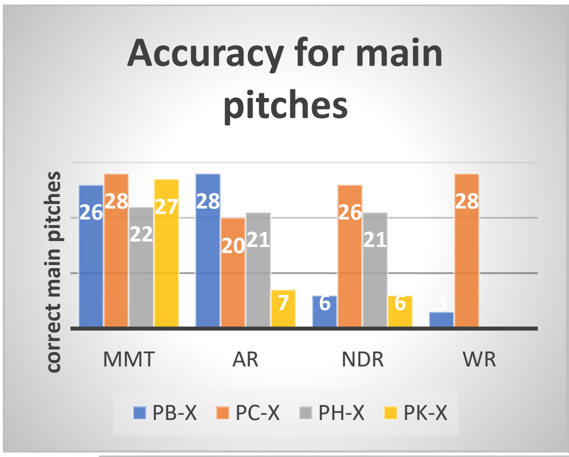
patterns, hence 'didn't know what to expect'. Therefore, for PL-Y 'it was really difficult to remember what was coming next', while the fast tempo at which it should be performed did not help. Nonetheless, most participants also performed it under tempo.

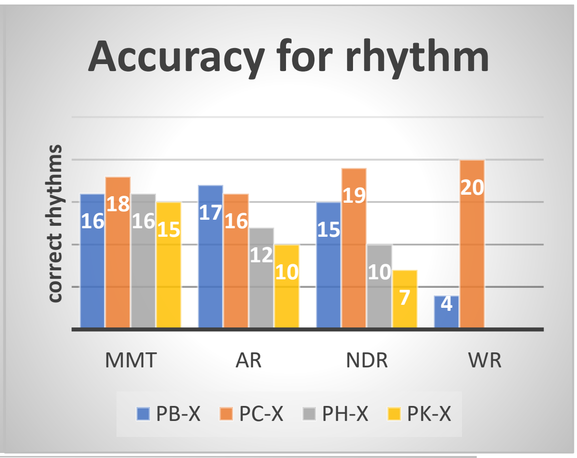
Additionally, PL-Y, who also struggled the most with my strategies, 'actually found it easier' to just memorise the piece in its original form, as this participant usually relies 'on movements to memorise'. PL-Y's results for Excerpt 3 made clear, though, that solely combining kinaesthetic memory with perfect pitch was not a reliable strategy, since accuracy decayed both in the AR and NDR. Therefore, this approach might not be so effective in the short term for this repertoire. That said, PL-Y's memorisation was severely conditioned by having to follow an unnatural approach for this participant. Group X's parallel phenomenon of PL-Y's low results for Excerpt 3 was PK-X, who had a similar level of education, received postgraduate training in recent post-tonal music and knew Excerpt 3. This suggests that previous experience in this repertoire does not guarantee a better performance. Also, short and long-term memories might still considerably decay, if conceptual memory is not engaged, as suggested PK-X's results.

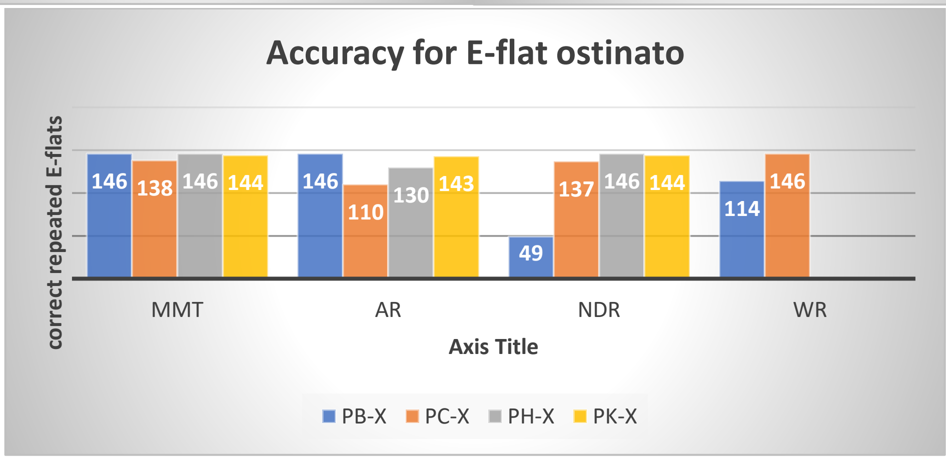
Finally, most participants performed Excerpt 3 using one hand for the E♭-ostinato and the other for the rest. Thus, they might have struggled in identifying and using horizontal symmetry to monitor the performance, especially at a fast tempo. However, participants had limited time to learn the excerpt, therefore such hand arrangement was faster to coordinate and made more sense interpretatively, since they just had to focus on the movements of a single hand.[20] Consequently, for Group Y, simplifying the ostinato implied simplifying one hand.

Table 7.11: Comparison of Group X's and Group Y's average results for Excerpt 3.

	MMT		AR		NDR	
Group	**Average Timing**	**Average Score**	**Average Timing**	**Average Score**	**Average Timing**	**Average Score**
X	49:53	(144 + 26, 16)	7:15	(132 + 19, 14)	2:51	(119 + 15, 13)
Y (without PG-Y)	56:36	(142 + 26, 15)	6:17	(131 + 23, 13)	5:52	(135 + 22, 15)







[20] In my own performing experience, the best hand arrangement is to play the ostinato and the main pitches with both hands, which gives more precision in the longer term. See further details on this live video recording of my performance: https://youtu.be/BTZh_SJd8DA.

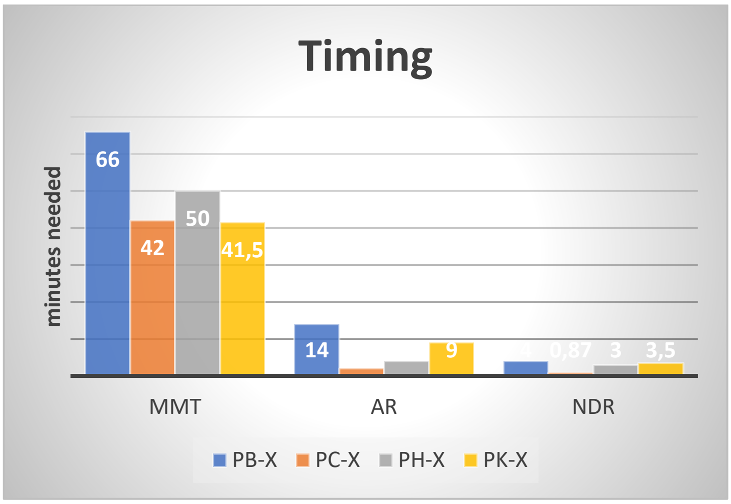
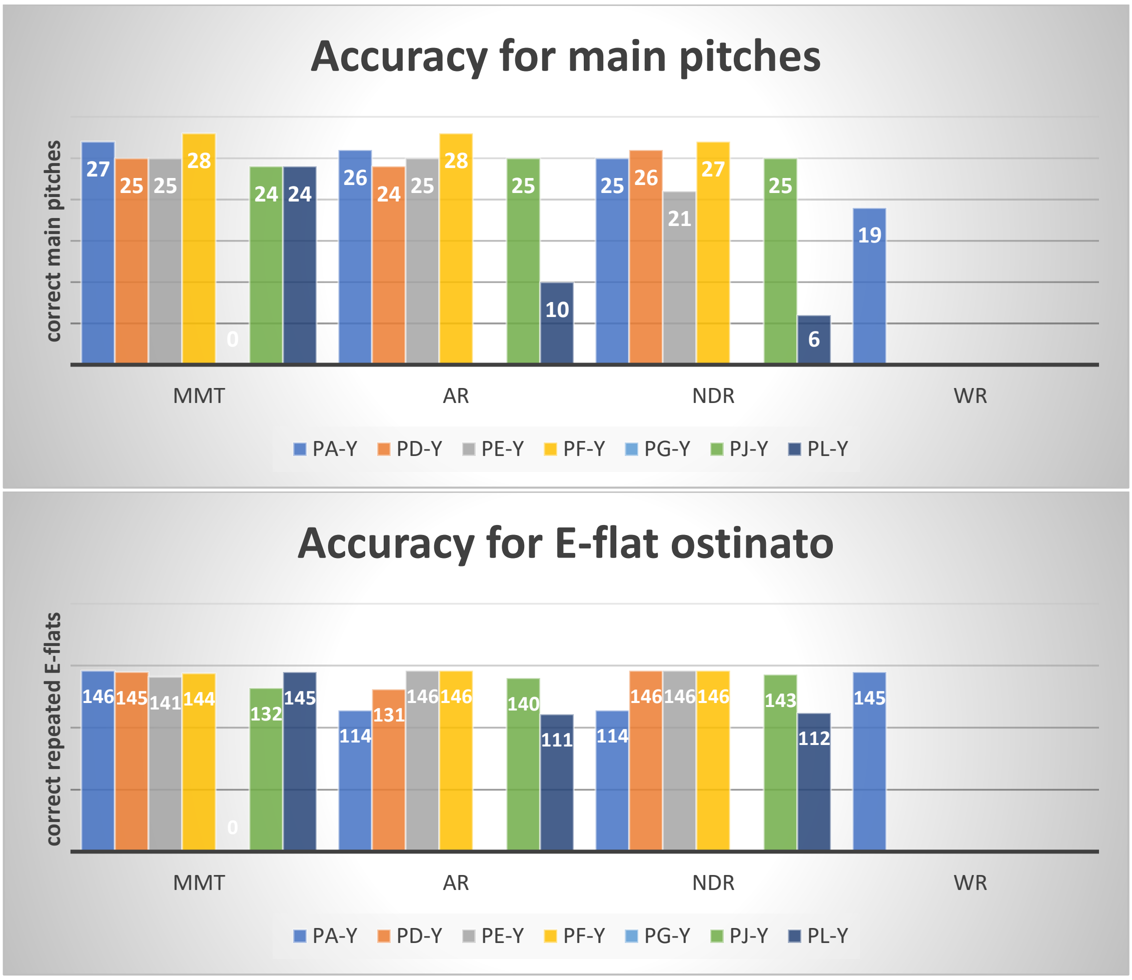


Figure 7.9: Group X's results for Excerpt 3.



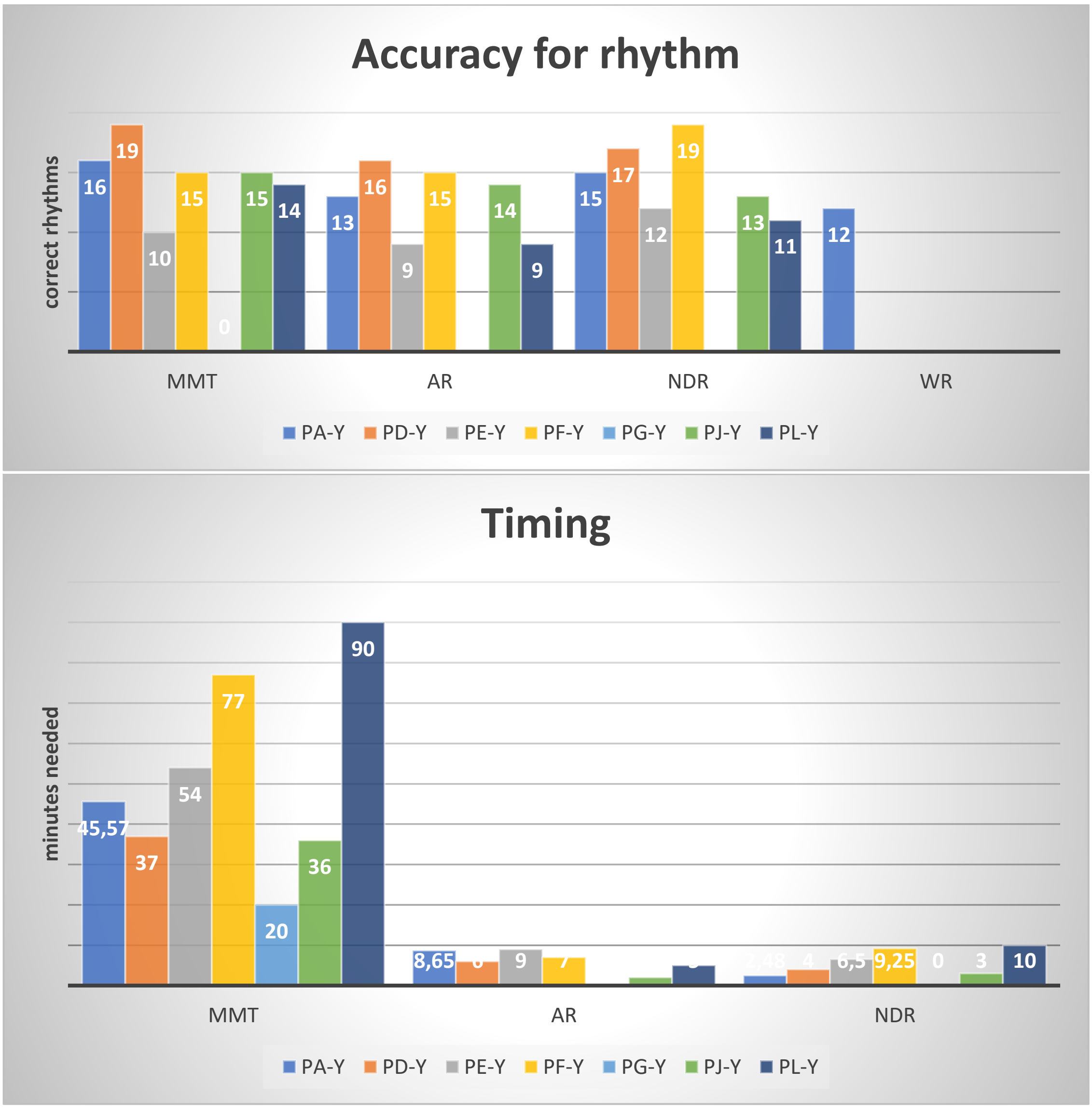


Figure 7.10: Group Y's results for Excerpt 3.

For Excerpt 4, the results of the Main Study are presented in Table 7.12 (Main Study); and Figure 7.11 (Group X) and Figure 7.12 (Group Y):

Table 7.12: Main Study. Results of the Memorisation Test for Excerpt 4. Expected Timing: 20 min. Max Score: (23, 18).

	MMT		AR		NDR	
ID-Group	**Timing**	**Score**	**Timing**	**Score**	**Timing**	**Score**
PD-Y	17:00	(23, 18)	4:00	(23, 17)	2:00	(23, 18)
PE-Y	10:00	(19, 12)	1:30	(17, 15)	0:25	(19, 17)
PF-Y	12:00	(19, 14)	1:27	(23, 15)	0:56	(19, 15)
PG-Y	15:00	(23, 18)	3:00	(22, 14)	4:00	(23, 17)
PH-X	5:00	(23, 18)	2:00	(21, 17)	1:00	(21, 17)
PJ-Y	10:00	(23, 17)	3:00	(9, 17)	3:50	(11, 17)
PK-X	4:00	(23, 18)	4:00	(3, 16)	1:00	(14, 15)
PL-Y	5:00	(23, 18)	3:00	(1, 14)	5:00	(15, 18)

The averages in Table 7.13 convey that, although Group Y initially invested more time during the MMT, they performed better in subsequent recalls, especially in terms of pitches.

Table 7.13: Comparison of Group X's and Group Y's average results for Excerpt 4.

	MMT		AR		NDR	
Group	**Average Timing**	**Average Score**	**Average Timing**	**Average Score**	**Average Timing**	**Average Score**
X	4:30	(23, 18)	2:00	(12, 17)	1:00	(18, 16)
Y	11:30	(22, 16)	2:40	(16, 15)	2:42	(18, 17)

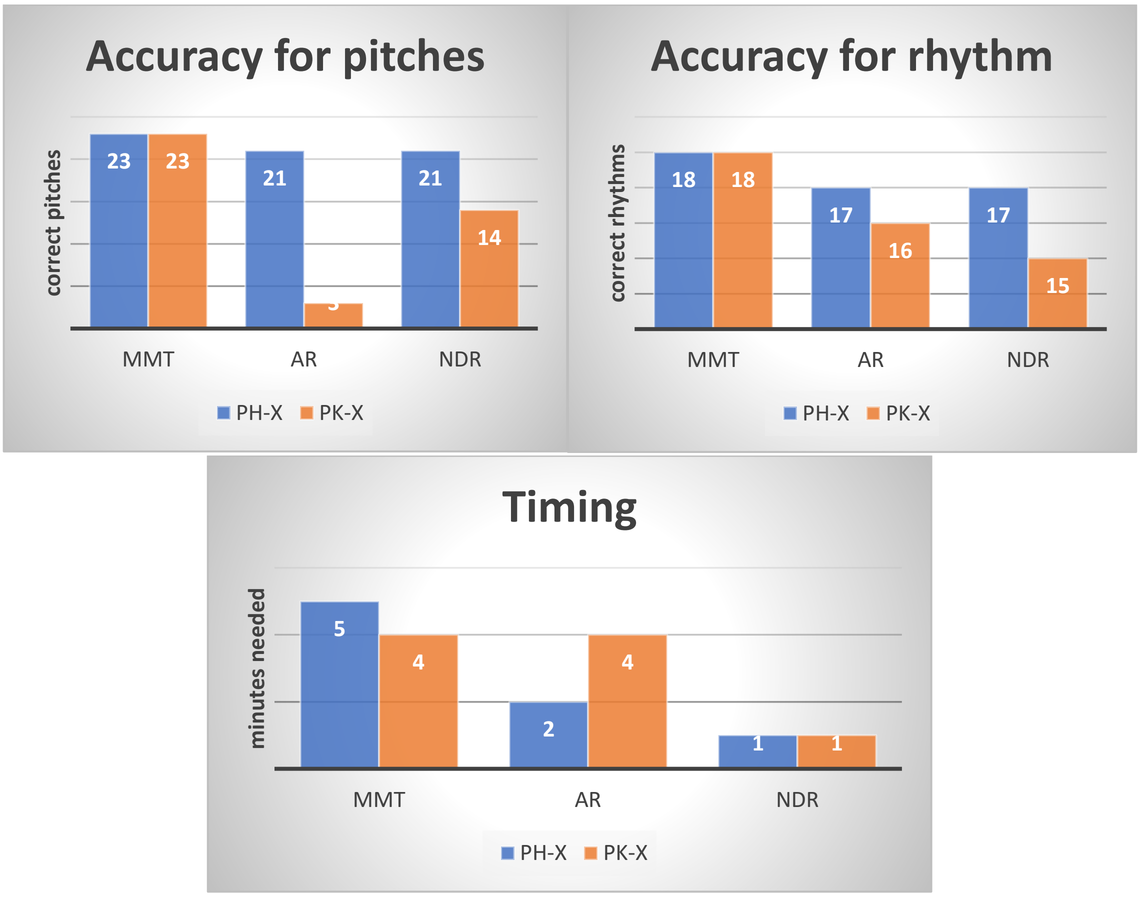
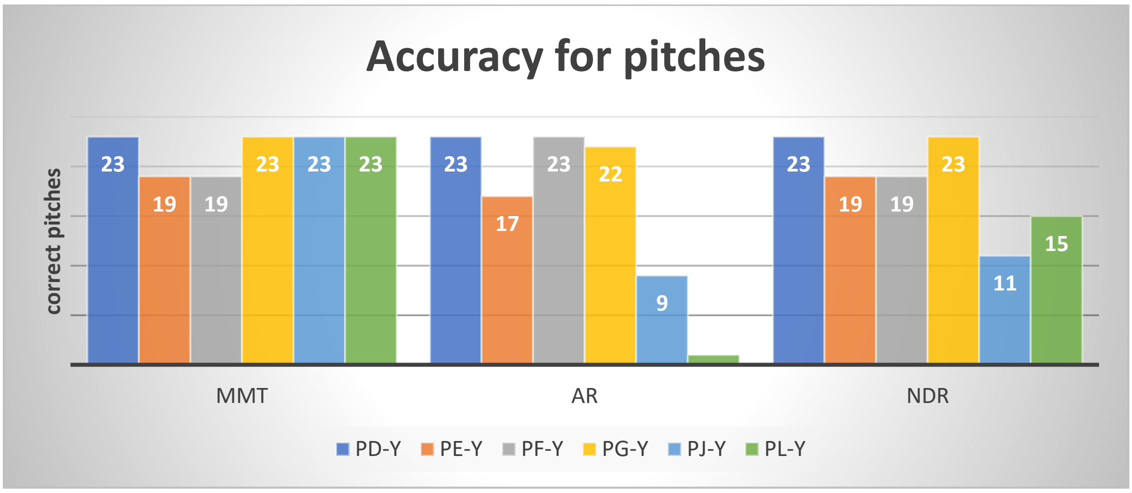


Figure 7.11: Group X's results for Excerpt 4.



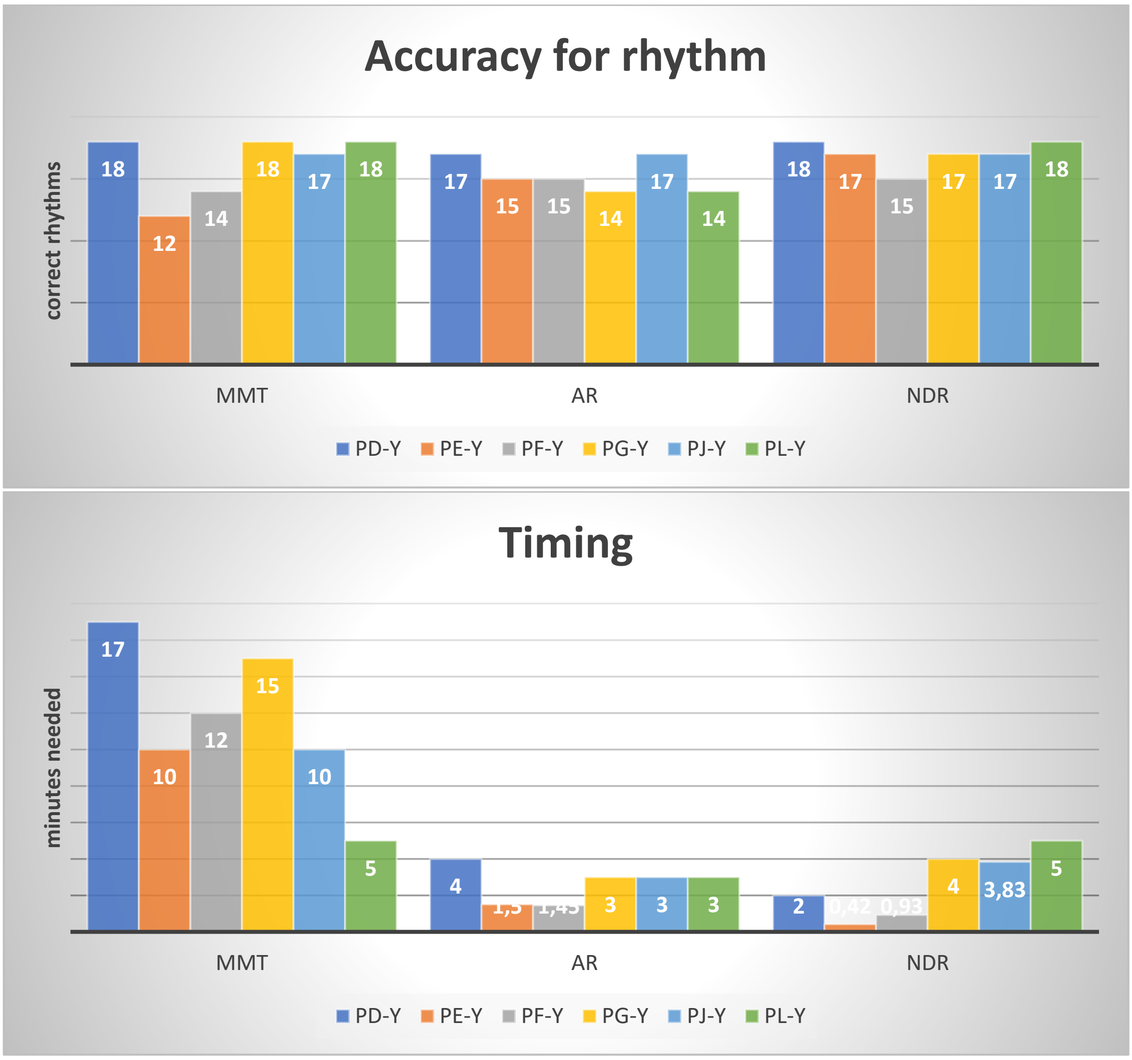


Figure 7.12: Group Y's results for Excerpt 4.

The next section discusses the strategies used by participants in both groups.

7.4 Memorisation Strategies: Testing Conceptual Simplification

This section discusses which simplifying and conceptualisation strategies were most useful for participants. Also, whether these varied across the excerpts. The suggested strategies are summarised in Appendix E,[21] and Table 7.14 provides below an overview of the strategies included in the instructions, those strategies suggested by the participants and which of those strategies were found most useful.

Table 7.14: Resulting themes from the thematic analysis on the interviews with participants.

THEME 1: Strategies used for Excerpt 1

Subtheme 1.1 Strategies included in the instructions (Group Y)

Code 1.1.1 *Simplifying Octaves*
Code 1.1.2 *Simplifying Chords*
Code 1.1.3 *Simplifying Hands*
Code 1.1.4 *Simplifying Rhythm*
Code 1.1.5 *Chord Conceptualisation*

Subtheme 1.2 Strategies suggested by the participants

Code 1.2.1 *Learning the right hand first (Simplifying Hands)*
Code 1.2.2 *Identifying the pattern behind the inversions of the chords (Chord Conceptualisation)*
Code 1.2.3 *Chunking single chords according to music theory (Chord Conceptualisation)*
Code 1.2.4 *Figuring out the left hand from the right hand (Interval Conceptualisation)*
Code 1.2.5 *Perfect pitch*
Code 1.2.6 *Sensory Learning Styles (aural memory, visual memory, kinaesthetic memory)*
Code 1.2.7 *Reading the transposed score while playing in the original register*
Code 1.2.8 *Writing down the root positions of the chords (Simplifying Chords)*
Code 1.2.9 *Playing at a slower tempo (Simplifying Tempo)*
Code 1.2.10 *Segmentation (Simplifying Structure)*

Subtheme 1.3 Most useful strategies

Code 1.3.1 *Simplifying Octaves*
Code 1.3.2 *Simplifying Hands*
Code 1.3.3 *Simplifying Tempo*
Code 1.3.4 *Chord Conceptualisation*
Code 1.3.5 *Sensory Learning Styles (aural memory, visual memory, kinaesthetic memory)*

THEME 2: Strategies used for Excerpt 2

Subtheme 2.1 Strategies included in the instructions (Group Y)

Code 2.1.1 *Simplifying Octaves*
Code 2.1.2 *Simplifying Hands*

[21] Ideally, the implementation of Conceptual Simplification should be done mentally, so the learning process is faster, and memorisation starts earlier. This means that the score should not be physically modified according to the simplifying strategies. However, each practitioner should decide whether is more helpful and clearer for them to write down reductions or modified versions of the score according to these, as PG-Y mentioned during the interview. For Group Y, the scores from the Memorisation Test were modified, so it was clearer for participants how the strategies were to be implemented.

