Absent Performers, Absent Tools, and Their Role in Musical Composition:

Exploring Integrated Competencies in the Extended Musical Mind.

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ABSTRACT

The tools and performers which surround the composer are not simply a means to communicate musical ideas, they take part in the formation and development of those ideas. Essentially, musical composition does not only take place in the head. This is the compelling perspective provided by the application of '4E' theories of cognition, and related ideas from phenomenology and cognitive science, to musical creativity, where the cognitive processes of musical composition can be seen as varyingly embodied, embedded, enacted, extended, distributed, and materially engaged. This thesis attempts to break new conceptual ground through applying these ideas to musical composition with a focus on *absent* tools and performers.

The insights gained from compositional practice, both inherent and explicitly analysed, function alongside the other methodological approaches. A portfolio of compositions and recordings therefore forms a core part of the thesis. The process of recording the compositions is often as important to the research as the process of their composition – the recordings are not simply there to allow the pieces to be heard. The analysis of his portfolio forms an essential part of the written portion of the thesis.

The thesis therefore undertakes its enquiry in two ways, through theory and through practice. The written portion of the thesis is also divided into two parts. The first part lays out the relevant, existing theories, and any existing applications thereof to music, and then applies these ideas to musical composition. This provides an understanding of the role of *present* tools and performers in the cognitive processes of composition. The second part builds on this understanding, through asking how we should understand processes of composition which take place while the tools, environments, and collaborators are *absent* (i.e., imagined, remembered, or virtual). This requires the development of a conceptual framework, 'Integrated Tool Competency', which is first applied to tools, and then to performers. In this way, the thesis develops a new way of understanding musical composition. It also has the potential to contribute substantially to the theories through which that understanding was reached.

CONTENTS

Composition Portfolio

des colombes et des crocodiles…, for string orchestra
Score (.pdf), 19 pages
Recording (.wav), length 06:58

Emergence//Overture, for large orchestra including 12 soloists
Score (.pdf), 22 pages
Recording (.wav), length 09:28

Symmetry II, 'dare mighty things', for 20 string players
Score (.pdf), 27 pages [see note on title page]
Recording (.wav), length 14:25

Symmetry I, 'resonance', for solo piano
Score (.pdf), 05 pages
Recording (.wav), length 05:12

Table of Figures

CHAPTER ONE: Introduction

Origin

This thesis grew from a desire to understand the role of things outside of a composer's head in the creative process of musical composition. The germination of this idea occurred while reading Elizabeth Le Guin's *Boccherini's Body*,[1] in which she describes the embodied relationship she felt with a long-dead composer when performing and analysing his works for cello. As a composer, I was drawn to explore how that relationship might work in reverse.

Of course, death is only one way in which a collaborator might be absent. In fact, when composing, due to the nature of time only flowing in one direction, the piece is likely to be written for a *future* performer.[2] These future performers might even be purely fictitious, at the time of writing, or perhaps based on memories of previous performers, who may well be those intended to first perform the work. In the age of digital technology, these 'absent' collaborators might be more present, but also further disembodied, in the case of virtual performers and sampled instruments.

The term 'disembodied' provides an initial link to the externalist theories which underpin this research. '4E' (Embodied, Embedded, Extended, and/or Enacted) theories of cognition have risen in prominence over the past three decades, and argue for the roles of bodies, environments, and technology in relevant cognitive processes. These ideas are very much related to and enmeshed in the field of phenomenology and the work of its key mid-20th century thinkers. While much of this work is purely theoretical, there is also a growing body of empirical evidence which points to how bodies and tools constitute, shape, and re-shape our minds.

While I initially approached these ideas with a view to understanding the composer/performer relationship, it became clear that, in order to