Code 2.1.3 *Simplifying Rhythm*
Code 2.1.4 *Simplifying Repetition*
Code 2.1.5 *Pattern Conceptualisation*

Subtheme 2.2 Strategies suggested by the participants

Code 2.2.1 *Identifying the pattern behind the octave transposition (Pattern Conceptualisation)*
Code 2.2.2 *Perfect pitch*
Code 2.2.3 *Sensory Learning Styles (aural memory, kinaesthetic memory)*
Code 2.2.4 *Reading the transposed score while playing in the original register*
Code 2.2.5 *Writing down the patterns (Pattern Conceptualisation)*
Code 2.2.6 *Segmentation (Simplifying Structure)*
Code 2.2.7 *Singing*

Subtheme 2.3 Most useful strategies

Code 2.3.1 *Simplifying Octaves*
Code 2.3.2 *Simplifying Hands*
Code 2.3.3 *Pattern Conceptualisation*
Code 2.3.4 *Sensory Learning Styles (aural memory, kinaesthetic memory)*
Code 2.3.5 *Singing*

THEME 3: Strategies used for Excerpt 3

Subtheme 3.1 Strategies included in the instructions (Group Y)

Code 3.1.1 *Simplifying Pitch*
Code 3.1.2 *Simplifying Octaves*
Code 3.1.3 *Simplifying Rhythm*
Code 3.1.4 *Solkattu Verbalisation and Clapping*
Code 3.1.5 *Pattern Conceptualisation*

Subtheme 3.2 Strategies suggested by the participants

Code 3.2.1 *Memorising first the pitches, and after the rhythm (Simplifying Rhythm, Simplifying Pitch)*
Code 3.2.2 *Memorising simultaneously the pitches and the rhythm*
Code 3.2.3 *Counting*
Code 3.2.4 *Identifying the pattern behind the rhythm (Rhythm Conceptualisation)*
Code 3.2.5 *Perfect pitch*
Code 3.2.6 *Sensory Learning Styles (aural memory, visual memory, kinaesthetic memory)*
Code 3.2.7 *Writing down the patterns (Pattern Conceptualisation)*
Code 3.2.8 *Playing at a slower tempo (Simplifying Tempo)*
Code 3.2.9 *Segmentation (Simplifying Structure)*

Subtheme 3.3 Most useful strategies

Code 3.3.1 *Simplifying Pitch*
Code 3.3.2 *Simplifying Octaves*
Code 3.3.3 *Simplifying Rhythm*
Code 3.3.4 *Memorising simultaneously the pitches and the rhythm*
Code 3.3.5 *Solkattu Verbalisation and Clapping*
Code 3.3.6 *Counting*
Code 3.3.7 *Pattern Conceptualisation*
Code 3.3.8 *Sensory Learning Styles (visual memory, kinaesthetic memory)*
Code 3.3.9 *Perfect pitch*
Code 3.3.10 *Segmentation (Simplifying Structure)*

THEME 4: Strategies used for Excerpt 4

Subtheme 4.1 Strategies included in the instructions (Group Y)

Code 4.1.1 *Simplifying Octaves*
Code 4.1.2 *Simplifying Structure*
Code 4.1.3 *Simplifying Preceding Structure*
Code 4.1.4 *Interval Conceptualisation*

Subtheme 4.2 Strategies suggested by the participants

Code 4.2.1 *Memorising first the pitches, and after the rhythm (Simplifying Rhythm, Simplifying Pitch)*
Code 4.2.2 *Sensory Learning Styles (aural memory, visual memory, kinaesthetic memory)*
Code 4.2.3 *Writing down the patterns (Pattern Conceptualisation)*

Subtheme 4.3 Most useful strategies

Code 4.3.1 *Memorising first the pitches, and after the rhythm (Simplifying Rhythm, Simplifying Pitch)*
Code 4.3.2 *Interval Conceptualisation*
Code 4.3.3 *Sensory Learning Styles (aural memory, visual memory, kinaesthetic memory)*
Code 4.3.4 *Perfect pitch*
Code 4.3.5 *Segmentation (Simplifying Structure)*
Code 4.3.6 *Simplifying Preceding Structure*

These strategies are now further discussed by excerpts.

7.4.1 Excerpt 1

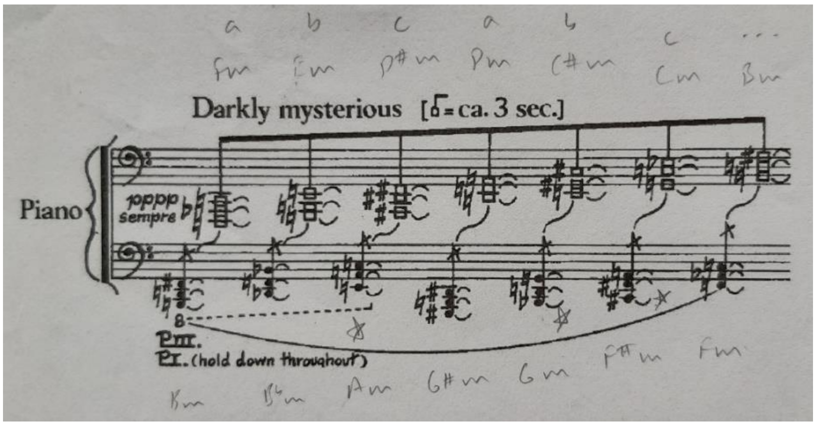
Group Y found the suggested strategies for Excerpt 1 useful and easy to follow, despite not understanding the purpose of all steps (e.g., PF-Y). Transposing into the middle register to gain clarity in the sound while comprehending better the patterns was also used by participants in Group X (e.g., PK-X).[22] Similarly, for PF-Y, having an adapted score for each step facilitated playing directly in the original register while following it transposed in the middle register. Additionally, PG-Y found it useful to write down the root of the chords.

Identifying the patterns behind the chromatic sequences proved also helpful, even for participants that rarely memorise in this way (e.g., PD-Y, PE-Y, PF-Y, PL-Y). Also, PB-X,

[22] According to PK-X: 'I think the difficulty in [Excerpt 1] was that it was so low down in the piano register, and with the pedal jammed down, that you can't really pick out. I did practise it up in the middle of the piano a few times, that maybe perfect pitch helped, then. But again, I was using basically only my memory of the pattern to do that one'.

PC-X and PK-X used this analytical approach, which PG-Y would still follow if not given any instructions. Furthermore, PB-X, PC-X, PD-Y, PF-Y, PG-Y and PK-X used the chord-inversion pattern (i.e., root position, first inversion, second inversion), which was not included in the instructions. This was reinforced practising hands separately: an approach that some participants (e.g., PE-Y) admitted that would use anyway.

Additional suggested strategies were learning the right hand first and using it as a reference for the left hand; segmentation and chunking tonal chords; playing at a slower tempo; and relying on the Sensory Learning Styles.[23] Concretely, PB-X and PC-X focused on identifying interval relationships between both hands. Example 7.1 provides further details of this strategy implemented by PC-X:



Example 7.1: George Crumb, *Makrokosmos I* (1972), 'Primeval Sounds', initial 49 seconds, PC-X annotations for Excerpt 1 during the Morning Memorisation Test (MMT). PC-X devised a system by writing stars (★) on those chords where the top note in the left hand was not a semitone higher from the bottom note in the right hand.[24] Similarly, PB-X observed that the left hand was 'just an augmented fourth lower' from the right hand.

Alternatively, PH-X identified semitone shifts as memory cues and 'tried to play the top melody of the right hand' multiple times until remembering it through aural memory. Then, PH-X did the same for the right-hand chords, dividing these into two parts. Finally, PH-X

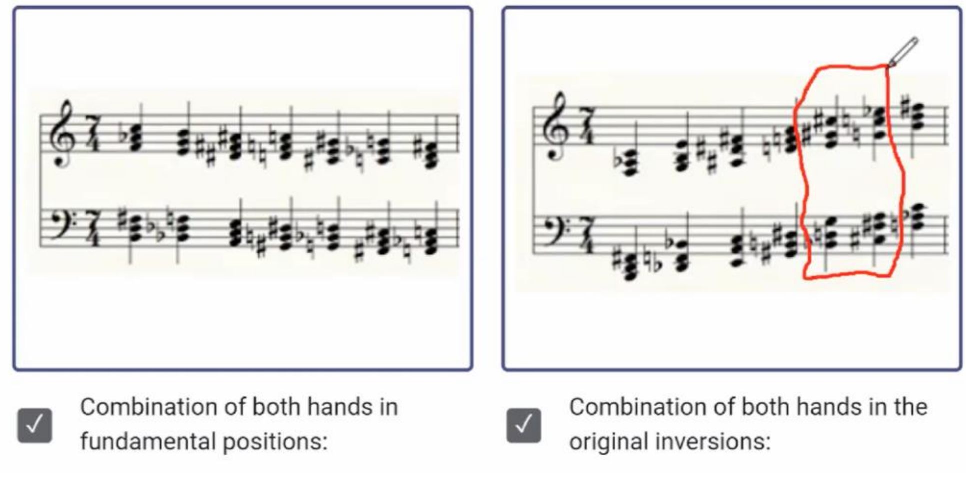
[23] See Chapter 2.
[24] Nevertheless, a star is missing in the second block of chords. An alternative to PC-X's star notation could be that the stars identify those exceptions in which the right hand needs to be played *supra* instead of *sotto*.

repeated it for the left hand and combined both hands. However, with more time, this participant would start learning the excerpt without the piano.

The strengths and weaknesses of using the Sensory Learning Styles for memorising Excerpt 1 can be discussed from PE-Y's perspective, who also used aural memory for the top melody in the right hand, although this 'is not very useful because you have chords to play… [and] it's very easy to get confused and play [a] different chord. But if you learn the chords that you have to play, then it's simpler and easier', because you understand the connection and how they relate with each other. This could be the reason why PD-Y initially followed the instructions, but then found herself 'feeling… looking at it and hearing it, rather than thinking logically', mentioning that it might have been more useful just to rely on perfect pitch. Nonetheless, PD-Y progressively felt more confident with Conceptual Simplification's approach in the subsequent recalls: 'When I couldn't remember the pitches, I tried to recall your instructions to start again, and they were in my head pretty well, I think. I still have them somewhere in my brain now [after the AR]'.

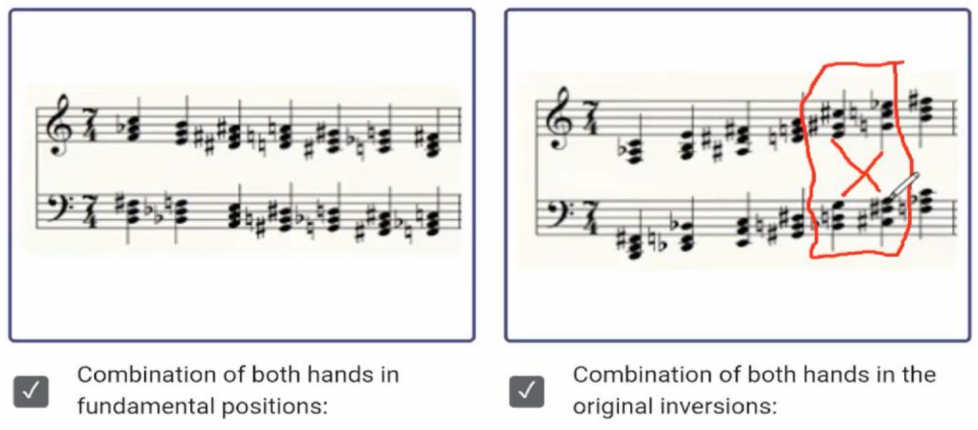
Visual and kinaesthetic learner PF-Y used black-and-white combinations, by identifying relationships between both hands: 'For example, for these two, I found that there was a relation between the left and the right hands. Again, it's a black-and-white combination. This is black-white-white and then white-black-black' (see Example 7.2).[25]

[25] PF-Y refers to the chords in first inversion circled in red on Example 7.2: G minor for the left hand and C♯ minor for the right hand.



Example 7.2: PF-Y's annotations for Excerpt 1, during the interview after the Morning Memorisation Test (MMT).

'And here's the exact reverse: that's black-black-white and white-white-black…[26] So, these two, I see them as like a reverse' (see Example 7.3):



Example 7.3: PF-Y's annotations for Excerpt 1, during the interview after the Morning Memorisation Test (MMT).

Finally, kinaesthetic memory was also used by PA-Y, PD-Y and PE-Y for overlearning the excerpt, while PF-Y and PH-X used it for memorising. For instance, when PE-Y practised hands separately, this participant repeated certain chord transitions to remember each hand

[26] PF-Y refers to the chords in second inversion circled in red: F# minor for the left hand and C minor for the right hand.

position, back and forth: 'Every two chords I would play chord number 1 and 2, and then 2 and 3, 3 and 4; or 2-3-4 and then 3-4-5'. Also, PE-Y repeated this process by combining both hands.[27] Conversely, PF-Y struggled in finding patterns using the black-and-white combination strategy, thus eventually memorising with kinaesthetic memory: 'I played 20 times, and then automatically, I memorised black-black-white and a white-white-black combination… I tried to also analyse, to see if there are any relationships between the thumbs or between the fingers… I found very little pattern to follow, so I gave up on that'. Additionally, PJ-Y 'tried to remember the shape of the chords and the sound', and after using the harmony to memorise, this participant 'began to recognise the shapes because it is the same for the right and left hand'.

The participants' perceived difficulty with Excerpt 1 was not unanimous. Those who identified the patterns (e.g., chromatic sequences, chord inversions) were the most successful and found the excerpt easier. Amongst these, there was PK-X, who described memorisation as 'just working out the patterns and a mental process of calculating'. Therefore, understanding was directly proportional to memorising easily. Otherwise, the excerpt was more challenging, as PH-X claimed: 'I didn't see such a pattern. So, you had just really different chords everywhere'. However, those Group-Y participants not inclined towards an analytical approach found it challenging to think on the patterns while playing, even when these were unveiled with the instructions. Concretely, for perfect-pitch possessor PD-Y, Excerpt 1 was 'difficult' because, while all the suggested steps 'made a lot of sense', this participant kept 'reverting back' to the usual procedures, instead of thinking chromatically. Consequently, for PD-Y, 'it was short, but it was probably the most difficult [excerpt] in terms of concepts'. Similarly, perfect-pitch possessor PL-Y found the suggested approach

[27] PE-Y's frequently uses this strategy both in forward and backward motion. However, during the test, this participant only used the forward modality because of the limited timing.

unnatural, preferring 'to go from the original inversions'. However, PL-Y found useful that I 'broke it down'. Similarly, although all the strategies were helpful, PE-Y and PF-Y needed some time to adapt to this way of thinking and memorising.

Participants were also asked which were the most and least useful strategies for Excerpt 1. Amongst the most useful were Simplifying Octaves, Simplifying Hands, Simplifying Tempo and Chord Conceptualisation, which was highlighted unanimously. Given that some suggested strategies were new or an uncomfortable memorisation approach, especially for perfect-pitch possessors, a combination of sensory strategies, such as repetition, hand position, visual memory, aural memory and perfect pitch, were also mentioned. Oppositely, amongst the least useful there were relying exclusively on the Sensory Learning Styles.

7.4.2 Excerpt 2

Group Y found the suggested strategies for Excerpt 2 clear, well-organised and amongst the most useful. Unexpectedly, those participants with perfect pitch who struggled in memorising Excerpt 1 with my instructions, found my approach for Excerpt 2 much easier than following their own. According to PD-Y: 'I had the perfect pitch of the melody, but it was easier to think that the left hand goes down and then comes up; and the right hand goes up, and then comes down, and then goes up again. So those patterns were better for this one, for me'. Similarly, PL-Y stated:

> I think the step for the second [excerpt] was the one that I most obviously thought: "Oh, this is helpful". Like, that helps me to remember. I think the second one was the one that clearly if I went to the excerpt itself, it would not have gone as easily as if I did the steps… [It] worked really well… You put it in a way that I understood the pattern in each hand.

This positive result was also attributed to the instructions simplifying the music in a way that it was easy to 'hear the tune', in PL-Y's words. Therefore, for perfect-pitch possessors (e.g., PL-Y), the music became easy 'to predict'. Similarly, PJ-Y described not 'thinking too much' after completing the instructions, because internalising the patterns made the music 'intuitive'.

When comparing this with Group X's experience, PB-X also ignored the repetition and PH-X 'played it in fours', that is two beats in each hand per bar, to have a clearer idea of the structure. Similarly, PH-X also transposed all notes to the same octave for analysing both hands as two independent melodies. One of the most interesting findings for this strategy, though, came from PE-Y, with perfect pitch as PD-Y and PL-Y, and sceptical about this strategy during the MMT: 'It was easier for me to put the notes where they are on the piano rather than on the same octave or just one octave in the middle'. However, after completing the AR, PE-Y admitted: 'it surprised me how it actually worked, putting all [the notes] together in the middle, although I couldn't understand this in the morning. So, I think that's my favourite [strategy][laughs]… Because when you have to play in octaves, you can't actually think of the melody that clear'. Even more unexpected was that PE-Y remembered the strategy and used it to recall Excerpt 2 during the AR. This helped this participant in remembering, without relying on kinaesthetic memory:

> I was trying to remember how it has to go. And you know what I did? I actually played what you suggested: everything in the middle [laughs], yes. And it was way easier. And now I understand why you suggested this in the morning. Well done! [laughs] Actually in the morning I was thinking: "No, why do I have to learn it this way? It's not helpful." […] I was singing the same line because that's my singing voice. So, it was easier for me as well. I didn't do it on the piano that much… [only] because it was on the instructions. But it didn't feel natural for me… But… in the afternoon… when I was trying to remember it, I [tried and] it

> worked quite well… Now this time… I wasn't relying on muscle memory[28] that much, because I was thinking: "I have to play that note and then that note."

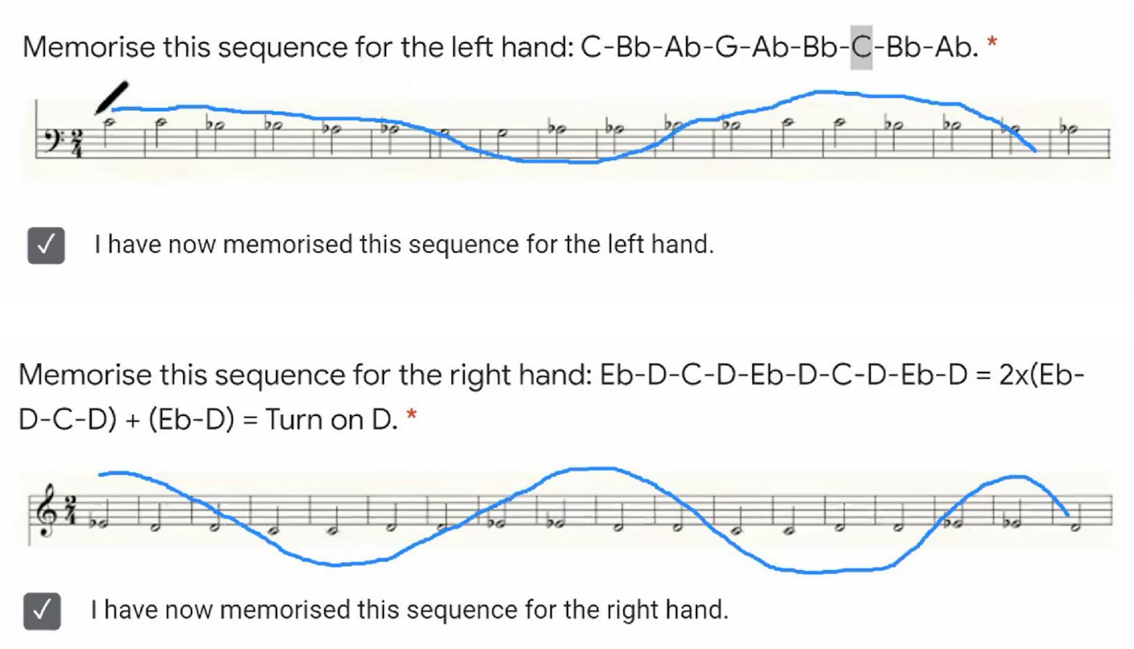
This was a significant achievement for PE-Y: 'If you have to memorise something, then it's always better to know what you're playing… I'm working very much with muscle memory and ear. So that's not always very helpful', especially in the longer term. Similarly, PG-Y highlighted the importance of understanding 'how the octaves are being displaced', admitting that spending more time on the steps that involved the reduction of the intervals, the patterns combined with the octaves and the rhythm broken down, might have allowed this participant to execute Excerpt 2 'better'.

When it came to identifying Excerpt 2's underlying patterns, Group X had no issues. The only exception was PC-X, who ignored the first E♭ in the right hand, and started the pattern on the D. Thus, this participant repeated the sequence D-C-D-E♭, adding an extra D at the end. PH-X also focused on the repeating rhythmical pattern for both hands: 'You have always two bars, the same note in one hand. And then, it sorts of shifts: one hand is changing, while the other hand is repeating the previous bar. With that sort of logic, it was easier to follow for me'.

Another important pattern was the octave changing, which was implicitly simplified with the instructions' sixth and seventh steps. Group X, though, solved it in different ways: PB-X simply remembered those points where 'it didn't change octave'; PC-X 'found the intervals between each other… to see where they change an octave'; and PK-X used a combination of 'calculating' and using the piece's tonal traces to 'hear if it wasn't what expected'.

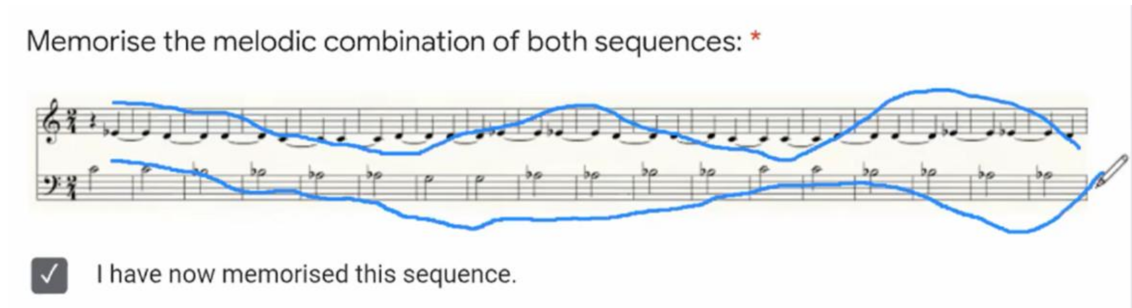
[28] "Muscle memory" is an informal way of referring to kinaesthetic memory.

Additionally, PF-Y developed a mapping strategy to visualise each melody's profile (see Example 7.4):



Example 7.4: PF-Y's annotations for Excerpt 2, during the interview after the Morning Memorisation Test (MMT).

Accordingly, when combining both hands, it was clearer 'which hand goes in which direction' and how both hands interact with each other, even if these are 'not oscillating at the same frequency' (see Example 7.5):



Example 7.5: PF-Y's annotations for Excerpt 2, during the interview after the Morning Memorisation Test (MMT).

PG-Y followed a similar approach to clarify further the octave-changing pattern. This participant first wrote the suggested indications on the printed score, to then locate where the greatest and smallest intervals happened for both hands. Finally, as anticipated with PK-X's strategies, aural memory played an important role when memorising Excerpt 2: this was selected from a postminimalism work and sounded quite tonal. Consequently, PE-Y found singing useful: 'I was singing the melody on the octave that you had written, like everything in the middle. But when I was playing it, it was easier for my hands to move lower or higher, where it was actually written'. Similarly, PH-X's previous aural model of Excerpt 2 also helped.

Overall, Excerpt 2 was easy to memorise for all participants, either because the suggested strategies were useful or because they succeeded in identifying the patterns. However, when coordinating both hands with the repetition, PB-X and PG-Y struggled to think of the patterns, switch hands or even count. In fact, Excerpt 2 seemed easy, but was challenging for hand coordination, while its self-referencing texture was misleading when performing from memory.[29] For example, after the MMT, PC-X claimed that performing Excerpt 2 successfully was just a matter of 'knowing when to come back or switch directions'. However, after the NDR, PC-X admitted: 'I think the second excerpt was a bit easier… [but] due to the hesitation… it's not that easy to remember, I guess'.

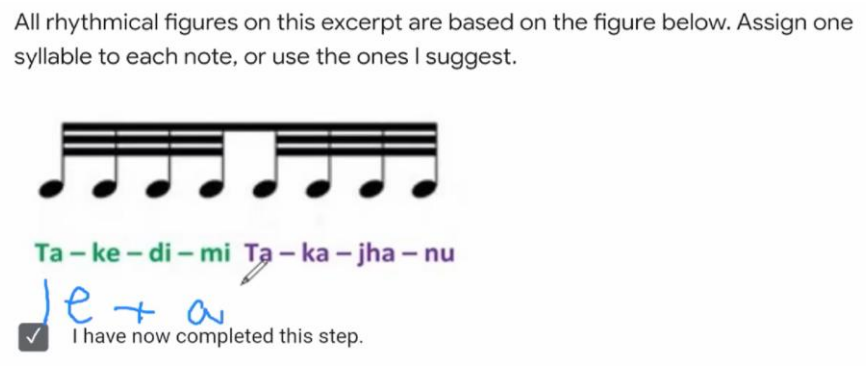
7.4.3 Excerpt 3

Excerpt 3 was the hardest for all participants, especially for rhythm, and it was generally played under tempo.[30] This challenge was identified during the Pilot Study, when PA-Y requested 'a technique for memorising really complicated rhythms'. Hence, further steps were included in the Main Study's instructions: participants were provided with *solkattu*

[29] In Excerpt 2, switches involved different changes of octaves or note resolutions.
[30] Particularly, PG-Y felt overwhelmed with it and only attempted some of the strategies.

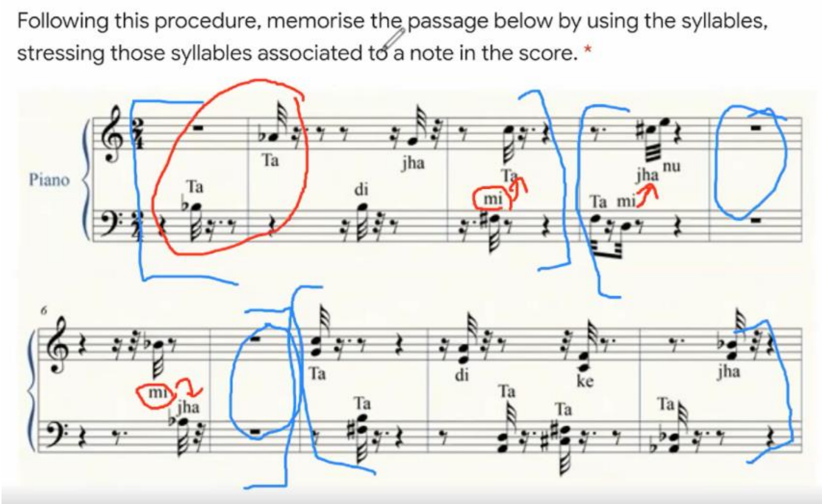
syllables, although they could use others. Group Y's results in the Main Study made evident that the Karnatic system requires some time to become useful, since most participants struggled with it during the test, although they could see its potential in a longer term.

After completing the AR, PJ-Y, who previously 'learned a bit' of this Karnatic rhythmical technique in Singapore, recognised that memorising 'with the Indian rhythm' would have allowed this participant to know on 'which beat' each rhythmical component 'was on', thanks to the syllables. 'But because' PJ-Y 'used numbers' instead for counting, this participant could only remember some of them. Again, PJ-Y did not persevere with *solkattu* for lacking familiarity in 'using that', and 'changed to numbers afterwards'. Similarly, PD-Y and PE-Y also switched to counting after trying *solkattu*, since they never came across it. Concretely, PE-Y found it 'very useful', but eventually 'swapped to the original thing' this participant is used to, indicating that *solkattu* could be useful and effective for memorising rhythm in the longer term. Conversely, Canadians PF-Y and PL-Y usually use the syllables 'One, E and A' (see Example 7.6), although PL-Y mentioned: 'I really liked these syllables [ta-ke-di-mi, ta-ka-jha-nu]. Because I use different ones, but I actually think that these are better. So, I would definitely use that'.



Example 7.6: PF-Y's annotations for Excerpt 3, during the interview after the Morning Memorisation Test (MMT), highlighting the syllables 'One, E and A' for tackling rhythm.

Some Group-X participants also memorised first the notes and then the rhythm, which PF-Y highlighted as helpful. Additionally, PH-X used segmentation to divide the excerpt into two parts, bars 1-6 (first part) and bars 7-11 (second part), to then divide these 'into parts of four', identifying 'when the drop notes come'. Playing these with one hand simply consisted in identifying at which count the right hand intervened, rationalising the rhythm. PF-Y also implemented this (see Example 7.7).[31] However, Group Y's perfect-pitch possessors (e.g., PD-Y, PL-Y), found it 'much easier' to memorise the notes and rhythm altogether.



Example 7.7: PF-Y's annotations for Excerpt 3, during the interview after the Morning Memorisation Test (MMT).

Pitch organisation was also important when memorising Excerpt 3, which consisted of a horizontal symmetry with an axis on E♭. Raising awareness of this geometrical structure was useful to PA-Y, PD-Y, PE-Y, PG-Y[32] and PJ-Y. However, for PJ-Y, it would be more helpful in the longer term since, after a while, this participant mostly focused on remembering 'the sound'. Furthermore, PE-Y stated that it 'was super easy just to think of the left hand and where it has to go'.[33] Oppositely, it was not useful at all for PL-Y, who relies on movements,

[31] PF-Y also used segmentation when memorising Excerpt 3, but this participant's structure was different from the one identified by PH-X. According to PF-Y, this consisted of three sections: b.2-4, b.5-8 and b.9-11 (see Example 7.7).
[32] PG-Y did not fully memorise Excerpt 3, but attempted the strategies related to pitch, and found these useful.
[33] Again, participants mostly chose one hand to perform the ostinato, and the other to play the rest of pitches.

sounds and sight; and for PF-Y, because the symmetrical relationship does not coincide with the bar structure, being more useful to find coherence within each bar.

By contrast, Group X struggled to identify any pitch organisation. PH-X focused on the resulting melody of the bouncing hand and PC-X attempted analysing the score, although this participant did not think about it too much when playing. Similarly, PK-X's strategies for Excerpt 3 were 'a hodgepodge', as this participant 'didn't find any patterns'. Consequently, Group X mostly relied on a combination of aural, visual and kinaesthetic memories. This was also used by Group Y when dealing with challenging excerpts for which the suggested strategies were either too novel or established a basis that permitted focusing on sensorial stimuli instead. PA-Y's awareness of the symmetry helped 'initially to understand… But then, after that, it became just a recognition of shapes'. Hence, PA-Y switched from actively thinking of the symmetrical relationships to a more intuitive and internalised performance, allowing her 'to speed up a bit'. PF-Y also used visual memory for identifying black-and-white combinations.

Therefore, Excerpt 3 was mostly difficult because of the rhythm, the pointillistic texture, and the required mental fluency for recalling and executing the pitches in the corresponding octaves, without compromising the rhythm. Additional challenges were rationalising pitch organisation, and figuring out fingering and hand arrangements. Hence, the most useful strategies for Excerpt 3 were removing the ostinato and octaves; identifying the patterns; memorising first the notes and then the rhythm; using syllables for the rhythm (e.g., *solkattu*);[34] and segmentation. All strategies were idiosyncratically combined with the Sensory Learning Styles and perfect pitch.

[34] However, in the shorter term, participants found easier to count in the traditional way, because this is what they are used to.

7.4.4 Excerpt 4

Finally, Excerpt 4 was brief and the most straightforward despite its atonality. Segmentation was useful to Group Y and PH-X, especially when combined with backward motion.[35] Notwithstanding, analytical strategies received a more varied reaction: conceptualising each bar using chromatic structures was controversial. Perfect-pitch possessor PD-Y found it 'really useful' because it allowed 'to connect' all pitches, which otherwise would be memorised by 'hand position'. Conversely, for perfect-pitch possessors PJ-Y and PL-Y, the analysis was an obstacle, although PJ-Y admitted that memorising through repetition instead was the reason for not remembering the excerpt in the subsequent recalls: a comparable decay in memory to PL-Y's, who solely memorised by ear. Similarly, PF-Y did not pay much attention to the analysis either.

Therefore, both the test's results and the interviews made clear that those participants who memorised without engaging conceptual memory had a bigger decay in their memory.[36] Occasionally, conceptualisation went further than music theory: PG-Y focused on the number of notes played by each hand, while PH-X paid attention to the shape or features of a whole gesture. Additionally, PF-Y memorised first the notes and then the rhythm, as suggested for excerpts 2 and 3, but not for Excerpt 4. This might indicate PF-Y's internalisation of the instructions' procedures and transferability to similar problems, as illustrated in Chapter 3 with Gauss' formula. However, PF-Y previously described a general memorisation strategy for tackling complexity: to memorise the notes first, followed by fingering, rhythm, articulation, phrasing, dynamics and tempo. Using fingering patterns as a retrieval strategy was also described by PL-Y: 'I decide what fingering I'm going to use and

[35] In Conceptual Simplification, this is Simplifying Preceding Structure. See Chapter 3 for further details.
[36] The only exception being PF-Y, who looked at the scores during the AR, as this participant misunderstood that the scores could be used again during the AR.

then when I'm playing I just think about: "this fingering, this fingering, this fingering, and then, this fingering"'.

Therefore, Excerpt 4 was easy for all participants. However, most perfect-pitch possessors did not welcome an analytical approach, finding it challenging. Nevertheless, they generally recognised that it was the best strategy in the longer term, especially in an under-pressure situation (e.g., exam, recital).

7.4.5 Summary

At the completion of the study, Group Y learned new memorisation strategies, regarding these as potentially helpful for their performance practice, even in the context of tonal music. Conceptual Simplification's scaffolded analysis was effective for the experimental group in different degrees and combinations with their regular strategies. For PD-Y, memorising Excerpt 2 without my instructions would have consisted in skipping some steps, such as the octaves and hands simplifications without the repetition. However, following all steps made memorisation 'faster'. This was also reported by PA-Y, PE-Y, PF-Y, PG-Y and PJ-Y. Additionally, PD-Y admitted that although removing the E♭-ostinato in Excerpt 3 was 'uncomfortable at first', this participant felt 'much more confident' with memory following my advice. This was also experienced by most of Group Y.

Therefore, some of the suggested strategies were the same that Group Y would have used on their own. However, my guidance was novel and effective for them, providing additional useful steps, and a fast and confident approach to memorisation. This was particularly relevant for those participants less experienced with this repertoire, who claimed not to know how to memorise the excerpts without instructions. This might explain why Group Y mostly replicated the instructions from memory when recalling the excerpts during the AR and NDR.[37] Likewise, the same participants stated that, for similar challenges, they would mix their usual strategies with the ones suggested.

Unexpectedly, those participants with perfect pitch and with less of a need for a memorisation method due to their ability, reported that the suggested strategies allowed them to memorise much more parameters at once, than by solely using perfect pitch, which only works for pitches. Furthermore, PG-Y mentioned the usefulness of writing down the simplified reductions, instead of processing these mentally, which is how these were initially intended with Conceptual Simplification.[38] Finally, participants found the method a helpful tool for revealing patterns in post-tonal music. Making this repertoire more accessible and achievable for less experienced performers motivated them to learn or perform it more often. As PJ-Y described: 'I haven't been exposed to much contemporary music. But I think after doing [this study], it made me realise that it's not as difficult as, or it's not as scary as we think, as long as we break it down. And this made me feel like I would like to look at more contemporary pieces'. To which PJ-Y added that if given a new work, this participant would be eager to learn 'how to break it down'. When comparing these outcomes with Group X, most successful strategies were the same included in the suggested instructions, which permitted identifying the underlying patterns.[39] Also, participants noted that setting deadlines and attempting recalls in different moments of the day, especially after sleeping, could be useful when learning new repertoire.

[37] Amongst these there was PA-Y, who thought that the excerpts were 'really complicated'. However, after following the instructions, every time PA-Y needed to recall an excerpt, this participant would 'come back' to the pattern: 'even though it sounds like a lot of notes, if you remembered what the pattern was, it came back quite easily'.
[38] See Chapter 3.
[39] Except for identifying the pattern behind the inversions of the chords in Excerpt 1, which I did not consider necessary in my own performance practice but was useful for some participants in both groups.

7.5 Influential Parameters

Participants were asked about their experience with sight-reading, perfect pitch, synaesthesia, mental practice, sleep and emotions, and how these relate to memorisation. Additionally, to gain a greater understanding of their LRT results, they were also asked about their science-related training or hobbies. This aimed at comprehending further why they found certain strategies more useful than others.

7.5.1 Sight-Reading

Most participants reported feeling confident to some extent at sight-reading (see Figure 7.13). PL-Y also specified generally feeling weaker at rhythm when doing so. Furthermore, they were also asked about how their sight-reading abilities linked to their memorisation.

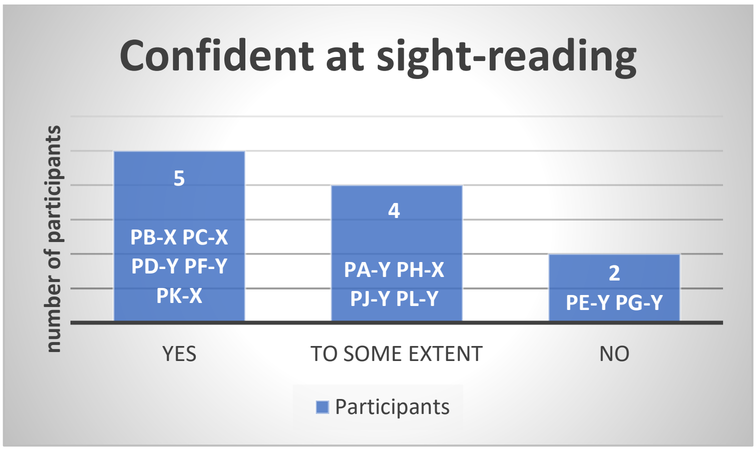


Figure 7.13: The participants' level of confidence with sight-reading.

For PD-Y, PE-Y, PF-Y and PJ-Y, sight-reading and learning are directly proportional. Amongst these, those confident at sight-reading (i.e., PD-Y, PF-Y, PJ-Y) stated that good sight-reading skills enhance chunking, boost pattern recognition and trigger fingerings associated with standard patterns (e.g., chords, scales). This process facilitates executing these faster on the piano, reflecting 'how quickly and familiar one is with recognising notes and their positions on the keyboard', to which PJ-Y added that this 'might translate to how fast one can absorb pieces'. Supporting this argument, PE-Y admitted that lacking confidence in sight-reading makes the 'learning process slower'. Other benefits of good sight-reading skills were enhancing visual memory and mental practice, which are useful for PA-Y, PC-X, and especially PB-X when reading 'sections of a score silently before playing'.

Then, participants explained how sight-reading links to memorisation. PG-Y, PL-Y and PH-X did not identify a link, and PH-X claimed these being 'two different approaches'. Conversely, PA-Y, PC-X, PE-Y and PK-X considered that memorisation and sight-reading abilities are inversely proportional. For PK-X, this link hampers effective memorisation, since this participant sight-reads and half-learns a lot of music 'instead of thoroughly learning and memorising'. However, PA-Y, who feels less confident in sight-reading than PK-X, sees this as an opportunity: 'I think in a way it is helpful not to be entirely confident at sight-reading as it can be easy to always play from the score. When there is conscious effort to read the score, I feel the notes are more likely to become ingrained in my memory'.

After the MMT, participants shared whether feeling confident at sight-reading was helpful when memorising the excerpts. PF-Y did not experience any advantages, despite being confident at sight-reading and not feeling the same way about memorisation. Similarly, for PK-X, confidence in sight-reading did not 'made much of a difference' for memorising 'such short pieces'. According to PK-X: 'The benefit of sight-reading when learning pieces is mainly being able to play the whole piece through and understand how it fits in the bigger picture together. And being able to decide what speeds go where'.

Alternatively, PB-X, PC-X, PD-Y, PJ-Y and PL-Y found sight-reading helpful during the MMT. PB-X mentioned not needing 'to spend time working out what the notes are', therefore, not memorising 'things that maybe other people would have to', with less sight-reading skills. PC-X agreed that sight-reading facilitates 'a brief analysis', 'see the patterns clearly', in PD-Y's words, and figure out how to memorise. The advantage when this process is straightforward, is that 'you wouldn't feel so tired when you start memorising', as PJ-Y stated, since both reading the notes and memorising can 'take up a lot of brain power'. This was reinforced by PE-Y, who is not confident at sight-reading and during the MMT felt like 'losing a few minutes in the beginning', especially in Excerpt 1, to 'find the notes' when playing and 'understand what is happening'.

7.5.2 Perfect Pitch

The number of perfect-pitch and relative-pitch possessors was quite balanced, as shown in Figure 7.14.

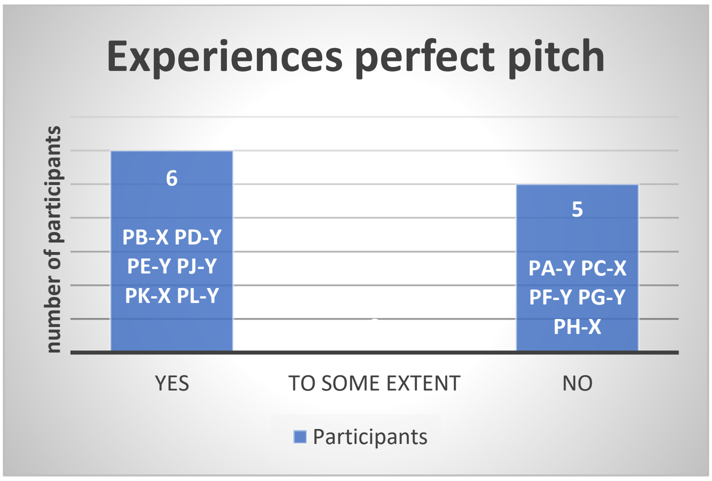


Figure 7.14: Experience of participants with perfect pitch.

Unlike the rest, PA-Y, PC-X, PF-Y, PG-Y and PH-X consider perfect pitch unrelated to memorisation. For perfect-pitch possessors PB-X and PD-Y, this enhances internal hearing: PB-X hears the score and has 'similar sensations to those' felt 'when playing it'; while PD-Y hears 'the pitches and their relationships' and 'immediately identify them'. Furthermore, PD-

Y, PE-Y, PJ-Y, PK-X and PL-Y use perfect pitch as a memorisation strategy for enhancing aural memory, and as a coping strategy for memory lapses. Moreover, PD-Y, PE-Y and PJ-Y listen to recordings for memorising through perfect pitch: PD-Y can be 'already very familiar with the music before' starting to learn a piece, even before seeing the score: 'If the music is popular, I already have the pitches in my head. If I can sing back the music, even in my head, then performing it on the keys becomes mostly a physical task'.[40] PK-X also uses perfect pitch for 'remembering the harmonic structure of a piece'. Therefore, using this ability to boost confidence and as a safety net: PE-Y would 'know' when hearing 'something "wrong"'; PJ-Y can 'find [the] way' whenever getting 'lost during a play-through'; and PL-Y is 'able to think of the precise note [PL-Y is] looking for', describing the memorisation process as 'intuitive' and relying on the 'feel' of the music.

Most perfect-pitch possessors found this ability helpful during the Memorisation Test, which PB-X defined as a tool for creating a mental framework of the pieces. The only exception was PK-X for Excerpt 3, as this participant thought 'of the note names, rather than the sounds'. Consequently, PK-X did not find perfect pitch beneficial for memorising this excerpt, although this was helpful for Excerpt 4, as it was for PD-Y and PL-Y. However, unlike PD-Y, PK-X mentioned not being able 'to pick out if was getting one of the middle notes wrong':

> I think in atonal music, it helps to hear the piece in your head to know when you've made a mistake. But for actually learning, I think it's more of just a general memory thing. I could hear in the big chord of Excerpt 4. I could hear when it wasn't right. [But] my ear isn't that

[40] PE-Y also mentally sang the notes using perfect pitch, and mentioned that, probably, this participant would have memorised faster if provided with some MIDI files or recordings of the excerpts. This is because when PE-Y learns something, especially when it is well-known, this participant usually listens to it before, and then, also learns it at the same time. Therefore, listening is a crucial step for PE-Y's memorisation process, which this participant also combines with kinaesthetic memory. This argument was also supported by PJ-Y, who also uses a combination of aural memory, guided by perfect pitch; and kinaesthetic memory. This would allow PJ-Y to memorise faster, needing to make less conceptual relations between the notes.

at tune to pick out six-, seven-note chords… I'm not sure if there is a distinction between a general aural memory and having perfect pitch. I would think the former helps on the latter.

7.5.3 Synaesthesia

None of the participants experienced synaesthesia: e.g., experiencing a sound as a colour. However, some use colours or visual imagery linked to sound in their performance practice. For instance, PC-X creates mental 'images' and links them to the sound, while PE-Y and PJ-Y either imagine or use colours as a mnemonic technique for classical pieces: PE-Y colours voices in a polyphonic texture and PJ-Y uses the 'feeling' of colours to produce a specific sound, which PB-X finds distracting during practice. Finally, all participants, except for PE-Y and PF-Y, did not identify a link between synaesthesia and memorisation.

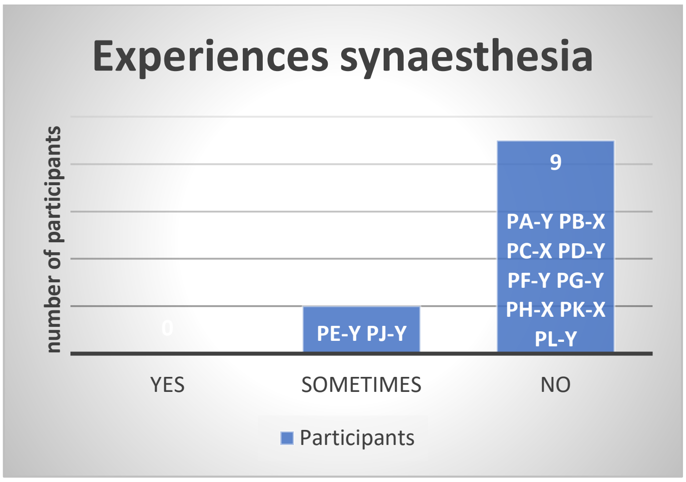


Figure 7.15: Experience of participants with synaesthesia.

7.5.4 Mental Practice

All participants, except for PF-Y and PK-X, reported that mental practice strengthens memory. This boosts confidence, helps in spotting flaws in conceptual memory, prevents exclusive reliance on kinaesthetic memory and contributes to efficient deliberate practice. According to PH-X, the mind becomes 'the ruler of [the fingers]', hence 'if [the] mind knows the music, [the] fingers will follow'. PJ-Y agreed: 'the head has to move faster than the fingers'. Therefore, mental practice helps in preparing for a confident performance and in focusing before going on stage. Additionally, for perfect-pitch possessors, it can also reinforce aural memory and internal hearing: PB-X finds it confusing to 'imagine the physical movements', but mental practice helps to 'hear the sounds' in the mind. Similarly, if PD-Y can 'perform the piece perfectly in [the] head', then this participant can 'replicate it in the physical world'.

As Figure 7.16 shows, the participants' peak usage of mental practice happens while memorising a piece, followed by the specific preparation for a concert and while learning before memorisation.

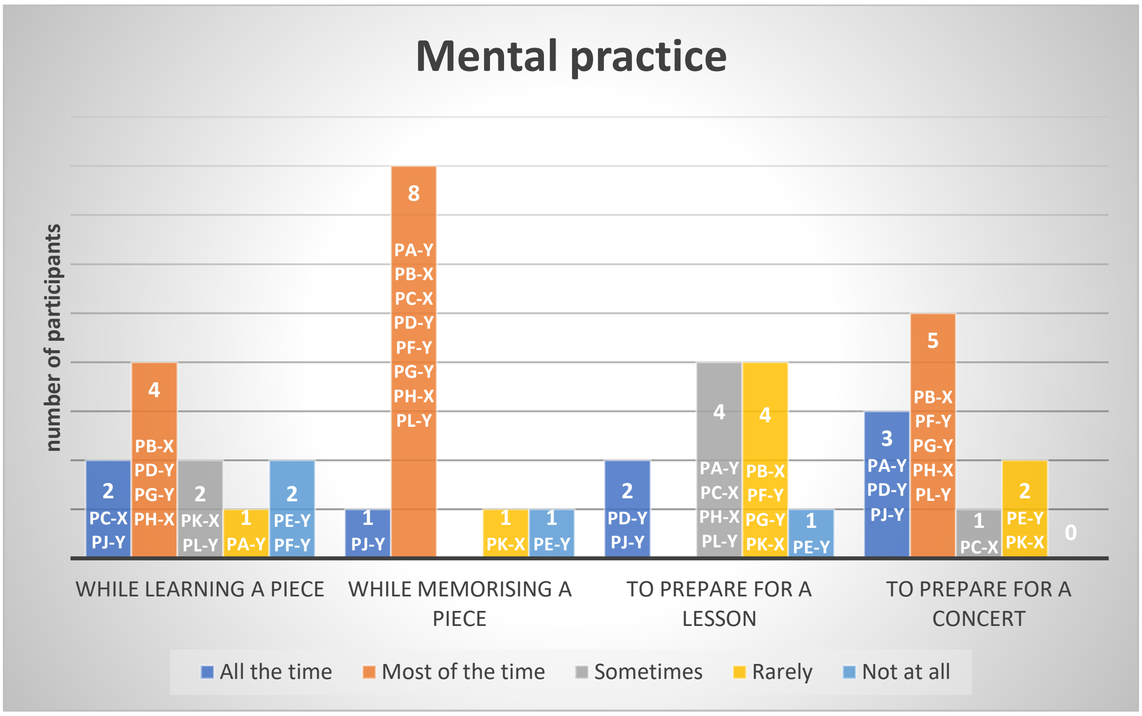


Figure 7.16: Proportion of usage of mental practice in the participants' routines.

7.5.5 Sleep

Participants were asked whether they used afternoon naps or ensured good-quality night's sleep, as part of their practice routines. Only PH-X and PL-Y reported regularly using it, while PC-X, PD-Y, PG-Y and PJ-Y did it sporadically (see Figure 7.17). The rest did not recognise sleep as an influential parameter in their performance practice. Amongst these, PB-X and PE-Y did not identify a link between sleep and memorisation. Nonetheless, for most participants, sleep has a positive impact on preserving, strengthening and integrating memory, resetting the brain and enhancing understanding. According to PC-X, PH-X and PL-Y, sleep helps in processing and consolidating information studied and enhances making newer connections that, eventually, facilitate performance. Therefore, if good-quality sleep is not guaranteed, memory can noticeably degrade, as PG-Y indicated. However, sleep alone does not make memory bulletproof, since as PF-Y suggested, information is lost over time when there is no attempt to retain it.[41]

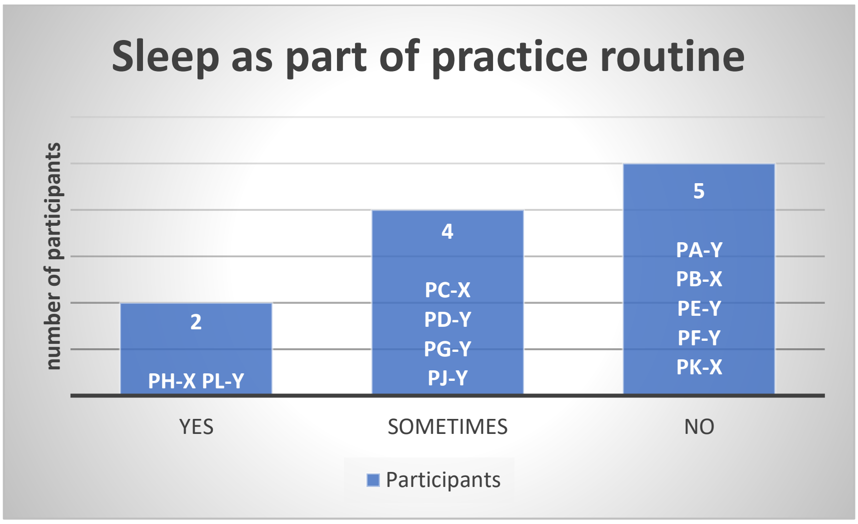


Figure 7.17: Proportion of usage of sleep in the participants' routines.

Additional considerations on sleep were that 'often the work' done on the previous day '"sinks in" overnight and feels much more comfortably memorised the next day' than 'at the end of the last practice session the day before', as observed by PA-Y. This makes it 'easier to remember a piece the day after an intense practice session' according to PK-X, which can be 'particularly useful before a concert', in PL-Y's experience. Therefore, 'this extra brain space', as PK-X defined it, that would be initially used for 'focusing on the notes' is liberated, so attention can be centred on 'other directions' such as 'dynamics', as PJ-Y indicated. Accordingly, participants were asked to sleep for eight hours between the AR and NDR, of which Figure 7.18 shows how many hours each participant eventually slept.

41 Ebbinghaus' ([1885] 1913) *forgetting curve* theorises the decline of memory retention over time (Baddeley et al., 2020: 280-281; Schacter, 2001).

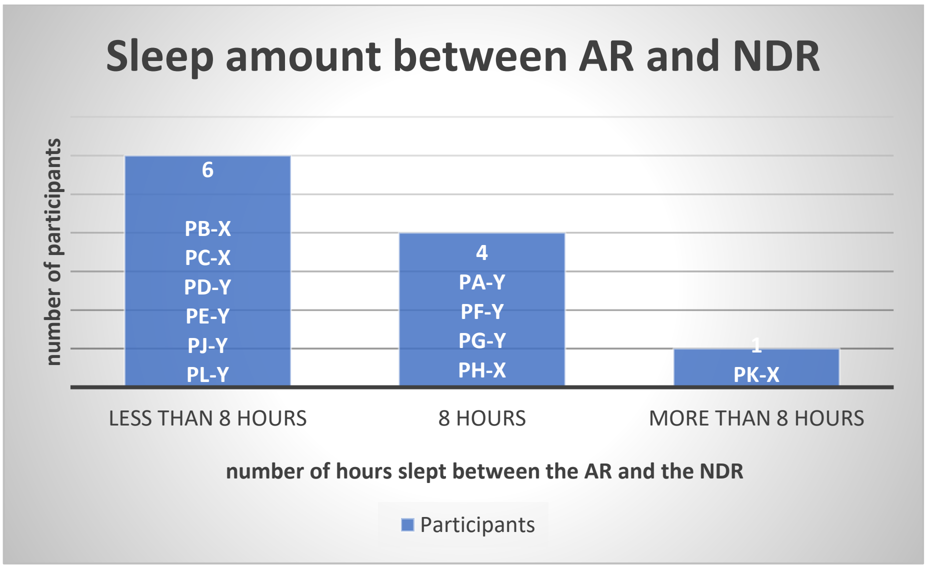


Figure 7.18: Number of hours slept by participants between the Afternoon Recall (AR) and the Next-Day Recall (NDR).

Generally, participants found that the NDR after a night's sleep and without practice was easier and quicker, taking significantly less time than in the MMT and AR. Among the improvements during the NDR, PA-Y felt 'faster [and] more confident' when recording, which coincides with PJ-Y feeling 'a bit more familiar' with the music, recalling it faster. PC-X played 'more accurately', despite 'not really thinking about everything', such as specific cues or annotations on the scores. For Excerpt 3, which was regarded as the hardest in terms of rhythm, PC-X just knew 'what happens when' and 'when to come in'. Similarly, PH-X 'was flowing much more' for all the excerpts and 'didn't even think about any methods or structure'; and PL-Y felt 'a little bit more clear-headed'. Also, according to amateur pianist PG-Y: 'I knew it more quickly this time. Yesterday evening [AR] I think I had to kind of remember a little bit more about the piece. Whereas this morning I already had it. And I think I was able to think about other things'. PG-Y also mentioned, though, that there were 'moments of hesitation' and was 'maybe a little ahead of' memory. This indicates that sleep might had a positive impact on all participants, regardless of their training and background.

Additionally, there were some interesting sleep-related findings with the implemented memorisation strategies. For instance, shorter timings were reported during the NDR. This should not be solely attributed to sleep but also to participants dealing with the same excerpts for the third time, progressively needing less effort to recall them.[42] Concretely, PE-Y needed more time with Excerpt 2 to implement all the suggested strategies, some of which this participant did not find useful before: 'Yesterday, I did only the different melodies, hands separately, on the same octave. Today, I first tried to put them, like you have suggested… hands together on the same octave, and then apart'. Group Y followed my suggestions when recalling the excerpts and mixed them with their own strategies. Particularly, for PD-Y, this was 'a mixture of the analysis [suggested, with] looking, and also hearing'. According to PD-Y: 'I was thinking about your method a lot. And that helped a lot. Maybe it's just like I needed to switch over'. After the NDR, PD-Y found it easier to follow the analytical approach, despite struggling with it before. Being able to switch the mental framework enabled PD-Y to find Excerpt 1 'a lot easier than yesterday [MMT, AR]', which was remarkable since this participant found this excerpt the hardest, along with Excerpt 3.

PD-Y also achieved a memory accomplishment with Excerpt 3: 'I realised that yesterday in the evening [AR] I forgot some of Excerpt 3. I forgot the F♯ and the C… But… this time I was playing through, and I was like: "Oh, no, I didn't remember this in the evening, yesterday!" And now I did remember it very easily'. PJ-Y experienced something similar: 'For the third one, there was the pivot point that you wrote, right?[43] The E♭. So, that one helped today with the notes. Which, yesterday, when I was doing it, I forgot about it. But I

[42] Therefore, participants did not have the chance to practice, but recalling the excerpts and, occasionally, also replicating from memory the instructions, could have influenced in decreasing the timing needed between the MMT and AR, and between the AR and NDR. Hence, this would relate to the established principle that the time needed for learning a piece decreases with practice (Chaffin et al., 2009; Chase and Ericsson, 1982; Ericsson and Kintsch, 1995).

[43] Here, PJ-Y refers to my indication of considering the E♭-ostinato as a horizontal axis of symmetry, hence, the rest of pitches become symmetrical to each other.

remembered it today, to find the notes'. Therefore, participants experienced memory lapses or initially felt incapable of recalling the excerpts, but they could rebuild their memory using the conceptual guidelines provided. Furthermore, the instructions implicitly supplied a scaffolded analysis of the music, as emphasised by some participants (e.g., PD-Y). Alternatively, those participants in Group X who exclusively relied on their usual memorisation strategies, still experienced a positive impact after sleeping between the AR and NDR, despite not being able to practise in between. PH-X expected subsequent recalls to be 'either the same as yesterday afternoon [AR], or a bit worse'. But instead, it was 'better' and 'more natural', feeling 'more settled and less controlled'. Also, despite some 'inaccurate' notes, overall, PH-X felt 'it was there already'.

Therefore, sleep might have positively influenced the participants' experience during the NDR, since except for PE-Y, PF-Y and PL-Y, they all felt more confident recalling and performing the excerpts then, as opposed to the MMT and AR. Exceptionally, PK-X felt equally confident during the MMT and NDR. Amongst those participants who rarely engage conceptual memory (e.g., PE-Y, PF-Y, PL-Y), they found the NDR more challenging, identifying their confidence peak immediately after memorising the excerpts (MMT). Nonetheless, given the study's short-term, all participants might have benefitted from kinaesthetic memory, which potentially helped in 'filling gaps' and 'connecting the analyses with the motoric aspect of the performance, as PG-Y highlighted; or even finding the NDR easier, knowing that they could not double-check with the scores, as PB-X, PJ-Y and PK-X noted.

7.5.6 Emotions

Generally, emotions did not play an important role in the participants' memorisation practice (see Figure 7.19), although some connections were identified. First, using emotions as meaningful encoding: PA-Y uses emotions to memorise dynamics, tempo and expression markings. Secondly, emotions can assist in articulating expressive content. Thirdly, using emotions as a retrieval strategy: PL-Y remembers 'musical phrases for the intention and character they convey', while PD-Y can 'access the music through the emotional state', if being 'in the right zone'. In PD-Y's words: 'If I sit down and hear and feel the music as I read over the score, it becomes easier to replicate that imagination of the piece in the physical sense'. This mnemonic technique is also reported by PH-X as an integration strategy when learning and memorising: 'My emotions are an association for me. If I remember an emotion, I can easily link it to the piece or part in a piece I want to remember. I sometimes like to build a full story with different emotions, that helps me to connect the memorised music'.

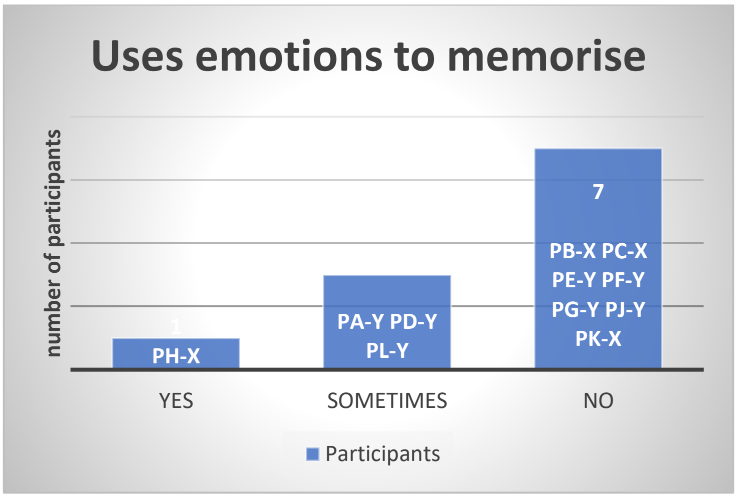


Figure 7.19: Proportion of usage of emotions in the participants' routines.

7.5.7 Scientific Background

Finally, PC-X, PD-Y, PF-Y, PJ-Y and PK-X, who scored higher in the Logical Reasoning Test (LRT), were asked about their scientific training to determine whether this was the reason behind their results. However, they did not have such training and no correlation was identified. Nonetheless, some hobbies might explain the results: learning languages[44] (PC-X); chess (PD-Y, PK-X); and logic puzzles (PD-Y). Conversely, PG-Y had advanced scientific training,[45] but reported not feeling any advantage when completing the LRT. Likewise, no special hobbies or training were identified for PJ-Y and this participant's good LRT results.[46]

The LRT was included to predict which participants might be more successful in the Memorisation Test, and for whom Conceptual Simplification would be more useful. Concretely, with the LRT, I intended to test the participants' hypothetical rationalisation of a score through the identification of rules for different patterns. In a way, this is what I was requesting from participants when memorising the excerpts. Nevertheless, a correlation between the LRT and the Memorisation Test results was not identified. For instance, it was true for PC-X and PD-Y; but not for PA-Y, who only scored 53'33% but was amongst the participants that did better at the Memorisation Test; or PK-X, who scored 86'67%, but did not obtain the best results when memorising. This could mean that the assessment provided with the LRT was not representative of what I intended to measure. Furthermore, the study's results made clear that no scientific training is required for effectively implementing Conceptual Simplification strategies.

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44 During the interview, PC-X mentioned that languages have 'lots of patterns' which could help on memorisation. This participant also studied biology, chemistry, Spanish, English and maths in school. PJ-Y also studied physics, mathematics and literature until the age of 18 years old.

45 PG-Y holds a bachelor's and master's in physics.

46 The scientific background was only enquired for those participants scoring higher in the LRT, with the goal of explaining their results. Furthermore, in PG-Y's questionnaire, this participant reported his scientific training as part of his educational background, since music is not his main activity.

7.6 Summary

Conceptual Simplification provided a systematic method for tackling post-tonal excerpts that were challenging for memory in terms of tonality, pitch organisation, harmonic progressions, switches, rhythm and spatial location. Within this context, the need to systematically "rationalise" the music was more needed, given the absence of familiarity with the musical language.[47] After implementing all steps, some participants (e.g., PJ-Y) reported switching back to their usual performance mode, since the music became 'intuitive'. By providing guidelines and strategies on how to tackle different memorisation challenges, perfect-pitch possessors could encode all pitches within a general rule.

The most effective strategies were those engaging conceptual memory for meaningful encoding. Concretely, participants found most helpful transposing all pitches to the same register, removing ornamental features and conceptualising sequences of pitches. These are flexible procedures that can be implemented in major works, and combined with other strategies, as observed with Group Y. Some Group-X participants figured out some of the suggested strategies, indicating that Conceptual Simplification can be an intuitive procedure and that no scientific training is required for effectively using this method. Participants less familiar with this approach found it mind-changing, with potential of including it in their performance practice. Therefore, Conceptual Simplification has potential as a tool to be taught in conservatoires, either on its own or mixed with other procedures.

Amongst the parameters tested, the most effective were mental practice and sleep, followed by perfect pitch. Likewise, sight-reading was suggested to be inversely proportional to memorisation: confident sight-readers tend to perform more often with the score and feel

[47] See pianist Gordon Fergus-Thompson's statements on this topic reported by Chen (2015: 134). See also Oura and Hatano (1988).

less confident with their memory. Similarly, not-confident sight-readers regarded memorisation as an alternative to overcome this lack of skill.

Those participants who did better at the Memorisation Test either implemented the suggested strategies (Group Y) or figured these out on their own (Group X). Similarly, when comparing the MMT, the AR and the NDR results, the timings decreased, as anticipated in existing literature.[48] Furthermore, results improved for most participants after sleeping, especially for those who memorised using conceptual memory. This suggests that, although it might seem faster to memorise using the Sensory Learning Styles or by skipping some of the steps, long-term retention requires breaking down the score as Conceptual Simplification encourages. This allowed many participants to secure memory faster, needing less repetition while enhancing coordination: once a mental framework is established through Conceptual Simplification, the same structure can be used for recalling or deducing the information (see Chapter 3). Furthermore, the Sensory Learning Styles provide additional stimuli to secure memory further, but memory tends to decay faster if memorisation exclusively relies on these, especially without further practice. This was the actual challenge behind the AR and NDR, becoming a major frustration for those not memorising with conceptual memory (e.g., PL-Y).

It was also highlighted the need for reaching a balance between physical and mental practice, avoiding obsessive routines based on sheer repetition. Instead, repetition should be used as an overlearning strategy to secure memory further since kinaesthetic memory alone lacks reliability. Moreover, mental practice can be useful for spotting flaws in memory and as a metacognitive strategy for planning the next practice session. Also, perfect-pitch possessors can use it for learning a new piece before trying it out on the piano or memorising faster.

[48] See Chapter 2.

However, effective memorisation strategies do not suffice if physical and mental health are not encouraged: healthy habits such as exercising, sleeping properly and promoting a positive mindset are essential. Otherwise, memory deteriorates, and negative self-talk sabotages preparation when feeling stressed or under pressure.

The next chapter comprises the discussion of this thesis.

Chapter 8: Discussion

This chapter discusses the findings of this thesis, to clarify how memorisation of post-tonal piano works can be improved. These are structured according to the Research Questions (RQ) defined in Chapter 1.

8.1 RQ1: What Parameters Influence the Memorisation and Performance of a Post-Tonal Piano Work?

Literature illustrated the intricate nature of piano performance in terms of perception,[1] cognition,[2] learning,[3] memory,[4] motion,[5] spatial mapping[6] and emotion;[7] and how all these integrate when playing. RQ1 aimed at understanding the influence of perfect pitch, synaesthesia, sight-reading, emotions and sleep on memorisation and performance. Given the nature of post-tonal piano music,[8] complexity emerged as an important factor for memorisation that needed to be discussed. The roles of expertise and mental practice were also analysed, when relevant, for each of the parameters described. The most influential were perfect pitch and sight-reading, while the effect of sleep and complexity were also found profound in memorisation. Finally, none of the pianists involved reported experiencing synaesthesia. Thus, this thesis cannot discuss any findings on how synaesthesia influences

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[1] Brancucci and San Martini (1999; 2003), Brancucci et al. (2005; 2008; 2009a; 2009b; 2012), Franciotti et al. (2011), Meister et al. (2004), Wong and Gauthier (2010).
[2] Gunter et al. (2003), Schön and Besson (2002), Stewart (2005).
[3] Stewart (2005), Stewart et al. (2003).
[4] Simoens and Tervaniemi (2013).
[5] Behmer and Jantzen (2011).
[6] Stewart et al. (2004).
[7] Jäncke (2008), Schubert (2013).
[8] The term *post-tonal* identifies compositions that do not completely fit within a tonal framework. Hence, post-tonal music includes two distinct categories: *non-tonal*, which refers to music that can still contain tonal elements; and *atonal*, which involves music with no traces of tonality.

memorisation of post-tonal piano music. Therefore, the parameters discussed here are complexity, perfect pitch, sight-reading, emotions and sleep.

8.1.1 Complexity

Conceptual Simplification's effectiveness was evaluated for post-tonal piano music, determining in what ways this repertoire differs or challenges learning and memorisation. This section discusses a potential model to assess complexity, based on this thesis' findings and existing literature. This is divided into two subsections: the main challenges for cognition and types of complexity. Strategies for simplifying complexity are discussed with RQ2.

8.1.1.1 The Main Challenges for Cognition

Evidence collected highlighted the importance of following an analytical approach and engaging conceptual memory when memorising. This replicates Craik and Lockhart's (1972) depth of processing principle in that more elaborate encoding leads to further long-term retention,[9] and the importance of integrating new content with pre-existing knowledge.[10] This allows the performer 'to represent the music mentally at global and local levels, and to move between the different levels of representation during practice', therefore, conceptual memory becomes a form of semantic and procedural knowledge that 'facilitates performance' (Ginsborg, 2004: 128-129). However, findings also illustrated the impact that individual learning styles have on memorisation.[11] During the Study with Participants, not all

[9] See Chapter 2, section 2.2.2.1 for further details.
[10] Fonte (2020), Nielsen (1999a), Ockelford (2011), Rostron and Bottrill (2000), Sloboda (1985; 2005), Soares (2015), Tsintzou and Theodorakis (2008).
[11] Or any other aspect of their performance (Héroux, 2016). This might be one of the reasons why there is so much literature on presenting, collating or reviewing different pianists' views on music, technique, practice strategies, memorisation approaches and interpretation. e.g., Fonte et al. (2022), Mishra (2005), Odendaal (2019), Svard and Maack (2002), Williamon (1999a).

participants in the control group identified the same patterns. Similarly, only some in the experimental group noticed additional patterns not included in the instructions. Unexpectedly, this outcome did not always correlate with their expertise in post-tonal music, as existing literature reported.[12] Furthermore, participants' capability in detecting patterns conditioned their later effectiveness in encoding and retrieving the excerpts.[13] Hence, this questions what could be the reasons behind such a difference when examining a new score.

Essentially, a musical score is a highly detailed visual input that requires previous training to be decoded.[14] The challenge of efficiently translating this visual input into meaning increases with a lack of expertise on its content,[15] which can be quite defiant for scores of certain post-tonal composers or styles,[16] as several recruited pianists reported. For Gasull's concerto, such difficulty increased when having to work with a handwritten score, as opposed to a computer-notated one; and when the visual appearance of the score changed, as PE-Y also reported. However, translating input into meaning is not exclusive to the musical domain, but also found in other areas (e.g., mathematics, language, chess, sports), in which significant differences are noted in the corresponding abilities of individuals for pattern recognition[17] and the nature of their 'visual experience' (Fan et al., 2022: 2683).[18] Little is known on how this perceptual learning relates to education.[19] However, the Study with Participants results suggested that Conceptual Simplification strategies were effective in increasing the efficient translation of visual input into meaning, boosting pattern recognition and understanding.

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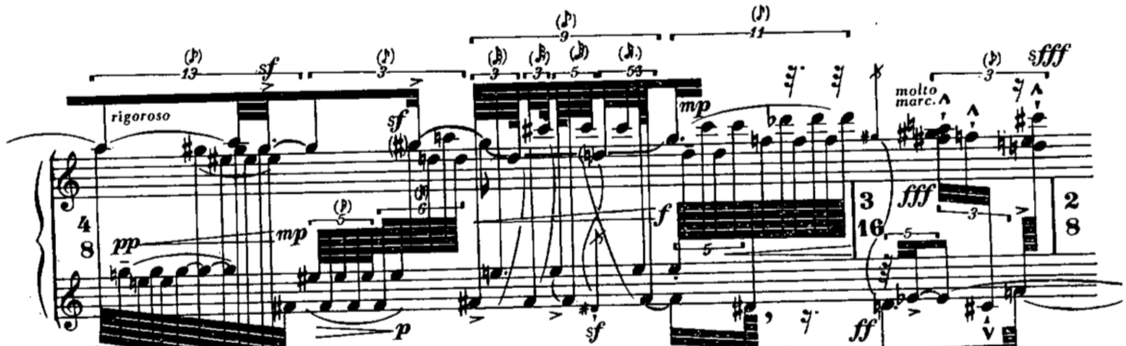
12 Gobet and Simon (1996a; 1996b), Sala and Gobet (2017), Soares (2015: 210), Starkes et al. (1990), Tsintzou and Theodorakis (2008: 7-9).
13 Concretely, see Theodorakis' statement in lines 3029-3040 (Fonte, 2020: 451) and Andrew Ball's statement in lines 256-269 (Fonte, 2020: 386). Similar reflections were provided in this thesis by Theodorakis and Hardink, referring to theatre. See also Gobet (2015).
14 Jónasson et al. (2022), Sloboda (1976).
15 Sloboda (1974), Tsintzou and Theodorakis (2008), Wong and Gauthier (2010).
16 Chen (2015), Chueke and Chaffin (2016), Fonte (2020), Fonte et al. (2022), Soares (2015), Thomas (1999).
17 e.g., Boggan et al. (2012), Duchaine and Nakayama (2006), Wong and Gauthier (2010).
18 See also Gauthier et al. (1998; 2003), Wong and Wong (2016), Wong et al. (2012).
19 Goldstone et al. (2010), Kellman and Garrigan (2009), Kellman et al. (2008), Odendaal (2019).

This was reported even when participants were unfamiliar with the style and inexperienced in performing and memorising post-tonal music.

8.1.1.2 Types of Complexity

Defining "complexity" was not the main goal of this research. Nevertheless, this topic frequently emerged when discussing memorisation. Theodorakis, Hardink, PB-X, PG-Y and I identified two main types and extremes of complexity for post-tonal piano music, particularly challenging for memory:[20]

> A) Highly detailed and multi-layered scores with puzzling rhythms (e.g., irrational rhythms, polyrhythms); disconnected melodic cells; unpredictable dynamics; and contrasting sections lacking repetition (e.g., Example 8.1). This first type was associated with New Complexity (e.g., Brian Ferneyhough, Michael Finnissy), but also composers such as Xenakis, Stockhausen and Jason Eckardt.



Example 8.1: Brian Ferneyhough, *Lemma-Icon-Epigram* (1981), bars 8-9, to exemplify Complexity Type A.

[20] Melikyan also implicitly alluded to these categories, although he was less specific.

B) Self-referencing scores with a significant presence of switches, potentially including long phrases without pauses (e.g., Example 8.2). This second type was associated with Minimalism (e.g., John Adams, Morton Feldman), but also specific works by Claus-Steffen Mahnkopf and Stefan Beyer.

Example 8.2: John Adams, *China Gates* (1977), bars 87-99, to exemplify Complexity Type B.

Both categories are relatable to many post-tonal composers, but these only represent two extremes of complexity, oversimplifying post-tonal repertoire's diversity.[21] Furthermore, evidence collected suggested a third type of complexity:

C) Scores combining different degrees of Complexity Type A and Type B at presenting features of both. For instance, Messiaen's music was considered a mix of these two kinds of complexity (e.g., Example 8.3): Theodorakis and Hardink highlighted Type B in Messiaen's compositions due to the high presence of switches, while PC-X highlighted Type A, for its level of detail. Complexity Type C would also include pieces with extended techniques. Evidence from Gasull's Self-

[21] e.g., Auner (2017), Nonken (2014).

Case Study, Fonte (2020)[22] and Farré Rozada (2018)[23] suggested that extended techniques can prompt switches, while providing an additional layer of complexity.

Example 8.3: Olivier Messiaen, *Vingt Regards sur l'Enfant-Jésus* (1944), 'Regard du Fils sur le Fils', bars 34-41, to exemplify Complexity Type C.

Participants identified Complexity Type A with their stereotype of "contemporary music" or non-canonical composers. For those less experienced, this pre-conceived idea prompts a fear of memorising or even playing this repertoire. Additionally, most participants with specific training in post-tonal music expressed their reluctance to memorise such complex scores. Conversely, Theodorakis and Hardink, with vast experience in memorising this type of complexity, recognised the time-consuming process this requires, since pitch, harmony, rhythm and context are taken to an extreme of detail and prominence.[24] For Hardink, the difficulty of these 'athletic types of pieces' is that spatial identification becomes an additional

[22] This involved the 10-minute commissioned solo piano work *If You Were Here* (2015) written by Wynton Guess. In this piece, the author as practitioner identifies complexity mostly in terms of rhythm, switches and extended techniques.
[23] This involved the 35-minute *Makrokosmos I* (1972) by George Crumb, which explores different kinds of extended techniques, as well as switches and multi-layered textures.
[24] Aiba and Sakaguchi (2018), Forte (1983), Lewandowska and Schmuckler (2020), Reina (2015).

milestone,[25] and that such complexity can hinder sight-reading.[26] These reflections around Complexity Type A align with those of professional specialised pianists interviewed in Fonte (2020). Notwithstanding, both Theodorakis and Hardink also acknowledged that once this work is completed, the information tends to be retained in LTM. This could be due to their work philosophy to memorise as they learn, but also to the extra cognitive effort that requires understanding, coordinating and memorising this level of difficulty.[27]

However, most recruited participants did not identify Complexity Type B as challenging, potentially due to a lack of awareness of switches or to underestimating the implications of these for memory, even within the context of tonal music.[28] Another reason could be a lack of familiarity with self-referencing pieces, most likely written in a minimalist or post-minimalist style, but not only. Similarly, most specialised pianists interviewed in Fonte (2020: 380-469) did not identify Complexity Type B as equally problematic when memorising post-tonal music as Type A. This might be explained with Fonte's (2020: 356-357) interview topic guide not prompting for such reflections; or to most of these pianists not frequently performing post-tonal music from memory, hence being less aware of specific strategies for tackling the memorisation of switches.[29] However, both Fonte (2020) and Soares (2015) reported as practitioners the challenges of self-referencing textures for memory, defining these as "switch sequences"[30] and "concision of material",[31] respectively.

But why one type of complexity is perceived as more difficult than another? One possibility could be *visual crowding*, which is the 'impaired recognition as a result of processes confusing

[25] Fonte (2020), Fourie (2004).
[26] Lewandowska and Schmuckler (2020).
[27] Bjork (1975; 2014), Bjork and Bjork (1992; 2011), Craik and Lockhart (1972), Ebbinghaus ([1885] 1913), Pyc and Rawson (2009), Rowland (2014), Schmidt and Bjork (1992).
[28] e.g., Chaffin and Lisboa (2008), Chaffin et al. (2002; 2010).
[29] Fonte (2020: 380-469).
[30] Fonte (2020: 123; 134; 143; 155-156; 163-164; 181; 193).
[31] Soares (2015: 127-128).

target and distracting visual features' (Fan et al., 2022: 2683).[32] Consequently, too much information, as a highly detailed and multi-layered score, can be more overwhelming than slightly modified repetitions. Crowding can be reduced with specific training,[33] but it is also expected that expertise in reading music shall diminish its effect.[34] Hence, a potential explanation of why less experienced pianists might find Complexity Type A more challenging than Type B could be that, by using the score for performance, they are constantly reminding themselves of Type A's difficulty, whereas following the score while playing might allow them to tackle Complexity Type B more easily. This argument could be supported by Theodorakis' and Hardink's claims that piano works featuring Complexity Type B tend to involve fast learning processes but time-consuming and daunting memorisation processes. Additionally, in Western musical institutions (e.g., conservatoires), rhythmical development is often overlooked and undertrained.[35] This might also explain why Complexity Type A, frequently featuring irrational rhythms and polyrhythms, might seem more unmanageable than switches. Also, recruited participants consistently struggled with rhythm more than pitch; and multiple professional pianists and students involved in this thesis and Fonte's (2020) coincided in that rhythm within the context of Complexity Type A needs some preliminary work. Behavioural evidence from the Self-Case Studies supports further this claim, although the implementation of *solkattu* in conjunction with Conceptual Simplification softened this struggle.[36]

Furthermore, Complexity Type A usually involves discordant and unrelated content that disrupts fluent recall. Concretely, *repetition suppression* accounts for the 'reduced activity' that the brain undertakes for 'processing a stimulus when that stimulus is repeated, compared to

[32] See also Maus et al. (2011), Pelli and Tillman (2008), Whitney and Levi (2011).
[33] Wong and Wong (2016).
[34] Wong and Gauthier (2012).
[35] e.g., Reina (2015).
[36] Further details of its implementation are provided in Chapter 3 and Chapter 5.

when it is encountered for the first time' (Baddeley et al., 2020: 146). Therefore, more effort is required to constantly review new information, as opposed to reencountering previous content. Similarly, *repetition priming* also favours Complexity Type B, because the 'enhanced processing of a stimulus' results from 'recent encounters' with it, contributing to implicit memory formation (Baddeley et al., 2020: 145): each time an idea is repeated, this is more familiar and seems a bit easier, regardless of whether this is sensorial or conceptual.[37] Hence, both repetition suppression and priming might explain why Complexity Type B might seem less daunting than Type A. However, Type B's difficulty resides in the competition assumption and the cue-overload principle, in which self-referencing triggers the same memory cues.[38] Consequently, the distinctiveness of certain elements in a Complexity-Type-A musical texture eventually makes it more memorable.[39] This might explain why Theodorakis and Hardink regarded Complexity Type A as slower but easier to memorise than Type B, therefore, satisfying the von Restorff effect.[40]

Finally, these types of complexity are not limited to post-tonal music. Beethoven's or Chopin's piano works are good examples of Complexity Type C, being challenging in terms of switches and rhythm.[41] Bach's polyphonies present multiple switches.[42] François Couperin's pieces and their ornamental coding require previous knowledge and familiarisation with the style.[43] Schumann's piano works demand certain musicological endeavour for comprehending its varied range of accents;[44] and Liszt's and Moscheles' virtuosity stand out for a varied articulation and richness of attack.[45] These are only some

[37] Schacter (1992).
[38] Both the competition assumption and the cue-overload principle are discussed in Chapter 2.
[39] Chee and Goh (2018), Hunt (2013), Tulving and Kroll (1995), von Restorff (1933).
[40] Distinctiveness and the von Restorff effect are discussed in Chapter 2.
[41] Chiantore ([2001] 2007; 2010), Drake (1994), Eigeldinger (1986). For instance, Chopin's pieces stand out for challengingly combining rhythmical precision with rubato (Eigeldinger, 1986).
[42] Anson-Cartwright (2014), Chaffin et al. (2002).
[43] Neumann (1969), Tunley (2004).
[44] Brown (1999), Langlois (2018).
[45] Chiantore ([2001] 2007: 279-283; 341-388).

examples of the challenges that tonal music presents in terms of complexity. Thus, the impact of effectively tackling complexity with Conceptual Simplification or other methods transcends post-tonal music, with potential transferability to other musical genres.

8.1.2 Perfect Pitch

Recruited perfect-pitch possessors generally regarded this ability as an influential parameter for effective memorisation. Perfect pitch is only possessed by 1 in 10,000 of the general population in Western countries,[46] and up to 15% of advanced music students.[47] Therefore, a well-balanced sample of performers with and without perfect pitch was unexpectedly obtained in all three studies. In terms of specialists, Melikyan and Theodorakis had perfect pitch and Hardink did not. Similarly, recruited participants involved six perfect-pitch possessors and five relative-pitch possessors. Finally, I have relative pitch. Such unexpected evenness between perfect-pitch and relative-pitch possessors could be partly attributed to their principal instrument being the piano, since learning a transposing, folk or vocal instrument from an early age can be an obstacle for developing perfect pitch.[48]

The influence of perfect pitch on memorisation was explored in general terms (Interviews), or related to specific repertoire (Self-Case Studies, Study with Participants). From these, the following findings emerged:

1) **Perfect pitch is a learning facilitator:** Perfect pitch can be useful for imagining how a score sounds, leading to the formation of an aural model of the piece.

[46] Bachem (1955), Profita and Bidder (1988), Takeuchi and Hulse (1993).
[47] Baharloo et al. (1998).
[48] Peng et al. (2013).

2) **Perfect pitch interacts with memory:** Perfect pitch can enhance memorisation and influence or determine the memorisation approach.

3) **Conceptual Simplification enhances the implementation of perfect pitch:** Conceptual Simplification was successful for perfect-pitch possessors, facilitating its implementation to post-tonal music.

4) **Perfect pitch enhances mental practice.**

These findings are now discussed in detail. Nonetheless, any comparison with previous research is limited. Existing studies observing practitioners' behaviours omitted how perfect-pitch possessors conditioned their findings:[49] perfect pitch was neither considered when collating their participants' profiles nor used to argue the obtained results. Consequently, their data does not correlate perfect pitch and memorisation. Additionally, there is scarce literature on perfect pitch and its influence on musical skill acquisition involving complex motor skills and cognitive procedures (e.g., playing a musical instrument).[50] Instead, most research on perfect pitch focuses on perception.[51]

8.1.2.1 Perfect Pitch is a Learning Facilitator.

Results from the Interviews and the Study with Participants showed that perfect pitch can be useful during the early stages of learning, particularly for imagining and mentally reproducing a score. This is known as '*inner hearing*, *auditory imagery* or *audiation*' (Fan et al.,

[49] e.g., Aiba and Matsui (2016), Chueke and Chaffin (2016), Fonte (2020), Jónasson and Lisboa (2015; 2016), Meinz and Hambrick (2010), Soares (2015), Tsintzou and Theodorakis (2008), van Hedger et al. (2015).
[50] Münte et al. (2002).
[51] See Deutsch (2013) for a review.

2022: 2685),[52] and can complement aural memory.[53] Interviewees with perfect pitch described it as an ability that permit, along with sight-reading, develop an overview of a piece,[54] while enhancing internalisation and even memorisation.[55] Recruited participants listen to recordings and use perfect pitch to explicitly retain the music aurally,[56] while linking sound to movement with mental practice.[57] However, for Theodorakis and Hardink, perfect pitch is not required for successfully imagining how a score sounds. Concretely, despite having relative pitch, Hardink can still read a score and play it mentally, although he recognised that having perfect pitch would make it easier. Finally, my experience during the Self-Case Studies was that of a relative-pitch possessor, during which evidence was provided of my pitch-related auditory memory. This is a system that I developed over the years to create an aural memory of the music, while consciously developing and encoding associations between each sound and its corresponding label on the keyboard. That is simultaneously remembering both the sound and the note's name, which was reported quite useful when memorising works with limited or no traces of tonality. Furthermore, as reported in Chapter 5, I rejected sight-playing for developing an aural model of the commissioned works. Instead, Conceptual Simplification allowed me to systematically downsize the difficulty of focusing on too much aural information at once.

Perfect pitch permits accurately identifying or producing a pitch, without any previous reference.[58] Usually, for Western-trained musicians, this ability is framed within a musical scale or the piano keyboard,[59] since perfect pitch's stability is conditioned by the 'cultural conventions for tuning' music (Hedger et al., 2013: 1496). Furthermore, perfect pitch has

[52] See also Brodsky et al. (2003), Kopiez and Lee (2006; 2008), Mishra (2004).
[53] Peretz and Zatorre (2005), Zatorre et al. (1994).
[54] Brodsky et al. (2003; 2008).
[55] Haueisen and Knösche (2001), Keller (2012), Peretz and Zatorre (2005).
[56] Mishra (2004; 2005; 2010), Odendaal (2019).
[57] Bernardi et al. (2013), Coffman (1990), Highben and Palmer (2004).
[58] Deutsch (2013), Hedger et al. (2013), Münte et al. (2002), Takeuchi and Hulse (1993), Ward (1999).
[59] Münte et al. (2002).

different proficiency levels, which vary between individuals who possess it, both in identification and production tasks, depending on the musical timbre or register.[60] Concretely, the piano timbre can facilitate accuracy in pitch identification,[61] which supports Theodorakis' description of his own experience. Moreover, this was also noticeable during the Memorisation Test, in which perfect-pitch possessors reported different experiences. For instance, PK-X hears when playing something wrong in atonal contexts but, within a cluster or atonal chord, this participant cannot individually distinguish each note. This contrasts with music savant Derek Paravicini, with perfect pitch and an astonishing accuracy for picking up individual notes of atonal tetrachords,[62] but who cannot reproduce an atonal composition.[63]

Moreover, perfect-pitch possessors do not encode pitches in terms of sound, but according to their names within the musical scale. Therefore, their aural memory is verbally encoded, which is a more advantageous and stable format for pitch memory. Such difference of memory processing with relative-pitch possessors can make perfect-pitch possessors more effective for aural memory, despite having the same memory capacity,[64] but less effective when tuning varies.[65] Although the Memorisation Test was harder than those tasks of previous perfect-pitch studies, such verbal coding was reported by perfect-pitch possessor PK-X, who for Excerpt 3 thought 'of the note names, rather than the sounds'.

All these findings might explain why consciously associating and memorising a pitch with its note label could have improved my internal ear toward more accurate discerning. This required many years of practice, but it was reported as a successful strategy during the Self-

[60] Takeuchi and Hulse (1993).
[61] Athos et al. (2007), Baharloo et al. (1998), Lockhead and Byrd (1981), Rakowski and Morawska-Bungeler (1987), Takeuchi and Hulse (1993), Ward (1999).
[62] In the following video it can be seen Derek Pavacini recalling up to 10-note piano clusters and orchestral clusters on the piano (watch from minute 4:11): https://youtu.be/r6HCXx8U6Ko
[63] See Ockelford (2011).
[64] Bachem (1954), Deutsch (2013), Takeuchi and Hulse (1993).
[65] Eaton and Siegel (1976), Rakowski (1972).

Case Studies. Furthermore, such experience of becoming better at recognising pitch without prior references was supported by perfect-pitch possessor Theodorakis, who recognised that not having it is not an obstacle for a 'good musical memory', and that alternative methods can be acquired for this goal. Also, that performing atonal repertoire can be 'a good training' for pianists with and without perfect pitch, to 'sharpen' such skill.

8.1.2.2 Perfect Pitch Interacts with Memory.

Two main results indicated how perfect pitch might influence memory. First, perfect pitch can enhance memorisation, making it instantaneous and intuitive. Secondly, those perfect-pitch possessors usually memorising effortlessly "by ear"[66] tend to omit or engage less conceptual memory.[67]

Regarding the first point, most participants with perfect pitch described it as a facilitator for developing aural memory and a useful memorisation strategy, also effective for coping with memory lapses. PD-Y, PE-Y and PJ-Y memorise by listening to recordings or their own playing. Concretely, given a well-known piece that PD-Y could sing or reproduce the pitches mentally, the act of performing it from memory becomes essentially a matter of translating such information into the 'physical task' of playing it on the piano. Other benefits were retaining the work's harmonic structure and detecting wrong notes during performance. Nonetheless, perfect-pitch possessors noted that what significantly increased their confidence was the ability to overcome a memory lapse by proficiently thinking and finding with precision a note using perfect pitch.

[66] Bangert et al. (2006), Ginsborg (2004: 130-131), Lahav et al. (2013), van Hedger et al. (2015: 169-170; 174; 176-177).
[67] Ginsborg (2004).

However, these perfect-pitch-related strategies do not prevent memory lapses per se. Some of these pianists' memorisation processes are incidental, rather than deliberate or analytical,[68] and rely on Sensory Learning Styles.[69] This approach was also reported by Melikyan, who did not identify any advantage of having perfect pitch for memorising. Nonetheless, he memorises incidentally, relying on implicit memory. Hence, perfect-pitch possessors can feel more confident during performance by assuming that they will patch through perfect pitch any potential disruptions to associative chaining,[70] since the intuitive recognition of pitches shall trigger the corresponding content needed. Therefore, perfect pitch might be more of a remedy than a preventing tool for memory lapses. Consequently, experienced professionals (e.g., Theodorakis) developed deliberate memorisation approaches, instead of exclusively relying on perfect pitch.

Regarding the second point, it was expected that relative-pitch possessors would report alternative memorisation strategies to perfect pitch. These participants were proactive in memorising deliberately to engage conceptual memory. Therefore, lacking perfect pitch led them to find alternatives to secure memory and feel confident on stage. Consequently, the advantages described and associated with perfect pitch are not exclusive to this ability: relative-pitch possessors can achieve the same outcomes differently. Furthermore, the role of perfect pitch in memorisation was found to be both explicit and implicit, depending on whether this was used consciously or unconsciously. For instance, a conscious use of perfect pitch was PD-Y's physical translation into keynotes of the pitches heard in the head; while an unconscious one was regarding memorisation as an intuitive process in which perfect pitch acts as a safety net, should the serial chain of cues collapse.[71]

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[68] Mishra (2005; 2010).
[69] Mishra (2004).
[70] See Chapter 2, section 2.3.
[71] Chaffin et al. (2009), Sloboda (1985).

Similarly, Theodorakis recognised the advantages of having perfect pitch for recalling unrelated pitches within an atonal context: a lack of tonality implies the absence of hierarchical references around a tonic.[72] This benefit was also highlighted by PK-X, although its implementation was unsuccessful at lacking an analytical approach towards memorisation. Hence, despite having perfect pitch, Theodorakis chunks music according to a tonal framework or known composition principles.[73] This permits him to memorise the corresponding sonorities of well-known patterns, due to his expertise.[74] Accordingly, he classifies triads, tetrachords and hexachords by their interval content in root position, but also on their possible inversions and octave transpositions, associating each of these units and their interval content with its corresponding degree of consonance or dissonance. However, not all participants with perfect pitch experienced this advantage of using perfect pitch to recall pitches not tonally related. PL-Y struggled to 'hear' the pitches using perfect pitch in Excerpt 3, attributing this to lacking expertise in recent post-tonal music. Hence, suggesting that experience is important for succeeding in using perfect pitch for post-tonal music. This premise is consistent with Theodorakis' profile and previous literature on such connection between chunking proficiency and expertise.[75]

Alternatively, relative-pitch possessor Hardink strengthens memory by altering an element of a passage and practising it accordingly. Since the result sounds inevitably different, this strategy might enrich and diversify Hardink's aural memory, by learning and associating different aural models to a passage. This was also reported by PJ-Y.

[72] Crutchfield (1990), Takeuchi and Hulse (1993).
[73] e.g., Set Theory, Dodecaphonism, Serialism, Sieve Theory.
[74] Charness (1976), Chase and Ericsson (1982), Ericsson and Staszewski (1989).
[75] Chase and Simon (1973a; 1973b), Gobet (2015).

8.1.2.3 Conceptual Simplification Enhances the Implementation of Perfect Pitch.

The Memorisation Test evaluated whether participants, regardless of their individual differences and learning styles, found Conceptual Simplification useful: perfect pitch could potentially disrupt or facilitate this analytical approach, influencing a pianist in successfully learning and memorising with this method. Additionally, it was expected that results would be conditioned by the participants' lack of familiarity and training with the guidelines given.

The suggested strategies were highly successful for most pianists tested, including those with perfect pitch. However, given the short amount of practice and exposition towards this approach, such success was not always reflected quantitatively, but informed by the participants' reflections after each test. Perfect-pitch possessors struggled more with Conceptual Simplification than those with relative pitch, suggesting that my strategies were closer to those working methods of relative-pitch possessors. Nonetheless, most perfect-pitch possessors could switch their working mode during the Memorisation Test, even mixing the suggested strategies with their own. Such evolution was significantly enhanced after sleeping. Unexpectedly, Conceptual Simplification even facilitated the implementation of perfect pitch to the post-tonal excerpts.

Many participants experienced resistance towards Conceptual Simplification: switching their usual approach for this novel method was not straightforward. Concretely, perfect-pitch possessors struggled at not being used to that amount of active thinking while playing. Thus, despite understanding the purpose of the steps, they kept reverting to their usual methods, which did not require so much brain power. For example, PD-Y was able to remember the patterns and follow the suggested steps from memory, although it felt like practically relearning the music when doing so. Therefore, perfect-pitch possessors reported that, ideally, they would learn and memorise the excerpts in their original form. However, they also recognised that in the longer term an analytical approach was better, especially with challenging repertoire for memory. Such statements were further emphasised when these same participants reported recalling the instructions from memory, whenever struggling to remember the pitches. Consequently, conceptualising the music was useful even for those pianists relying on perfect pitch, should the latter fail as a retrieval tool.

Concretely, Conceptual Simplification allowed perfect-pitch possessors to chunk more parameters at once than when solely using perfect pitch, which only works for pitches.[76] By simplifying the music into different and more manageable layers, they could hear the main melody better, which otherwise was tangled within the musical texture. Thus, simplification provided them the opportunity to downsize aural complexity into musical threads that were more memorable, enhancing their perfect-pitch ability. Likewise, their ability to listen for those same threads also improved when restoring the original excerpt. Furthermore, by implementing Simplifying Octaves, those with perfect pitch recognised better the pitches in the central register,[77] since accuracy decreases at higher and lower registers.[78] Therefore, Conceptual Simplification provided a method for tackling post-tonal music with an analytical approach, by engaging conceptual memory and enhancing Sensory Learning Styles. Such benefits were also reported by relative-pitch possessors. Consequently, despite being an initial obstacle for participants with perfect pitch, they ultimately found that the method ensured long-term retention, as opposed to the rapid decay of memorising by repetition or ear.[79] This being especially true for a stressful situation (e.g., public performance), and with post-tonal music.

[76] Deutsch (1970; 2013), Deutsch and Feroe (1981).
[77] Bachem (1948), Baird (1917), Miyazaki (1989), Rakowski (1978), Rakowski and Morawska-Bungeler (1987).
[78] Burns (1999), Lockhead and Byrd (1981), Pressnitzer et al. (2001), Semal and Demany (1990), Takeuchi and Hulse (1993).
[79] Bangert et al. (2006), Ginsborg (2004: 130-131), Hallam (1997), Lahav et al. (2013), Rubin-Rabson (1941c; 1941d), van Hedger et al. (2015: 169-170; 174; 176-177).

In conclusion, Conceptual Simplification was initially expected to be more useful for relative-pitch possessors, at these having a greater need for effective memorisation methods, at not memorising by ear.[80] Nevertheless, the study concluded that Conceptual Simplification could also be significantly beneficial for perfect-pitch possessors. This is further supported by Theodorakis' deliberate approach to memorisation, regardless of having perfect pitch. While his method differs from Conceptual Simplification,[81] it provides evidence from a professional expert pianist that perfect pitch alone does not suffice for effective memorisation of post-tonal music.

8.1.2.4 Perfect Pitch Enhances Mental Practice.

Mental practice was regarded, both by professionals and students in all studies, as one of the most effective strategies, which becomes easier with perfect pitch. Furthermore, Theodorakis and Hardink use mental practice for consolidating memory, although only Theodorakis can combine it with perfect pitch. For perfect-pitch possessors, mental practice can also reinforce aural memory and internal hearing. For instance, PB-X finds it confusing to 'imagine the physical movements', but mental practice helps in internally hearing the sounds. Similarly, PL-Y identified a strong connection between mental practice and perfect pitch, since being able to 'perform the piece perfectly in [the] head' helps this participant 'to replicate it in the physical world'. Finally, perfect-pitch possessors reported mentally learning new pieces with this ability, before trying it out on the piano, and even memorising faster. Concretely, Theodorakis described that, as a student, he learned pieces first by reading the score and imagining the music, including fingerings, pedalling and other nuances. Then, he tried it on

[80] Bangert et al. (2006), Lahav et al. (2013).
[81] During his interview, Theodorakis stated that he does not believe in simplifying parameters when learning and memorising. Instead, he follows a 'multi-task' approach.

the piano for a limited amount of practice. Similarly, PD-Y uses perfect pitch when practising mentally, which significantly enhances memorisation within tight deadlines.

This section reviewed this thesis' main findings regarding perfect pitch and its influence on memorisation of post-tonal piano music. Within this context, perfect pitch can be a learning and memorisation facilitator, and be further enhanced with Conceptual Simplification and mental practice. Previous studies evaluated how providing detailed instructions might influence participants' learning and memorising experiences of tonal music.[82] Nonetheless, these did not focus on the role of perfect pitch, and not all of them did recruit pianists or used real-world examples. Moreover, post-tonal music was neither considered. Hence, this thesis' results contribute to an under-researched area of memorisation, perfect pitch, and tonal and post-tonal music. The next section discusses sight-reading.

8.1.3 Sight-Reading

Along with perfect pitch, the ability to sight-read contributes to creating an overview of a piece. This visual input is the main source from which Western classical musicians are trained to learn new music.[83] Concretely, for pianists with good sight-reading skills, this ability prompts internalisation, while gaining an understanding of the score's challenges and how all the information fits together. This general outlook permits deciding how to approach practice.

Overall, recruited participants reported good sight-reading skills: five were confident, four were confident to some extent and two were not confident. All three interviewees were

[82] e.g., Bryant (1985), Ross (1964), Rubin-Rabson (1937), Williamson (1964).
[83] Ginsborg (2004), Sloboda (1984).

confident sight-readers,[84] while I feel confident to some extent. Nonetheless, fluency in sight-reading is not an indicator of performance ability,[85] especially when practice is involved.[86] This variety of experiences towards sight-reading was studied from two perspectives: in general terms (Interviews) and through reflection on practice-led experience (Self-Case Studies, Study with Participants). These led to three main findings:

1) **Sight-reading enhances understanding:** Sight-reading can be useful for learning new music. Fluency in this skill depends on how effectively the information is recognised and chunked into familiar patterns, and how quickly this is processed and transferred through the fingers.

2) **Sight-reading skills condition the memorisation approach:** Not-confident sight-readers tend to memorise earlier than those excelling in this skill. However, confident sight-readers are not necessarily good memorisers.

3) **Fluency in sight-reading is conditioned by complexity.** Familiarity with a certain style or composition principle also influences this ability. Conceptual Simplification facilitates and accelerates learning within contexts in which sight-reading is less effective.

These findings are discussed, supported by existing literature.

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[84] Theodorakis and Melikyan are also composers. The fact that both reported feeling confident at sight-reading aligns with Aiba and Matsui's (2016: 5) and Nuki's (1984: 158) findings that those participants that best sight-read in their study were also composers. This might indicate that pianists that are also composers might be more aware of composition principles or at spotting patterns, which is a conditional ability for being fluent at sight-reading (Lehmann and Ericsson, 1996).

[85] Arthur et al. (2020), Hambrick et al. (2014).

[86] Aiba and Matsui (2016), Ericsson and Lehmann (1994), Wolf (1976). World-class performers such as pianist Arthur Rubinstein or soprano Kiri Te Kanawa were reported to not have good sight-reading skills (Waters et al., 1998).

8.1.3.1 Sight-Reading Enhances Understanding.

Sight-reading is an influential parameter for learning and memorisation. Confident sight-readers rely on this ability to become acquainted with a musical work, internalising it and even start memorising it at an early stage. This outcome was expected, considering the literature's extensive results on the importance of acquiring "the big picture" of a piece before extensive practice begins,[87] and the role of sight-reading in this process.[88] Concretely, this was reported in studies observing practitioners' behaviours and strategies during learning,[89] including of post-tonal music.[90]

Nonetheless, for this thesis, it is particularly relevant to determine how sight-reading influences memorisation. An important topic emerged: good sight-reading skills require fast recognition of patterns. Therefore, just like expert chunking leads to optimal encoding,[91] fluent sight-reading results from the swift identification in the score and keyboard of familiar structures and patterns, as opposed to reading individual notes.[92] This permits anticipating upcoming bars, avoiding hesitations and stops during performance.[93] Recruited participants limited these patterns to fingering, melodic and harmonic entities, while Theodorakis extended it to understanding the 'style' and the 'compositional principles'. Hence, sight-reading improves and becomes more effective with experience and expertise.[94] Finally, none of the pianists mentioned the resulting geometry of visual and spatial patterns as an influential

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87 Chaffin et al. (2003; 2013), Fan et al. (2022), Mishra (2004; 2005), Mishra and Fast (2015: 71), Neuhaus ([1973] 2006: 17).

88 Chaffin et al. (2010), Ginsborg (2002; 2004), Gordon (1997), Lewandowska and Schmuckler (2020), Mishra (2004; 2005), Nuki (1984), Pike and Carter (2010), Richardson (2004), Rostron and Bottrill (2000), Waters et al. (1998), Wolf (1976), Wristen (2005).

89 e.g., Chaffin and Lisboa (2008), Chaffin et al. (2002; 2010), Nielsen (1999a), Nuki (1984), Rostron and Bottrill (2000).

90 e.g., Fonte (2020), Noice et al. (2008), Soares (2015).

91 Allard and Starkes (1980), Chase and Simon (1973a), De Groot (1978), Gobet et al. (2001), Underwood et al. (1994).

92 Fourie (2004), Pike and Carter (2010), Rayner et al. (2006), Richardson (2004), Underwood et al. (1990), Waters et al. (1998).

93 Fan et al. (2022), McPherson (1994), Sloboda (1985), Waters et al. (1998), Wolf (1976), Wristen (2005).

94 Arthur et al. (2020), Furneaux and Land (1999), Mishra (2014a; 2014b).

factor for sight-reading: e.g., the spatial proportion between ledger lines and notes, or a chord's visual appearance. This contradicts Aiba and Sakaguchi's (2018: 2) results that these visual features can be more helpful for sight-reading than 'grammatical rules of music notation'.

Regardless of their knowledge and experience, all pianists involved coincided in that fluency in sight-reading translates into 'how fast one can absorb' a musical work, in PJ-Y's words. Nonetheless, for all interviewees, sight-reading goes beyond playing through the piece. For Melikyan, sight-reading is the first step towards memorisation, while for Theodorakis it 'sharpens the ability of understanding the music'. Finally, for Hardink, sight-reading without the instrument first is a process of 'extreme intellectualisation of hearing the music before you even play it', in which such visual input is processed 'into music'. Consequently, supporting the literature's claims that "sight-reading" involves two different activities:[95] sight-reading, for imagining how a score sounds;[96] and sight-playing, for gaining a physical overview.[97] However, despite meaning different things, pianists involved in this thesis or previous studies[98] used the term "sight-reading" indistinctly.

8.1.3.2 Sight-Reading Skills Condition the Memorisation Approach.

A connection between sight-reading proficiency and learning was also found. Recruited participants indicated that a lack of fluency in sight-reading usually forces them to start memorising earlier since learning can be a slower process. This contrasts with the experience of confident sight-readers. For Melikyan, memorisation starts with sight-reading; while for

[95] Mishra (2005), Richardson (2004).
[96] Gordon (1997), Waters et al. (1998).
[97] Lewandowska and Schmuckler (2020), Pike and Carter (2010), Wolf (1976).
[98] e.g., Fonte (2020), Soares (2015), Tsintzou and Theodorakis (2008).

PB-X, PC-X, PD-Y, PJ-Y, PK-X and PL-Y, fluency in sight-reading allows investing less time in figuring out the notes, briefly analyse the music and spot the patterns. When this process is effortless, it provides guidelines for memory, exhausting less the brain before memorising. These arguments were supported by PE-Y, who is not confident at sight-reading and needed to spend some time during the Memorisation Test to figure out the notes and understand the general picture.

Consequently, sight-reading and understanding might be directly proportional, whereas sight-reading and memorisation tend to be 'inversely proportional', in PC-X's words. This negative correlation was illustrated by PK-X, who admitted that the downside of good sight-reading skills can be relying too much on these, instead of 'thoroughly learning and memorising' the music. This statement coincides with Matsui and Aiba's (2015) findings that good sight-readers are not necessarily good memorisers. However, this thesis also provides evidence that when learning and memorisation are regarded as the same thing (e.g., Theodorakis, Hardink), memorisation happens deliberately and benefits from sight-reading. Similarly, those participants who identified the patterns of the excerpts succeeded the most at memorising them. This aligns with Sloboda's (1984) suggestion that sight-reading should be regarded as a kind of musical understanding and perception that engages cognition.[99]

All this suggests that sight-reading is, along with perfect pitch, an ability that conditions a musician's learning style. Those pianists with good sight-reading skills tended to avoid deliberate memorisation in a similar way that pianists with perfect pitch tended to neglect conceptual memory. Conversely, pianists with worse sight-reading skills tended to memorise earlier. This could explain why those reporting feeling more confident performing from the score were good sight-readers, whereas those less skilled in this ability preferred to perform

[99] See also Mishra (2014a; 2014b), Nuki (1984).

from memory. The latter was described as advantageous (e.g., PA-Y), since the required 'conscious effort to read the score' is more likely to translate into better retention, satisfying the desirable difficulty hypothesis.[100] Nonetheless, the Study with Participants focused on memorisation, not sight-reading, and participants could only engage in short-term practice. Therefore, the Memorisation Test results were also conditioned by kinaesthetic memory,[101] and each participant's ability, especially those with perfect pitch, to enhance their sight-reading with auditory imagery.[102]

But what happens with the unconscious internalisation of mistakes when one favours sight-reading? PK-X acknowledged this problem as 'half-learning' the music; Melikyan internalises the music faster when constantly learning new repertoire; and Hardink plays less accurately from the score, and even does not spot certain mistakes when the piece is not memorised. Finally, I do not regard sight-playing as the best method for developing an overview of a piece. During the Self-Case Studies, whenever sight-playing, I was prone to commit mistakes while being unable to spot all of them at once.[103] This was particularly true with increasing difficulty and unfamiliarity with the language or style.[104] Evidence of the latter is further supported by Fonte's (2020) longitudinal case studies.[105] However, the problem resides in encoding wrong information in memory, which could be accidentally recalled again.[106] Preventing that from happening implies additional work.[107] Consequently, during the Self-Case Studies, I opted for sight-reading, instead, by reviewing the score and listening to a

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[100] Bjork (1975; 2014), Bjork and Bjork (1992; 2011), Schmidt and Bjork (1992). The desirable difficulty hypothesis is discussed in Chapter 2.
[101] Aiba and Matsui (2016), Baddeley et al. (2020: 148), Chaffin et al. (2002), Chen (2015: 147-148), Fonte (2020: 109; 156; 424-425), Hallam (1997), Mishra (2004: 233; 2005: 81-83; 2007), Svard and Mack (2002).
[102] Aiba and Matsui (2016), Brodsky et al. (2003), Kopiez and Lee (2006; 2008).
[103] e.g., Wristen (2005).
[104] Aiba and Matsui (2016), Alexander and Henry (2012), Arthur et al. (2020), Fonte (2020), Richardson (2004), Waters and Underwood (1998).
[105] See Fonte (2020: 131-138; 289-291).
[106] Anderson et al. (1994), Chaffin et al. (2002: 146; 183-184), Nellons (1974: 29).
[107] See Baddeley et al. (2020: 300-305), Fonte (2020: 400, lines 849-855), Melton and Irwin (1940).

recording.[108] The positive impact of listening to a recording before deliberate learning starts was expected.[109] Both sight-reading and listening facilitated the Triage stage, in which I identified potential effective strategies.[110] Thus, learning functioned as a blank canvas without previous mistakes ingrained in memory. This is particularly important since mistakes are also remembered:[111] each time these are triggered, its probability to be retrieved again increases, becoming the prominent response. This phenomenon is known as *associative blocking*.[112]

Such a problem was encountered during the Self-Case Studies, which presented several challenges for sight-playing. For the concerto, these were switches,[113] and a lack of piano idiomatic patterns.[114] Furthermore, working first with a handwritten and general score was also an important obstacle for memory.[115] For Ben-Amots' piece, these were also switches and lacking familiarity with certain pitch and chord patterns, and unusual tempo changes. Even when summarising some of these gestures, all these challenges were an obstacle for effective sight-playing. Hence, by temporarily removing the physicality of playing, I gained a clearer overview. Finally, the learning periods that emerged from the Self-Case Studies showed that favouring sight-reading conditioned my memorisation approach. Concretely,

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108 e.g., Fonte (2020), Soares (2015). Given that all works involved in the Self-Case Studies were commissioned, these recordings were computer-generated. I only used them to gain an overview of the piece before the learning process started; and in Gasull's Piano Concerto, also for rehearsing with the orchestral accompaniment.

109 e.g., Bangert et al. (2006), Buckner (1970), Cash et al. (2014), Haueisen and Knösche (2001), Lahav et al. (2013), Lotze et al. (2003), Meister et al. (2004), Rubin-Rabson (1937), Schlabach (1975). This approach towards learning a new piece was also reported by PH-X:

> If I decide to learn a piece of memory, I plan much more time for learning it. I cannot rush this process. At the beginning I try to listen to it many times, so my ear gets used to it. Afterwards, I still don't use the piano: I try to imagine myself playing the piece. Additionally, I analyse the piece, try to find patterns; logic; a story line. And the last step would be to try it out on the piano. If the piece is rather challenging, I use more piano at the beginning, especially when its virtuoso, I need my hand to get used to it physically.

110 In the first three movements of Gasull's Piano Concerto, I found it to be a better approach to start first with sectional practice throughout the piece without memorising, and then to start memorising. However, in Gasull's last movement and in Ben-Amots' solo piece, deliberate memorisation from the start in combination with a sectional approach was a more useful strategy.

111 Baddeley et al. (2020: 299-300).

112 Anderson et al. (1994). In Chaffin and Imreh (1997a), pianist Gabriela Imreh refused to attempt a physical recall of the third movement of Bach's *Italian Concerto* after 27 months without physical practice. She argued that any potential mistakes of such recall could 'interfere with her later re-learning of the piece' (Chaffin and Imreh, 1997a: 330).

113 e.g., Chaffin et al. (2002).

114 e.g., Sloboda et al. (1998).

115 Aiba and Sakaguchi (2018).

for the first three movements of Gasull's concerto, this resulted in engaging longer in the notational practice phase instead of engaging straight away with conscious memorisation,[116] as done with Ben-Amots' piece.

8.1.3.3 Fluency in Sight-Reading is Conditioned by Complexity.

Successful sight-reading depends on chunking rapidly enough so that visual input transforms into physical and aural output without delay.[117] But, beyond experience and expertise, are there other factors that can alter such process? This thesis identifies the potential of complexity or the difficulty of a piece for hampering sight-reading. Such complexity might translate into a lack of 'predictable or straightforward patterns' that hinder the ability of looking ahead and anticipating the music (McPherson, 1994: 217).[118] These patterns may involve tonality,[119] recognisable chords,[120] phrasing[121] and rhythm.[122] When this happens, sight-reading performances are less accurate, even for experts.[123] While familiarity with post-tonality and recent composition principles can be developed, as Theodorakis exemplified in this thesis and Fonte's (2020), not all practitioners may internalise such knowledge well enough to become easily recognisable and useful for performance practice.[124] For instance, Hardink illustrated the obstacles that technical difficulty or complexity can pose for sight-reading, by comparing his experience when learning a new piece by Eckardt with a Mozart Piano Sonata. For Mozart, he feels capable of memorising by sight-reading the score without the instrument; whereas for Eckardt, he needs to sketch first 'how everything fits together'

116 Mishra (2004; 2005).
117 Lehmann and Ericsson (1996), Sloboda (1985), Waters et al. (1998).
118 See also Aiba and Matsui (2016).
119 Fine et al. (2006), MacKenzie et al. (1986).
120 Cox (2000).
121 Sloboda (1977).
122 Boyle (1970), Elliott (1982), McPherson (1994).
123 Alexander and Henry (2012), Arthur et al. (2016; 2020), Waters and Underwood (1998).
124 Fonte (2020), Soares (2015).

by 'solving the math of how the different voices align', before even learning it. This description highlights three main features that can be problematic for sight-reading: tonality, rhythm and texture.

Lewandowska and Schmuckler (2020) studied in what ways tonality and texture influence sight-reading,[125] suggesting that pianists struggle more with atonality and minor tonalities than with major tonalities. Also, with atonal excerpts, pianists committed mistakes 'that actually made the passages more tonal than they were initially intended' (Lewandowska and Schmuckler, 2020: 1939). These results extended existing evidence on the influence of tonality in sight-reading.[126] It could also explain why in Sloboda's (1978) sight-reading test with a score manipulated by the researcher to contain outlier notes of the tonality, participants would unconsciously "correct" those notes, to fit these into a tonal framework. Researchers explained this as an unconscious technique used by pianists less familiar with atonal music to assist their performance.[127]

Furthermore, MacKenzie et al. (1986) and Fine et al. (2006) showed that rhythm and pitch accuracy decreased when sight-reading was attempted for atonal music. Similarly, Lewandowska and Schmuckler (2020) found that performance accuracy in sight-reading decreased as complexity in musical texture increased. Particularly, when two hands were involved instead of one, and when notes tended to appear simultaneously, instead of successively. Additionally, the implications for sight-reading of rhythmic complexity were also studied,[128] and coincided with the pianists' experiences in this thesis. Recruited

[125] Lewandowska and Schmuckler (2020: 1920) define *tonality* as 'the cognitive organisation of tones around a central reference pitch'; and *texture* as 'the organisation of music in terms of the simultaneous versus successive onsets of tones, as well as the number of hands (unimanual versus bimanual) involved in performance'.
[126] Alexander and Henry (2012), Fine et al. (2006), MacKenzie et al. (1986), Sloboda (1978), Wolf (1976).
[127] Stephan et al. (2015; 2016), Zatorre et al. (2007).
[128] e.g., Gregory (1972), McPherson (1994), Reina (2015).

participants struggled with rhythm in Excerpt 3, and even confident sight-readers (e.g., PL-Y) stated feeling weaker when sight-reading rhythm. This problematic was also reported by professionals and students in Fonte (2020) and Soares (2015) for post-tonal piano music. Finally, although extended techniques were only involved in Gasull's concerto and studied through my own experience,[129] these were relatively easy to grasp when sight-reading, due to my previous experience.[130] Nonetheless, Fonte (2020: 192) reported struggling when sight-playing and sight-reading 'glissandos, harmonics or tremolos', which were attributed to a lack of experience with extended techniques.

Finally, this thesis tests and formalises Conceptual Simplification, while presenting evidence of how this can be enhanced. Thus, since sight-reading plays an important role in learning and memorisation, it would be reasonable to consider whether this skill can be improved with specific strategies too. The pianists involved highlighted the importance of expertise as 'extensive knowledge of the "rules" of western art music' (Arthur et al., 2020: 452), for sight-reading successfully.[131] However, piano students are rarely trained to improve their fluency in this skill.[132] Partly, due to the assumption that good sight-reading skills might be an innate ability,[133] depending on larger WM capacity.[134] Existing literature also illustrated how WM capacity can limit performance,[135] indicating that expert knowledge or deliberate practice might not suffice for becoming proficiently fluent in sight-reading,[136] although it can help.[137] Additionally, it would also explain why some recruited participants were not confident in this

129 The implications that extended techniques could potentially have for practice were only briefly discussed with Theodorakis.
130 See www.laurafarrerozada.com for further details.
131 Johnson (1998), Thompson and Lehmann (2004).
132 Kornicke (1995), Lehmann and McArthur (2002), Pike and Carter (2010), Zhukov (2005).
133 Kornicke (1995), Wolf (1976), Zhukov (2006; 2014).
134 Arthur (2017), Baddeley (1992), Lee (2003), Meinz and Hambrick (2010).
135 Meinz and Hambrick (2010).
136 Hambrick et al. (2014).
137 Ericsson and Charness (1994), Ericsson et al. (1993), Lee et al. (2007), Mishra (2014a; 2014b).

skill, despite their advanced music education and performing experience.[138] Nevertheless, previous research also suggested that training focused on rhythm,[139] pitch,[140] pattern recognition[141] and collaborative playing[142] leads to steady improvement in sight-reading,[143] as reflected the experiences of Theodorakis, Hardink, PB-X and PK-X.

However, if sight-reading skills cannot be improved or are not useful, Conceptual Simplification permits simplifying complexity, while facilitating the identification of patterns. Hence, less-fluent sight-readers requiring additional time to figure out the notes can implement the method for assisting chunking: Conceptual Simplification manipulates texture while enhancing familiarity with the musical language and the composition's style. Therefore, allowing to recognise better the main patterns once the original texture is restored. This also applies to good sight-readers when dealing with greater difficulty or complexity, particularly with post-tonal music. Future research could elucidate whether this approach could also compensate a limiting WM capacity. The next section discusses emotions.

8.1.4 Emotions

This thesis reveals two main connections between emotions and memorisation. The first one is the relationship between memory and performance anxiety: performing from memory can either be a trigger of performance anxiety or a coping strategy. The second one implies using emotions as meaningful encoding. This aligns with Performance Cue Theory, which explains

[138] Arthur et al. (2020).
[139] Fourie (2004), Gudmundsdottir (2010), Hodges and Nolker (2011), Kostka (2000), McPherson (1994), Zhukov (2006).
[140] Pike and Carter (2010), Zhukov (2017).
[141] Cox (2000), Halsband et al. (1994), Hodges and Nolker (2011), MacKenzie et al. (1986), Sloboda (1977), Waters et al. (1998).
[142] Kopiez and Lee (2006), Lehmann and Ericsson (1993; 1996), Lehmann and McArthur (2002), Wristen (2005).
[143] Zhukov (2014; 2017).

how musicians create different types of landmarks for memory retrieval.[144] Concretely, recruited pianists use expressive cues for encoding expression, emotional content and character; and interpretative cues, for dynamics and articulation. Moreover, PH-X uses emotions as an integration strategy, to build 'a full story with different emotions' and connect the music memorised. This strategy was also reported by a pianist in Li (2007: 86).

Performers use expressive cues for learning and memorising tonal music.[145] Emotional encoding was also explored through the analysis of performance cues for post-tonal piano music.[146] Concretely, Soares (2015: 122) used emotions to tackle switches, while Fonte (2020) illustrated through semi-structured interviews how professional post-tonal specialists use emotions to memorise. Finally, Melikyan admitted that emotions might be an obstacle for him when performing from memory certain post-tonal works that 'require ultimate and stable focus on the score'. He exemplified this phenomenon with pieces by Stockhausen, Xenakis and Berio.

8.1.5 Sleep

Sleep was amongst the most influential factors for achieving effective memorisation. Also, recruited pianists in all three studies reported including it in their practice routine. However, not all participants were aware of sleep's potential for enhancing memory and performance. Still, evidence suggested that sleep can positively impact learning and memorisation of post-tonal piano music. This section presents in what forms sleep-related benefits were reported and how these findings are supported by the literature.

144 Chaffin et al. (2002; 2010), Ginsborg and Chaffin (2011a; 2011b), Ginsborg et al. (2012).
145 e.g., Chaffin et al. (2002; 2010), Chen (2015), Ginsborg and Chaffin (2011a; 2011b), Noice et al. (2008).
146 Chueke and Chaffin (2016), Fonte (2020), Soares (2015).

First, I used sleep during the Self-Case Studies in the form of 30-minute naps between morning and afternoon practice sessions.[147] Furthermore, I stuck to the 8-hour sleep standard for overnight sleep quality.[148] Secondly, Theodorakis also uses afternoon naps to sleep over learning-related problems, whereas Melikyan did not report any memory improvements after sleeping, although he practises mentally before going to sleep. Thirdly, only two recruited participants regularly use naps in their practice routines, while the rest do so sporadically or not at all: most of them did not recognise sleep as an influential parameter for their performance practice. Notwithstanding, many reported unexpected improvements during the NDR after a night's sleep. Therefore, discussing the implications of sleep on memory for all three studies is also an opportunity to contrast musicians' attitudes towards sleep with its actual potential.

Research identified multiple sleep benefits for memory:[149] consolidation,[150] integration of memories,[151] enhancement of performance,[152] gaining insight into hidden solutions,[153] the abstraction of general rules,[154] and the creative association of unrelated ideas and concepts.[155] However, sleep research on musical memory only focused on short-term memory of one-handed keyboard melodies,[156] and tonal piano excerpts.[157] Therefore, this research explored the role of sleep in learning, memorisation and performance of post-tonal piano music in the

[147] This has also been a regular for me, for many years.
[148] Banks and Dinges (2007), Lewis (2014), Randall (2013), Walker (2017).
[149] Cairney et al. (2011), Lewis (2014), Lewis and Durrant (2011), Randall (2013), Walker (2017).
[150] Diekelmann and Born (2010), Drosopoulos et al. (2007), Stickgold (2005), Walker (2002; 2005; 2009), Walker and Stickgold (2006).
[151] Dumay and Gaskell (2007), Ellenbogen et al. (2007).
[152] Brashers-Krug et al. (1996), Duke and Davis (2006), Korman et al. (2003), Simmons and Duke (2006), Walker et al. (2002).
[153] Wagner et al. (2004), Yordanova et al. (2008).
[154] Djonlagic et al. (2009), Durrant and Lewis (2009), Durrant et al. (2011), Fischer et al. (2006), Gómez et al. (2006), Hupbach et al. (2009).
[155] Cai et al. (2009).
[156] Allen (2007; 2013), Cash (2009), Duke and Davis (2006), Duke et al. (2009), Simmons (2007; 2011; 2012), Simmons and Duke (2006).
[157] van Hedger et al. (2015).

short term (Study with Participants), the long term (Self-Case Studies) and professional pianists' practice routines (Interviews). The main findings were:

1) **Memory consolidation:** Practice alone does not ensure long-term retention. Sleep and rest intervals, either short (e.g., distributed practice); or long (e.g., a night's sleep, resting the piece for a while), enhance understanding and consolidate memory.

2) **Memory enhancement:** Implicit memory deteriorates faster than explicit memory. Those recruited participants who engaged conceptual memory when memorising the excerpts could fill gaps in memory by replicating their steps. This process was even more effective after a night's sleep since some participants recovered forgotten information in previous recalls. Sleeping enhanced the integration of pre-existing knowledge with newly acquired one. This process was easier when new knowledge was related to tonal patterns.

3) **Performance enhancement:** Sleeping improved mental and physical performance. Recruited participants found easier to substitute their usual strategies for a new approach after sleeping, becoming aware of the goal of the suggested strategies. Sleeping increased creativity and confidence in physical performance, diminishing cognitive overload.

These findings suggest that sleep should be actively incorporated into a musician's practice routine to boost learning and memorisation.[158] Further details are now discussed.

[158] Allen (2013: 800).

8.1.5.1 Memory Consolidation: The Effect of Sleep and Rest Intervals.

Results from the studies illustrated the impact of off-line learning,[159] highlighting the advantages of distributed practice (i.e., practice divided into several sessions across multiple days); as opposed to massed practice (i.e., practice concentrated in a single session).[160] Essentially, distributed practice benefits from the spacing effect,[161] which Hardink implements by distributing repetition across the day and combining different repertoire: repeatedly exposing himself to the struggle of recalling the music eventually engages him in the process of relearning it. Hence, repeating this process at different moments of the day and over several days is Hardink's strategy for strengthening memory, especially for pieces with many switches.

The spacing effect describes how interspersing practice with rest improves retention, while massed practice tends to diminish such retention.[162] Relearning is easier for massed practice: there is no struggle in recalling that information continuously practised. However, time intervals placed between distributed sessions prompt potential forgetting of the music. Therefore, a greater effort is needed to recall the information. Both the desirable and the retrieval difficulty hypotheses posit that this extra difficulty triggers deeper cognitive processes, eventually leading to longer-term retention.[163] Hence, the harder this process is, the stronger the resulting LTM. Consequently, relearning, beyond being effective for spotting flaws in memory, can also be 'an iterative process in which we learn, forget, and then relearn as many times as necessary to achieve a specified level of retention' (Mazza et al., 2016: 1328). This iterative process is even more successful when rest intervals placed between practice are

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159 Luft and Buitrago (2005), Mazza et al. (2016), Robertson (2009), Robertson et al. (2004b), Walker (2005).
160 Baddeley et al. (2020: 120), Carter and Grahn (2016), Rubin-Rabson (1940a), Simmons (2011).
161 Bell et al. (2014), Benson and Feinberg (1975), Castaldo et al. (1974), Cepeda et al. (2008), Dail and Christina (2004), Ebbinghaus ([1885] 1913), Kim et al. (2019), Shea et al. (2000), Soderstrom et al. (2016).
162 Cepeda et al. (2006), Dail and Christina (2004), Shea et al. (2000), Tsutsui et al. (1998).
163 Bjork and Bjork (1992; 2011), Pyc and Rawson (2009), Rowland (2014), Schmidt and Bjork (1992). Both the desirable and the retrieval difficulty hypothesis are discussed in Chapter 2.

occupied with sleep, instead of other wakeful activities,[164] since relearning and long-term retention are boosted with sleep-dependent consolidation,[165] without the prejudice of memory interference.[166] This approach is particularly useful for switches, as discussed in chapters 3 and 5.

The impact of the spacing effect and the desirable difficulty principle also emerged in the Self-Case Studies. During these, distributed practice was programmed, allocating 1-hour practice slots to each piece (i.e., solo piece, concerto movement) per day. Beyond facilitating focus throughout the session, it also required a bigger effort at the beginning to recover that performance fluency achieved in the previous session.[167] This approach implied considerable struggle at first, but eventually translated into retention and fluency, progressively needing less practice time for that purpose.[168] Additionally, 15-minute timed alarms were programmed as a time-management strategy to monitor and structure the session. Practice slots were interspersed with 10-minute breaks, to reset the ability to focus. Such metacognitive decisions reinforced further the spacing effect.[169]

Finally, the Study with Participants' design also prompted off-line learning and the spacing effect, by placing tests at different moments of the day, across two consecutive days. Concretely, the main purpose of the AR and NDR was to test the participants' retention before and after sleep, although they were allowed additional time to recall the excerpts,

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[164] e.g., Albouy et al. (2013), Butler (1921), Diekelmann and Born (2010), Gais et al. (2007), King et al. (2017), Korman et al. (2007), Kuriyama et al. (2004), Lahl et al. (2008), Mazza et al. (2016), Mednick et al. (2002; 2003; 2008), Peigneux et al. (2001), Walker (2005), Walker et al. (2003).
[165] Benson and Feinberg (1975), Castaldo et al. (1974), Dail and Christina (2004), Mazza et al. (2016), Shea et al. (2000).
[166] Brown and Robertson (2007a; 2007b), Fischer et al. (2006), Robertson et al. (2004a).
[167] Baddeley and Longman (1978), Bjork and Bjork (1992), Mazza et al. (2016: 1328).
[168] Chaffin and Imreh (1997b), Chaffin et al. (2002: 216-229), Chase and Ericsson (1982), Ericsson and Staszewski (1989).
[169] Berardi-Coletta et al. (1995), Colombo and Antonietti (2017), Fairbrother et al. (2021), Hallam (2001), Jabusch (2016), Karpicke et al. (2009), Ste-Marie et al. (2013), Veenman et al. (2006), Velzen (2017).

should they need to figure out the music from memory again. Therefore, this process could be regarded as a kind of practice that influenced the participants' memory.[170] Additionally, participants found the most challenging excerpts easier after sleeping, but equally or even more difficult between the MMT and AR. These excerpts required explicit thinking and deliberate memorisation, and could not be confidently memorised through perfect pitch or kinaesthetic memory. This result coincides with van Hedger et al.'s (2015), who found that conceptual errors can significantly decrease after a night's sleep. Moreover, the spacing effect reemerged with the written recalls (Pilot Study) since the participants' memory was preserved for up to a 20-day gap without practice. Furthermore, some participants (e.g., PB-X) and Hardink reported leaving a piece for a few days for securing memory further.

All these findings suggest that interspersing sleep with practice is an effective strategy for learning and memorisation, confirming what was anticipated in a non-musical context by Mazza et al. (2016), and for procedural musical memory by Simmons (2011). Therefore, sleep is an influential parameter for musical memory. Furthermore, participants admitted that setting a deadline for learning the excerpts and attempting recalls at different moments of the day, especially after sleeping, was an effective memorisation strategy for new repertoire. Thus, confirming the benefits of the retrieval difficulty hypothesis.[171] Accordingly, it should be explored whether including an additional sleep strategy to Conceptual Simplification could reduce the practice needed for learning and memorising a piece, as anticipated in Chapter 3 with Switches Conceptualisation and existing sleep studies.[172]

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170 Chaffin et al. (2009), Chase and Ericsson (1982), Ericsson and Kintsch (1995).
171 Bjork and Bjork (1992), Pyc and Rawson (2009), Rowland (2014).
172 e.g., Allen (2013), Mazza et al. (2016), Simmons (2011).

8.1.5.2 Memory Enhancement: Conceptualisation and Recovery.

Participants' recalls suggested that explicit memorisation was more effective than implicit, aligning with existing research.[173] Participants were not allowed to practise between the tests or look at the scores, and had to engage in their original daytime schedule. This forced them to exclusively rely on off-line learning.[174] Those participants in the control group who identified the patterns and devised their own encoding principles recovered the music faster in the subsequent recalls. Furthermore, the experimental group was generally capable of replicating the instructions from memory and confidently retrieving the excerpts. This procedure also allowed them to fill gaps in their memory.

Unexpectedly, after a night's sleep, some experimental group participants recovered information during the NDR previously forgotten in the AR. Such recovery was either spontaneous, by realising playing something not recalled before; or deliberate, by implementing from memory the instructions. Therefore, indicating that the suggested steps permitted developing conceptual guidelines, which transformed and summarised the excerpts into recognisable patterns or general rules. Consequently, the unfamiliar post-tonal excerpts were presented in a hierarchically structured manner that facilitated content-addressable memorisation.[175] This produced a more salient content,[176] prompting the fulfilment of off-line enhancement,[177] through sleep-dependent triage and replay.[178] Similarly,

173 Austin and Berg (2006), Barry and Hallam (2002), Carter and Grahn (2016), Chaffin et al. (2008), Ginsborg (2004: 129), Hallam (1997: 95-96), Renwick and McPherson (2000), Sloboda (1985: 91; 96).

174 Brashers-Krug et al. (1996), Duke and Davis (2006: 119), Muellbacher et al. (2002), Walker (2005), Walker et al. (2003).

175 Baddeley et al. (2020: 241), Bower et al. (1969), Chaffin and Logan (2006), Chaffin et al. (2008: 352), Dehaene (2015: 11).

176 Darsaud et al. (2011), Fischer and Born (2009), Lewis et al. (2011), Robertson et al. (2004a), van Hedger et al. (2015).

177 Feld and Born (2017), Fenn et al. (2003), Fischer et al. (2002), Gais et al. (2000), Karni et al. (1994), Korman et al. (2003), Squire et al. (2015), Stickgold et al. (2000), Walker (2005), Walker and Stickgold (2004), Walker et al. (2002).

178 Baddeley et al. (2020: 152), Ji and Wilson (2007), King et al. (2017), Lewis and Durrant (2011), Maquet et al. (2000; 2003a), Peigneux et al. (2004), Rasch and Born (2013), Stickgold and Walker (2013), Walker (2005), Walker and Stickgold (2006), Walker et al. (2002), Wamsley (2022).

those participants in the control group who developed their own principles experienced a similar effect.[179] For the most challenging excerpts, those participants using Conceptual Simplification, either suggested (Group Y) or deduced on their own (Group X), were more successful than those using alternative approaches. However, those control group participants who exclusively relied on alternative strategies for memorising, still experienced a sleep benefit between the AR and NDR.

Furthermore, those experimental group participants who recovered forgotten information from Excerpt 3, the most difficult from the test, provided evidence that overnight consolidation tends to focus on challenging content to consolidate weaker spots in memory.[180] Concretely, participants reported that such recovery was possible thanks to actively thinking of the symmetry and the pitch equivalences: e.g., such thinking allowed both PJ-Y and PD-Y to figure out the pitches. Also, PD-Y recalled the instructions to rebuild memory from the steps. Therefore, this participant did not remember the exact information but recalled instead how to deduce it, as suggested with Gauss' formula in Chapter 3. Realising new ways of restructuring previously learned information after sleeping was also observed in previous studies.[181] Furthermore, the intentional acquisition of a skill (e.g., learning how to play and memorise a piece), is a goal-based task that triggers overnight improvements:[182] such conceptual memory improvement for Excerpt 3 aligns with van Hedger et al.'s (2015) findings for tonal excerpts. However, most importantly, these 'high-order associations' allowed participants to reconstruct during sleep those memories that were

[179] Also, the participants' own preferences and likeability of the excerpts might have played a role during the sleep memory triage (Payne and Kensinger, 2018; Payne et al., 2008; Tsintzou and Theodorakis, 2008: 9), and how important they considered it was to excel at this test (Baddeley et al., 2020: 139).
[180] Drosopoulos et al. (2007), Kuriyama et al. (2004), van Hedger et al. (2015). See also Walker and Stickgold (2004) for a review.
[181] Ellenbogen et al. (2007), Fischer et al. (2006), Robertson (2009), Wagner et al. (2004), Yordanova et al. (2008).
[182] Cohen et al. (2005), Robertson et al. (2004a), Walker and Stickgold (2004).

‘disrupted during the day’ (Robertson, 2009: 16),[183] showing how participants managed to use knowledge to rework incomplete memories.[184]

Moreover, participants’ recovery of forgotten knowledge coincides with Mazza et al.’s (2016) results, who reported the effect of sleep on unrecallable items. Concretely, they used the relearning paradigm,[185] to test how interspersing practice with sleep could influence the amount of practice needed for relearning. They found that those participants in the sleep group, which learned the material in the evening session and relearned it the following morning after a night’s sleep, were able to recover earlier forgotten items during relearning; compared to the group without sleep. Additionally, the sleep group’s improved performance was not influenced by their initial retention.

Mazza et al.’s (2016) results are not directly transferable to mine: their task involved declarative non-musical memory, significantly differing from the skills associated with playing a musical instrument.[186] Nevertheless, their results can explain the evolution of my participants’ conceptual memory, including forgetting. According to Mazza et al. (2016: 1328): ‘even memories not explicitly accessible at the beginning of relearning had also been transformed during sleep’. This suggests that my participants might have experienced an oblivion of knowledge as their brains processed other content,[187] or unconsciously self-regulated their cognition.[188] However, this type of interference eventually prompted the integration of the learned information.[189] Hence, as observed in both groups, memory

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[183] See also Drosopoulos et al. (2007), Fenn et al. (2003).
[184] Baddeley et al. (2020: 3), Robertson (2009).
[185] i.e., Nelson (1985).
[186] Münte et al. (2002), Wulf and Shea (2002).
[187] Brown and Robertson (2007a), Crick and Mitchison (1983), Drosopoulos et al. (2007), Fenn et al. (2003), Robertson (2009).
[188] Anderson (2003), Bjork (1988), Bjork et al. (2006), Hardt et al. (2013), Quian Quiroga (2012a; 2012b), Richards and Frankland (2017).
[189] Cohen and Robertson (2012), Robertson (2009).

restoration and reconstruction materialised both for declarative memory, increasing the participants' corresponding recall;[190] and procedural memory, resulting in the enhancement of physical performance.[191] Since during wakefulness, declarative knowledge can be lost due to a memory interference with the acquisition of a procedural skill,[192] this might indicate that forgetting declarative content could be essential for how the brain processes memory during sleep.[193] Nonetheless, as the results of some participants suggested, such loss was not permanent, but only temporary.

The experimental group recalled the excerpts using their own strategies mixed with mine. This process was enhanced after sleeping, showing an improvement in their ability for integrating pre-existing knowledge (i.e., their strategies) with a new approach (i.e., the instructions). On a deeper level, it also became easier for them to recognise 'hidden patterns' after sleeping (Robertson, 2009: 15),[194] which were purposely related to a tonal framework through Conceptual Simplification strategies. Furthermore, some Group Y's participants also reported how these patterns became 'intuitive' after sleeping, in PJ-Y's words, allowing to focus instead on more creative aspects of the performance. This reflects why sleep might have been so crucial for participants in boosting their practice during the MMT, since they became fluent in monitoring the performance according to these patterns, which translated into an enhanced declarative and procedural physical recall.[195] Notwithstanding, those participants not engaging conceptual memory (e.g., PL-Y), failed at the test. Consequently, Conceptual Simplification's scaffolded analysis proved effective for other practitioners (i.e., the recruited participants) when memorising post-tonal piano music.

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190 Fischer et al. (2006).
191 Fischer et al. (2002), Kuriyama et al. (2004), Robertson et al. (2004a), Spencer et al. (2006), Walker et al. (2002).
192 Brown and Robertson (2007a).
193 Robertson (2009).
194 See also Ellenbogen et al. (2007), Fischer et al. (2006), Wagner et al. (2004), Yordanova et al. (2008).
195 Fischer et al. (2002; 2006), Kuriyama et al. (2004), Robertson et al. (2004a), Spencer et al. (2006), Walker et al. (2002).

8.1.5.3 Performance Enhancement

For the Self-Case Studies, less practice was progressively needed to achieve the same result, suggesting an evolution in retention.[196] This might have been accelerated by purposely interspersing practice with sleep,[197] since each piece was only practised one hour per day. The same phenomenon was observed in the Study with Participants, in which most participants improved their results and timings between the AR and NDR after sleeping. This tendency was stronger for those who memorised engaging conceptual memory, whereas accuracy decayed between the MMT and AR. This result coincides with similar studies,[198] highlighting the effect of sleep between the AR and NDR, although timings also decreased between the AR and MMT.

Similarly, participants recalled the excerpts faster after a night's sleep and without practice. They argued that the music seemed more familiar,[199] resulting in more confident and accurate performances while paying less attention to monitoring their playing:[200] they did not need to focus on basic details (e.g., pitches, rhythm), at having a broader view of the excerpts.[201] This suggests that sleeping contributed to diminishing cognitive overload associated to performance by effortlessly automatising many motor skills overnight.[202] This contrasts with Performance Cue Theory, which identifies these skills with basic cues,[203] and explains its

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196 Bahrick (1979), Chaffin and Imreh (1997b), Chaffin et al. (2002: 216-229), Chase and Ericsson (1982), Ebbinghaus ([1885] 1913), Ericsson and Delaney (1999), Ericsson and Kintsch (1995), Ericsson and Staszewski (1989), Nelson (1985), Roring et al. (2007: 169).
197 Mazza et al. (2016).
198 e.g., van Hedger et al. (2015: 175).
199 Balas et al. (2007), Bartlett ([1932] 1995), Diekelmann and Born (2010), Lewis and Durrant (2011), Mazza et al. (2016).
200 Atienza and Cantero (2001), Atienza et al. (2002; 2004), Brashers-Krug et al. (1996), Duke and Davis (2006), Karni et al. (1994), Korman et al. (2003), Kuriyama et al. (2004), Maquet et al. (2003a; 2003b), Mednick et al. (2002; 2003), Simmons and Duke (2006), Stickgold et al. (2000), Walker et al. (2002; 2003).
201 e.g., Chaffin et al. (2003; 2013), Fan et al. (2022), Mishra (2005), Rubin-Rabson (1937).
202 Allen (2013), Brashers-Krug et al. (1996), Duke and Davis (2006), Dumay and Gaskell (2007), Ellenbogen et al. (2007), Korman et al. (2003), Kuriyama et al. (2004), Maquet et al. (2003a), Simmons and Duke (2006), Walker et al. (2002; 2003).
203 Chaffin and Imreh (1997a), Chaffin and Lisboa (2008), Chaffin et al. (2002; 2009; 2010; 2021), Chen (2015), Chueke and Chaffin (2016), Ginsborg and Chaffin (2011a), Ginsborg et al. (2006a; 2006b), Lisboa et al. (2015).

automation through physical practice instead of sleep-dependent consolidation.[204] Such consolidation of procedural memory allowed participants to focus instead on other cues (e.g., expressive, interpretative).[205] This was possible 24 hours after learning, which differs from previous studies in post-tonal music,[206] in which basic cues had a more prominent role throughout learning and memorisation. However, the Study with Participants was not longitudinal, therefore, kinaesthetic memory also influenced the results.[207] Furthermore, the same finding resonates with Mazza et al.'s (2016) results in that sleep might reduce the amount of practice needed for reaching a certain goal. Either way, the results reflected a noticeable effect of sleep on the participants' memory.[208]

Additionally, most of Group Y understood the goal behind the steps after sleeping, being able to switch their usual approach to mine, despite not having a scientific background. This is important since no correlation was identified between the Logical Reasoning Test results and the successful implementation of Conceptual Simplification strategies. The most notable examples of these were PE-Y's evolution with Simplifying Octaves; or PD-Y's experienced benefits of combining perfect pitch with my instructions, and the importance of not skipping any steps. By substituting their usual working method for Conceptual Simplification, some of them succeeded more on the most difficult excerpts (e.g., PD-Y for Excerpt 1).

The role of sleep on musical memory was not a topic thoroughly discussed during the Interviews, but Theodorakis uses it for re-approaching problems when practising.[209] For

[204] Baddeley et al. (2020: 148), Chaffin and Lisboa (2008), Chaffin et al. (2002; 2010), Chen (2015), Fonte (2020: 109; 156; 424-425), Hallam (1997).
[205] Chaffin and Imreh (1997a), Chaffin and Lisboa (2008), Chaffin et al. (2002; 2009; 2010; 2021), Chen (2015), Chueke and Chaffin (2016), Ginsborg and Chaffin (2011a), Ginsborg et al. (2006a; 2006b), Lisboa et al. (2015).
[206] e.g., Fonte (2020).
[207] Baddeley et al. (2020: 148), Chaffin et al. (2002), Chen (2015: 147-148), Fonte (2020), Hallam (1997), Mishra (2004; 2005), Soares (2015).
[208] The literature's reported benefits of sleep are discussed in Chapter 2.
[209] Robertson (2009), Wagner et al. (2004), Yordanova et al. (2008).

mental practice, Theodorakis also reported being more successful with mental run-throughs in the morning after a good night's sleep, coinciding with Walker's (2005) enhancement. Finally, although participants memorised different excerpts during the same session, these were substantially different to avoid potential memory interference, as previous studies observed for similar materials.[210] Furthermore, the Memorisation Test's design provided with snapshots of the participants' memory evolution.[211]

In summary, evidence illustrated that perfect pitch alone does not ensure effective memorisation of post-tonal piano music. Also, that Conceptual Simplification can compensate for lacking the ability of perfect pitch or good sight-reading skills; or when these are not helpful due to the score's complexity. Furthermore, emotions presented a subjective approach toward memorisation, whereas off-line learning, and particularly sleep-dependent consolidation, routinely strengthens memory.

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210 e.g., Allen (2013), Duke and Davis (2006).
211 Robertson (2009), Robertson et al. (2004b), Walker (2005).

8.2 RQ2: Which Practice Strategies Can Be Effective for Performing a Post-Tonal Piano Work from Memory?

RQ2 focused on testing, extending and formalising Conceptual Simplification. Concretely, the Self-Case Studies permitted revising, broadening and restructuring the method's strategies, which are discussed in chapters 3, 5 and 7. A summary of how these strategies were tested is now provided, before contrasting these with the participants' experiences and the literature. Thus, this section discusses the effectiveness of the resulting method's simplifying and conceptualisation strategies, along with other strategies.

8.2.1 Strategies for Simplifying Complexity

The method's simplifying strategies, based on the transform-and-conquer paradigm,[212] consist in removing layers of pitch, octaves, voicing, chords, hands, rhythm, repetition, tempo, extended techniques, structure and preceding structure. These are grouped into the categories of pitch, harmony, rhythm and context (see Chapter 3). Such classification was the main outcome of the Self-Case Studies. However, the Study with Participants tested Conceptual Simplification with other practitioners and four excerpts that challenged memory in different ways. Excerpt 1 involved a sequence of chords in the lower register, where pitches are less discernible.[213] Excerpt 2 presented a self-referencing texture, with multiple switches for melody, harmony and octave changing.[214] Excerpt 3 was based on a symmetrical pitch organisation, which was key for encoding the pitches, displayed within a challenging rhythmical scheme.[215] Finally, Excerpt 4 consisted of two independent events without any

212 Levitin (2012: 201-250).

213 Burns (1999), Lockhead and Byrd (1981), Pressnitzer et al. (2001), Semal and Demany (1990), Takeuchi and Hulse (1993).

214 Excerpt 2 was also challenging in terms of hand coordination for keeping the uniform repetition. This became even more difficult for participants when switching notes in either hand.

215 Excerpt 3 also presented a considerable technical challenge in terms of deciding fingering, hand arrangements and motor coordination.

explicit patterns. The first three excerpts were non-tonal, while the last was atonal. Hence, participants faced the main challenges of complexity, previously discussed in this chapter and Chapter 3. Since their practice time was limited, extreme examples of complexity could not be tested. Nonetheless, the excerpts were selected to meet these features.

Excerpts 3 and 4 represented Complexity Type A, while Excerpt 2 represented Type B. Moreover, Excerpt 3 was conceptually challenging and based on a horizontal symmetry. Therefore, attention was focused on whether those participants aware of this composition principle were more efficient in memorising the pitches. Finally, Excerpt 1 aimed to challenge perfect-pitch possessors, with an advantage in auditory imagery,[216] or in remembering easier through aural memory.[217] Moreover, despite Excerpt 1 being mostly homophonic, it also challenged memory harmonically. This is relevant since some participants (e.g., PC-X, PK-X) find polyphony harder to memorise. Finally, although Excerpt 1 did not present a complex polyphonic texture, this was mitigated with Excerpt 4.

The suggested strategies were those that I used for the original works, and their efficacy was tested through my experience beforehand. Consequently, the participants' implementation of these same strategies on shorter excerpts did not imply an additional difficulty, but removed the longitudinal dimension associated with learning and memorising the original work.[218] Hence, it simulated the participants' potential behaviour and experience when working on a specific section, which was predetermined by the excerpt provided. Given that this sectional approach is the learning period in which deliberate encoding mainly happens,[219] it was also the most relevant for testing these strategies.

[216] Brodsky et al. (2003; 2008), Kopiez and Lee (2006; 2008).
[217] Highben and Palmer (2004), Peretz and Zatorre (2005).
[218] As opposed, for instance, of Fonte's (2020: 197-308) multiple-case study.
[219] e.g., Chaffin et al. (2002: 93-138; 2010), Fonte (2020: 130-137), Soares (2015: 44-47).

Amongst all simplifying strategies, Simplifying Octaves was the most useful for identifying patterns. This was a novel strategy for most participants: only PH-X consciously used it, although the rest might have done so unconsciously or differently. Concretely, PH-X transposed all pitches of Excerpt 2 into the same octave and analysed both hands as two independent melodies, which was the purpose of including this strategy in Group Y's instructions. However, PH-X had heard Excerpt 2 before.[220] Therefore, having a previous even if only vague aural memory might have influenced this participant's learning and memorisation approach:[221] transposing all notes into the same octave could have highlighted those traces more easily recognisable to this participant's aural memory (e.g., changing harmonies, melodic cells). However, while this pianist usually focuses on identifying patterns for memorising, PH-X did not use Simplifying Octaves in other excerpts (e.g., Excerpt 1, Excerpt 3) with which this participant struggled and failed to identify most patterns. Since PH-X had experience in post-tonal music, a potential explanation for this result might be visual crowding.[222] Excerpt 2 contains significantly less information than the rest: single notes repeated in each hand, that asynchronously shift every two bars, creating many tonal references. Conversely, Excerpt 3's pitch organisation was not evident if the symmetry was not identified, and Excerpt 1's chords were difficult to discern due to notation and register. Also, Excerpt 4 was significantly shorter than the rest, and most participants memorised it without prior analysis. Finally, excerpts 3 and 4 required additional expertise to realise the patterns.[223]

[220] Further details of this are provided in Chapter 7.
[221] Bangert et al. (2006), Buckner (1970), Cash et al. (2014), Fonte (2020), Haueisen and Knösche (2001), Lahav et al. (2013), Lotze et al. (2003), Meister et al. (2004), Mishra (2004: 231), Rubin-Rabson (1937), Schlabach (1975), Soares (2015).
[222] Fan et al. (2022), Jónasson et al. (2022), Maus et al. (2011), Pelli and Tillman (2008), Whitney and Levi (2011).
[223] Chueke and Chaffin (2016), Fonte (2020: 106-108; 134; 293; 440; 443; 452), Soares (2015: 148).

Similarly, PK-X also identified the patterns in Excerpt 2 but did not report using Simplifying Octaves. Two potential explanations could justify this. First, PK-X could have identified these intuitively: this participant has perfect pitch, as opposed to PH-X, and did not mention using any strategy for identifying these. Concretely, for PK-X, playing Excerpt 2 consisted in 'calculating' its patterns and how these developed in the corresponding octaves. Secondly, PK-X could have used Simplifying Octaves, but not regarded it as a "strategy", either for being too obvious to mention or being unaware of using it. Similarly, perfect-pitch possessor PB-X 'worked out' simple sequences of notes in both hands, after removing the repetition. However, while this participant could easily remember the octave changes, PB-X was confused when restoring the repetition. Finally, relative-pitch possessor PC-X did not implement Simplifying Octaves physically or consciously, but annotated each hand's sequences, showing an analytical approach prior to physical practice.[224]

Alternatively, Group Y regarded Simplifying Octaves as one of the most effective strategies for all four excerpts. This was also true for perfect-pitch possessors, allowing them to simplify the music to hear the melody clearly and improve their perfect pitch ability. Furthermore, Simplifying Octaves was proved a useful analytical strategy for discerning clearer the patterns within pointillistic musical textures and disconnected melodic cells. This was also reported by Theodorakis in Fonte (2020)[225] to facilitate harmonic analysis in Xenakis' *Herma* (1961). Concretely, both in Fonte (2020) and in this thesis, Theodorakis exemplified how he relates atonal music to a tonal framework or a familiar composition principle. Hence, his implementation of Simplifying Octaves enhances such recognition of

[224] Aiello (2000), Chaffin and Imreh (1997a: 317), Chaffin et al. (2002), Ginsborg (2004: 14), Hallam (1997), Mishra (2002; 2004; 2005), Ross (1964), Rubin-Rabson (1937).
[225] See Fonte (2020: 442, lines 2625-2646).

chords. However, once his analysis is completed, he memorises pitches in their original octaves.[226]

Furthermore, given that Theodorakis has perfect pitch, Simplifying Octaves might also permit him to enhance further this ability. This hypothesis could be supported by existing literature showing that perfect pitch is more accurate in a central register,[227] and less accurate at the 'high and low extremes of the musical range' (Deutsch, 2013: 168).[228] Moreover, condensing all notes within a single octave might be an optimal strategy, because perfect pitch's accuracy within a central register varies too, being most accurate between the central C4 of the keyboard[229] and C6:[230] hence, within a two-octave range.[231] Also, for Group Y's perfect-pitch possessors, Simplifying Octaves permitted them recognising better the melody, boosting their ability 'to hear the tune', in PL-Y's words, facilitating memorisation, which could be Theodorakis' case too. Finally, this effect could also be due to Western classical music's tendency of mostly unfolding in a central register.[232] This cultural environment might favour ear training in that musical range, although this latter argument needs further investigation.[233]

[226] Fonte (2020: 442, line 2640).
[227] Bachem (1948), Baird (1917), Miyazaki (1989), Rakowski (1978), Rakowski and Morawska-Bungeler (1987).
[228] See also Burns (1999), Lockhead and Byrd (1981), Pressnitzer et al. (2001), Semal and Demany (1990), Takeuchi and Hulse (1993).
[229] This is Middle C at 261.63 Hz. Depending on the system used for counting octaves, this can be labelled as C3 or C4.
[230] i.e., 1046.50 Hz. This would be until C5 or C6, depending on the system used for counting octaves.
[231] Deutsch et al. (2011), Miyazaki (1989).
[232] Chiantore ([2001] 2007).
[233] Deutsch (2013).

Except for PL-Y, all participants found useful the rest of simplifying strategies suggested for pitch,[234] chords,[235] hands,[236] rhythm,[237] repetition and preceding structure.[238] Some of these strategies are frequently used in piano pedagogy,[239] and were also reported by several participants. However, to the best of my knowledge, this is the first time that a specific and structured pool of simplifying strategies are provided for analysis, learning and memorisation. Concretely, the resulting steps of these simplifying strategies contributed into 'much more confident' and fast memorisation, in PD-Y's words, although some of these intermediate stages were uncomfortable at first, particularly for perfect-pitch possessors.

Finally, Simplifying Extended Techniques was significantly successful when memorising Gasull's concerto for two main reasons. First, it allowed me to focus on the underlying patterns, fluently learn and memorise what had to be played on keys and incorporate into my performance an adapted version of the extended techniques. This finding replicated the results of my previous Farré Rozada (2018) self-study. Secondly, the concerto involved an ongoing collaborative process with the composer. Therefore, learning extended techniques detached from their location inside the piano permitted me to be flexible when Gasull changed some effects for others. Both findings provide evidence of a more effective approach towards extended techniques memorisation than Fonte's (2020: 118-196).

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234 Pike and Carter (2010: 234), Reina (2015).

235 Ginsborg (2004), Mishra (2002; 2010).

236 Brown (1933), Chiantore ([2001] 2007), Fonte (2020: 153; 222; 229; 235; 256; 394; 396), Gruson (1988), Mishra (2004: 233; 2010), Rubin-Rabson (1939), Soares (2015: 128; 193; 212).

237 Fonte (2020: 248), Nellons (1974: 27-46), Pike and Carter (2010: 235), Soares (2015), Tsintzou and Theodorakis (2008: 6).

238 e.g., Fonte (2020: 222), Ginsborg and Chaffin (2011a: 346), Jordan-Anders (1990: 34), Miklaszewski (1989), Mishra (2004; 2010), Soares (2015: 42; 61; 137; 193).

239 e.g., Berman (2010), Chasins (1982), Chiantore ([2001] 2007), Neuhaus ([1973] 2006).

8.2.2 Conceptualisation Strategies

Conceptual Simplification's last stage involves Interval, Chord, Rhythm, Pattern, Switches and Dynamics Conceptualisation, along with *Solkattu* Verbalisation and Clapping. Like the simplifying strategies, these are discussed in Chapter 3, after refining and restructuring them with the Self-Case Studies. Given their relevance for chunking, the following discussion involves findings from both the Interviews and the Study with Participants.

The most effective conceptualisation strategies were those regarding pitch and rhythm. Existing results, Theodorakis' statements and Group X's reported strategies made clear that using a tonal framework for chunking and encoding unfamiliar material is a successful strategy for memorising post-tonal music.[240] This was further supported by Group Y's reactions to Chord and Pattern Conceptualisation, and the Self-Case Studies. Moreover, implementing the simplifying strategies contributed to diminishing visual crowding,[241] and enhancing conceptualisation by layers, reflecting Conceptual Simplification's modus operandi,[242] based on the divide-and-conquer paradigm.[243] This was confirmed with Theodorakis' descriptions on how to group pitches into familiar entities, and those Group X's participants who failed in identifying patterns. Additionally, being aware of a piece's composition principles does not necessarily provide the key for memorising or monitoring the performance.[244] Alternatively, it might be better to develop principles that work for one's understanding and individual learning style.[245] This was validated with Theodorakis' memorisation procedures for several compositions by Xenakis, my own experience with

[240] Chueke and Chaffin (2016), Fonte (2020), Gordon (2006: 84), Miklaszewski (1995), Nuki (1984), Ockelford (2011: 237), Oura and Hatano (1988), Sloboda (1978), Sloboda et al. (1985), Soares (2015: 75; 194), Tsintzou and Theodorakis (2008: 8).
[241] Fan et al. (2022), Jónasson et al. (2022), Maus et al. (2011), Pelli and Tillman (2008), Whitney and Levi (2011).
[242] See Chapter 3.
[243] Brassard and Bratley (1995: 226-228), Cormen et al. (2009: 30-35; 65), Levitin (2012: 131-168).
[244] Chueke and Chaffin (2016), Fonte (2020: 106-108; 134; 293; 318-319; 439-452), Imberty (1993), Kivy (2001), Lerdahl (1992), Meelberg (2006), Packalén (2005), Soares (2015: 148-149).
[245] Bourdieu ([1984] 2010: 80-81; 233), Chueke and Chaffin (2016), Fonte (2020: 298; 318-319; 439-450), Li (2007), Odendaal (2019), Soares (2015), Svard and Maack (2002), Tsintzou and Theodorakis (2008: 7).

Ben-Amots' piece based on mathematical principles, and Group Y's reactions to Excerpt 3. Finally, expertise with post-tonal music did not always ensure successful memorisation, analysis or identification of patterns, contradicting existing research on this topic.[246] For example, PC-X was a novice in post-tonal music, but this participant succeeded in identifying most patterns, while PK-X, with more training and experience in this repertoire, was not equally successful. Likewise, evidence from the three studies illustrated how pattern identification can also be used with switches (see Chapter 3), and in combination with interspersing practice with sleep.[247]

Another important finding regarded rhythm. Theodorakis provided empirical strategies for dealing with polyrhythms, which simplify rhythmical complexity through the identification of the basic root of the pattern: e.g., the longest rhythmical value and easiest relatable to the main pulse. However, the most promising strategy for memorising rhythm was *solkattu*, with the future perspective of incorporating further Karnatic rhythmical techniques to Conceptual Simplification.[248] Both Group Y and my self-reports showed that implementing *solkattu* to complex rhythms contributed to performance fluency and confident memorisation, as anticipated in similar studies on sight-reading.[249] Participants consistently struggled with rhythm, since post-tonal music explores this parameter in terms of complexity.[250] Concretely, this is observed when comparing technical challenging pieces, such as tonal and post-tonal etudes. For example, Czerny's and Chopin's etudes present rhythmical uniformity but focus on a challenging distribution of pitches, whereas Ligeti's or Chin's are inclined towards rhythmical complexity.

246 e.g., Gobet and Simon (1996a; 1996b), Hallam (1997), Mishra (2004: 233), Nuki (1984), Sala and Gobet (2017), Soares (2015: 210), Starkes et al. (1990), Tsintzou and Theodorakis (2008: 7-9), Williamon and Valentine (2002).
247 e.g., Allen (2013), Duke and Davis (2006), Mazza et al. (2016), van Hedger et al. (2015).
248 See Reina (2015) for a compilation of such techniques.
249 e.g., Pike and Carter (2010).
250 e.g., Forte (1980; 1983), Hasty (1981), Hyde (1984), Kramer (1985; 1988; 1996), Lewin (2007), Marvin (1991).

Furthermore, although interviewees memorise dynamics mostly with kinaesthetic memory, both Dynamics Conceptualisation and PD-Y's statements reinforced the importance of rationalising this musical parameter for strengthening memory. Particularly, when this permits successfully tackling switches:[251] dynamics are sometimes the only distinctive element in self-referencing or resemblant material.[252] Lastly, those less-experienced participants in memorisation and post-tonal music found Conceptual Simplification strategies a useful tool for approaching this repertoire from different perspectives. Therefore, prompting their interest for engaging more frequently with this repertoire. Making Conceptual Simplification available to performers could contribute to correcting the lack of exposure that post-tonal music has in educational settings and performing contexts.[253] Moreover, thorough preparation of this repertoire for performance might enhance the audience's experience, prompting their interest for discovering further literature.

8.2.3 Additional Strategies

As discussed, combining distributed practice with sleep benefits from encoding variability.[254] However, other metacognitive strategies were identified: most importantly, Hardink's methods for removing the context-dependent memory effect and the encoding specificity principle.[255] Concretely, Hardink practises on different pianos and alters the material in different ways to strengthen his understanding and knowledge of the music, but also for coping with potential memory lapses on stage. Therefore, benefitting from Craik and

[251] e.g., Chaffin et al. (2002).
[252] Chaffin and Lisboa (2008), Chaffin et al. (2002; 2010), Chee and Goh (2018), Eysenck (1979b), Hunt (2013), von Restorff (1933).
[253] Fonte (2020: 77-117; 380-469), Fonte et al. (2022), Jónasson and Lisboa (2016).
[254] Baddeley et al. (2020: 125), Craik and Lockhart (1972), Craik and Tulving (1975), Kerr and Booth (1978), Memmert (2006), Shoenfelt et al. (2002). The implications of encoding variability are discussed in Chapter 2, section 2.4.2.
[255] Baddeley et al. (2020: 245; 254-258), Godden and Baddeley (1975), Mishra and Backlin (2007), Smith and Vela (2001).

Lockhart's (1972) depth of processing principle. Furthermore, Hardink also practises in different moments of the day. Both Hardink's memorisation approaches align with Smith's (1982) suggestions on combining different contexts when learning and memorising, and the benefits of processing information associatively, rather than through repetition.[256] Thus, Hardink's strategy for manipulating his performing experience and the sensorial appearance of the music prompts a meaningful and subjective organisation of new information, positively impacting retrieval.[257] But, it also implicitly advocates for Conceptual Simplification's modus operandi, in which the music is modified as necessary to fulfil understanding and long-term retention.

Similarly, PL-Y and PJ-Y also reported playing run-throughs 'in different registers, dynamics, styles', and 'performing on different pianos and room acoustics', in PJ-Y's words, although this is a habit of piano students and professionals, at not having the opportunity to always perform on the same instrument.[258] Furthermore, PJ-Y reproduces all actions associated with a public performance: e.g., putting on 'the attire' and opening the piano. This strategy benefits from the transfer-appropriate processing principle, in preparing for the performance by recreating the retrieval environment.[259]

Finally, some Group Y's participants struggled when practising certain reductions of the excerpts after implementing simplifying strategies. Nonetheless, such strategies challenge cognition in different ways, prompting further long-term retention according to the desirable

[256] Glenberg (1997), Smith and Vela (2001).
[257] Bower et al. (1969), Tulving (1962). For music, evidence is provided by Chaffin (2007), Chaffin and Imreh (1997a; 2001), Chaffin and Logan (2006), Chaffin et al. (2003; 2010), Chueke and Chaffin (2016), Fonte (2020), Miklaszewski (1989), Nielsen (1999a), Noice et al. (2008), Ockelford (2011), Rubin-Rabson (1937), Soares (2015), Tsintzou and Theodorakis (2008), Williamon and Valentine (2002).
[258] Mishra and Backlin (2007).
[259] Baddeley et al. (2020: 173), Fisher and Craik (1977), Morris et al. (1977).

difficulty hypothesis,[260] and facilitating encoding variability.[261] Ultimately, all these metacognitive strategies point toward a bigger philosophy reported by Theodorakis, Hardink and several recruited participants, and which is the core of Conceptual Simplification: in Theodorakis' words, 'to learn is to memorise'. Thus, an effective memorisation approach is using one's own metacognitive knowledge to select and combine those strategies that permit one to learn and comprehend the information,[262] in a way that memorising is a direct consequence of understanding.[263] According to PJ-Y, Theodorakis and Hardink, this process makes music 'intuitive', reminding Stanislavski's famous method for actors,[264] and that requires not overloading practice sessions.[265]

[260] Bjork (1975; 2014), Bjork and Bjork (1992; 2011), Schmidt and Bjork (1992).
[261] Baddeley et al. (2020: 125), Craik and Lockhart (1972), Craik and Tulving (1975), Kerr and Booth (1978), Memmert (2006), Shoenfelt et al. (2002).
[262] Antonietti et al. (2009), Berardi-Coletta et al. (1995), Colombo and Antonietti (2017), Dehaene (2015), Fairbrother et al. (2021), Gardner ([1983] 2011), Hallam (2001), Jaarsveld and Lachmann (2017), Jabusch (2016), Karpicke et al. (2009), Ste-Marie et al. (2013), Veenman et al. (2006), Velzen (2017).
[263] Dehaene (2015), Jaarsveld and Lachmann (2017), Köhler (1947), Sternberg and Davidson (1995), Walker (2005).
[264] Stanislavski ([1936] 2013; [1950] 2013; [1961] 2013).
[265] Allen (2013), Carter and Grahn (2016), Cash (2009), Duke and Davis (2006), Duke et al. (2009), Rubin-Rabson (1940a), Simmons (2011), Soares (2015: 193-194; 205).

8.3 RQ3: Which Performance Strategies Can Be Effective for Performing a Post-Tonal Piano Work from Memory?

The most important finding for RQ3 was mental practice's potential for coping with performance anxiety. Hardink uses this strategy to keep a positive mindset before going on stage and convince himself that he thoroughly knows the piece. Mental practice was also reported by Theodorakis, many recruited participants and me, as a useful strategy for reviewing content learned and focusing on the performance. While these results require further investigation, existing research stated that a combination of physical and mental practice might be the most effective approach for successfully performing from memory.[266] Furthermore, I reported using a "fingering trigger" strategy in virtuosic passages for mentally anticipating the next fingering, therefore, triggering the corresponding motoric sequences accurately, or the right track for switches. Likewise, Theodorakis reported using fermatas and rests for anticipating upcoming content, and PL-Y also described the fingering trigger strategy in practice. The efficiency of these mental strategies relies in that accessing declarative knowledge activates the brain's motor areas associated to that content.[267] Hence, mental practice reduces the amount of practice needed,[268] strengthening Conceptual Simplification's approach in developing a conceptual framework.

However, as some participants indicated (e.g., PA-Y), thinking in analytical terms during the performance or explicitly monitoring step-by-step automatised passages can lead to disrupting technical sequences: a phenomenon known as choking and studied in sports with explicit monitoring theories.[269] Therefore, a better option is relying on kinaesthetic memory

[266] Bernardi et al. (2013), Coffman (1990), Driskell et al. (1994), Highben and Palmer (2004), Hinshaw (1991), Iorio et al. (2022), Keller (2012), Lim and Lippman (1991), Ross (1985), Rubin-Rabson (1941c).
[267] e.g., Miller et al. (2018).
[268] Iorio et al. (2022), Keller (2012).
[269] Baddeley et al. (2020: 149), Beilock and Carr (2001), Chaffin et al. (2002), DeCaro et al. (2011), Flegal and Anderson (2008), Mackenzie (1990), Otten (2009), Schooler and Engstler-Schooler (1990).

in under-pressure situations, towards achieving a clutch performance: an improved performance under pressure.[270] Finally, another important issue raised by all interviewees and most participants was the importance of preparing according to the conditions of the performance. They emphasised that a performance from the score should be prepared accordingly, whereas a memorised performance should be planned well in advance, for developing thorough memorisation.[271]

After answering the Research Questions (RQ), the next chapter provides the final conclusions of this thesis, including a summary of the main findings.

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[270] Otten (2009: 584).

[271] Chaffin and Imreh (1997a: 316), Chaffin and Logan (2006), Chaffin et al. (2002), Fonte (2020: 318-319; 439-450), Hallam (1997), Halpern and Bower (1982), Miller (1956), Mishra (2005), Oura and Hatano (1988), Sloboda et al. (1985), Soares (2015: 148), Tsintzou and Theodorakis (2008).

Chapter 9: Conclusions

This thesis contributes to answering the principal question: How can memorisation of post-tonal piano works be improved? Accordingly, it proposes Conceptual Simplification as an effective method for that purpose (see Chapter 3). It also examines influential parameters and effective practice and performance strategies for successfully performing this repertoire from memory. The main findings are now summarised.

The most influential parameters for memorisation are complexity, perfect pitch, sight-reading and sleep. Concretely, the main outcomes are:

- Three main types of complexity are identified, depending on the structure's clarity, amount of detail, layers of information, technical challenges, perceived coherence and how frequently and in what ways ideas repeat (e.g., switches).

- Perfect pitch is a learning facilitator that influences memory and enhances mental practice, while Conceptual Simplification assists its implementation to post-tonal music. Therefore, while this memorisation method was developed from a relative-pitch perspective, perfect-pitch possessors found Conceptual Simplification effective for memorising.

- Sight-reading enhances understanding and determines the memorisation approach. Fluency in this skill is conditioned by the repertoire's difficulty or complexity.

- Sleep is essential to memory consolidation, enhancing memory and performance. Therefore, besides practice, sleeping is the most effective activity for strengthening memory: most participants found it easier to recall the excerpts after sleeping, in comparison to the previous day in which these were memorised. Consequently, distributed practice should be interspersed with sleep.

- Emotions can be useful as meaningful encoding and to develop a coherent story of the piece and characters to convey. However, negative emotions can self-sabotage preparation, triggering performance anxiety. Mental practice can be an effective prevention tool, which also helps to thoroughly prepare beforehand. Similarly, memorisation can be a strategy to cope with performance anxiety, but also a trigger if failing to memorise successfully.

- Expertise is not always effective for identifying patterns, if lacking a system for that purpose: e.g., Theodorakis' encoding methods or Conceptual Simplification.

The most effective practice strategies for memorising post-tonal piano music are those for simplifying complexity (i.e., Simplifying Layers of Complexity), particularly Simplifying Octaves; conceptualisation strategies (i.e., Conceptual Encoding); and metacognitive strategies to optimise practice and lessen both the context-dependent memory effect and the encoding specificity principle. Since research on musical memory focuses on pitches but not rhythm, this thesis' findings suggest that *Solkattu* Verbalisation and Clapping could be a long-term effective strategy for memorising rhythm. Likewise, the most effective performance strategies are anticipating upcoming information when performing (e.g., fingering trigger strategy); and mental practice, both for reviewing internalised content and for coping with performance anxiety: deliberate practice and effective memorisation strategies might not suffice for successfully performing from memory due to self-sabotage. Consequently, urging to find self-regulation strategies to prompt confidence before and during performance.

Finally, it is important to prepare according to the performance's conditions: e.g., performing from memory versus performing from the score.

The following sections review the original contributions and further paths for future research, concluding with a final summary of this thesis' outcome.

9.1 Original Contributions

This thesis' main original contribution is Conceptual Simplification, as formalised in Chapter 3 and Chapter 5. While I produced the first prototype of this method with my master's thesis Farré Rozada (2018),[1] this PhD permitted academically testing it with other practitioners and further repertoire, providing a range of evidence that Conceptual Simplification is a coherent system that works for different learning styles and types of complexity. During this process, the method's theoretical underpinning was extended and refined, reorganising strategies and adding new ones, while comparing these with other pianists' working methods (Interviews, Study with Participants). Additionally, Conceptual Simplification's implementation was further developed, to also assist learning and analysis. Moreover, this thesis presents a novel implementation to musical memorisation of group theory, number theory, geometry; and the paradigms of divide-and-conquer, decrease-and-conquer and transform-and-conquer. To the best of my knowledge, this is the first time that music, mathematics and computer science are connected within the field of human memory and musical performance, providing a ground-breaking precedent in this direction.

[1] Further details of this first version of Conceptual Simplification can be found in Appendix A.

Regarding minor original contributions, there were some methodological developments. First, data analysis differed from standard case studies on musical memory, which rely on the SYMP method (see Chapter 4). However, neither SYMP's statistical outcomes nor Performance Cue Theory's interpretation of data were useful for the purpose of this research.[2] Consequently, an adapted version of the LAMap method[3] was used to observe my practice, providing an alternative. Similarly, a qualitative-and-quantitative analysis method for recordings was also developed.[4] Secondly, for observing recruited participants, a research design that divided practitioners into a control and an experimental group was chosen, to test the effectiveness of Conceptual Simplification strategies. Unlike similar studies, the excerpts were not commissioned but selected from existing works, seeking a real-world study. Other novelties were using a logical reasoning test for measuring the participants' ability to rationalise music and a Memorisation Test that explored how sleep influences consolidation of post-tonal music memorisation. Concretely, this consisted of a memorisation session followed by two subsequent recalls without practice (AR, without sleep; NDR, with sleep), and an optional written recall.

Furthermore, the Self-Case Studies involved substantially more repertoire than similar previous research on post-tonal music,[5] comparing the results of two major post-tonal works in two different contexts: soloist and soloist with orchestra. Also, for the first time, a memorisation method was tested by a practitioner-researcher, providing first-person accounts of how Conceptual Simplification can be adapted in different contexts. Moreover, a new model of learning periods emerged from the data (see Chapter 5), although this was flexible to some variations. Finally, the Interviews provided a snapshot of the views and

[2] Also, as stated earlier, the SYMP software became obsolete.
[3] See Chapter 4, section 4.5.2.
[4] See Chapter 4, section 4.5.3.
[5] e.g., Chueke and Chaffin (2016), Fonte (2020: 118-196), Soares (2015: 34-188).

perspectives on memorisation of pianists Hayk Melikyan, Ermis Theodorakis and Jason Hardink. These are established specialised performers, who actively collaborate with living composers. Thus, their testimonies also inform the performance practice and analysis of the works featured.[6]

9.2 Future Research

This section discusses potential future research, structured according to the three studies presented.

9.2.1 Self-Case Studies

The results of these studies urge replicating them with additional repertoire and broader performing contexts, including pieces with electronics or other interdisciplinary components. Furthermore, it should also be explored Conceptual Simplification's applicability to other genres (e.g., lied, chamber, ensemble, orchestral settings), and the benefits of memorisation within these contexts.

Given the vast possibilities of these potential enquiring paths, immediate future research can be narrowed down to existing data collected during this PhD that could not be included in the thesis: the commissioned 30-minute Piano Concerto *Tautening skies* (2020), written by British composer Angela Elizabeth Slater.[7] This was world-premiered on 4 November 2022

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[6] Concretely, Theodorakis was Xenakis' predilect interpreter, and recorded his complete piano works. This is relevant since several works by Xenakis were featured to illustrate Theodorakis' strategies. See further details in https://www.ermis-theodorakis.com/index.php?language=EN&page=biography https://www.ekathimerini.com/culture/20395/an-ideal-performer-of-contemporary-musical-works/

[7] Angela Elizabeth Slater (2015) *Angela Elizabeth Slater, composer*. Available at: www.angelaslatercomposer.co.uk/ [Accessed 22 April 2022].

at the Bradshaw Hall with RBC Symphony Orchestra conducted by Yannick Mayaud, with a second performance at the CBSO Centre on 12 November 2022.

Finally, Conceptual Simplification could be further evaluated by commissioning a set of piano etudes that challenge memory in different ways, informed by this research. Along with the above-mentioned options, this is suitable for a postdoc.

9.2.2 Interviews

This study demonstrated that memorisation of post-tonal piano music is idiosyncratic, and varies depending on the repertoire and composition principles, but also on the pianist's abilities and skills. Consequently, enquiring about memorisation strategies demands further research, in this case, by interviewing as many specialised pianists as possible. Moreover, those soloists interviewed should also be recruited for the Study with Participants, to provide further insight into Conceptual Simplification by specialised pianists in this repertoire.

Finally, the role of performance anxiety in memorisation was an unexpected finding, which arose both in the Interviews and the Study with Participants. Despite being beyond the scope of this thesis, this data shall be used for future research.

9.2.3 Study with Participants

This study only tested a guided implementation of Conceptual Simplification, instead of evaluating whether participants could use the overall method by themselves. The evidence collected provided positive results in that direction, but a longitudinal study is needed to evaluate how recruited participants adapt their working methods and use Conceptual

Simplification on their own. Nevertheless, given Covid-19's imposed limitations, future research should first focus on running again the Study with Participants with a bigger sample, since more participants could lead to more conclusive results. For example, no participants experienced synaesthesia, therefore, this parameter could not be evaluated. Similarly, the influence of emotions on memorisation requires a specific study.

The Study with Participants' outcome encourages developing Conceptual Simplification training initiatives in conservatoires. These results also highlighted the prominent obstacle that complex rhythm poses for memorisation, urging to develop specific memorisation strategies accordingly. But also, the problematic of rhythm not being taught effectively in Western musical institutions. This was emphasised with the participants' reactions to challenging rhythmical patterns. Accordingly, *solkattu* is only the tip of the iceberg of Karnatic music's method for rhythm, which could be a more intuitive pedagogical approach, especially for complex rhythms. Again, this indicates another fruitful path of research.

Finally, the observed benefits of sleep for musical memory were amongst the most promising results for motivating future studies in this direction, especially for comprehending in what ways this should be incorporated into a performer's practice routine. This is still an underrepresented topic in musical research, despite its ground-breaking results in other fields,[8] and along with mental practice, it deserves further exploration on how to be fitted within Conceptual Simplification's framework.

[8] The Study with Participants was exploratory and requires further investigation, along with systematic measures frequently used in sleep research. For instance, engaging specialised facilities (e.g., Sleep Labs); systems such as NightCap (Ajilore et al., 1995) to produce reliable sleep recordings of the participants; or including official measure tools into the research design such as Pittsburgh Sleep Quality Index (Buysse et al., 1989), the Horne and the Ostberg morning/evening questionnaire (Horne and Östberg, 1976), to determine the circadian influences at recall and retention, determined by the moment of the day in which training and retesting occur (Simmons and Duke, 2006: 259); the Epworth Sleepiness Scale (Johns, 1991), and subtests from the Wechsler Adult Intelligence Scale IV (WAIS-IV; Wechsler, 2008) and the Wechsler Memory Scale III (WMS-III; Wechsler, 1997). Considering all this, the results of this thesis on sleep should be interpreted as merely

9.3 Summary

Conceptual Simplification has the potential to be an effective analysis, learning and memorisation method for practitioners with different learning styles and no scientific background.[9] The scope of this research limited its testing to post-tonal piano music. However, this new method could be adapted to other instrumentalists, singers and conductors, and musical genres. More ambitious applications could involve non-musical domains, since Conceptual Simplification essentially scaffolds complexity, proceeding in a non-linear manner, hence, avoiding time-consuming procedures. Further developments could involve including additional strategies or guidelines for structuring practice and interspersing this with sleep. It also welcomes any potential improvements for becoming an effective pedagogical tool for approaching post-tonal music: both for performers and the audience.

Finally, Conceptual Simplification also indicates promising additional benefits such as alleviating performance anxiety and reducing the potential for injuries, given its systematic approach toward engaging conceptual memory and reasoning. This leads to more confident memorised performances, while needing less repetition during practice. This is important since performance anxiety's main triggers are the fear of forgetting and self-sabotage. Therefore, Conceptual Simplification's possibilities as a tool for providing mental scripts and preventing this from happening, just as athletes do,[10] needs further research. Additionally, Conceptual Simplification could be further enhanced by developing an app or software that implemented the method's strategies on the scores, to assist performers in their practice.[11]

informative of promising future research, and a first attempt to evaluate the effect of sleep on memorisation of real-life musical excerpts, focusing on post-tonal piano music.

[9] The method is thoroughly discussed in Chapter 3 and a summary of the strategies is provided in Chapter 5.

[10] e.g., Williams et al. (2013).

[11] For example, similarly to what Smith (2009) did for training sight-reading.

Ultimately, beyond this thesis' ground-breaking contribution to existing research, Conceptual Simplification has evolved over the years according to my performance practice, and growing familiarity and experience with post-tonal music. Therefore, just as my master's thesis and this PhD provided a testimony of my working methods as a practitioner, these are expected to keep evolving with my ongoing career.

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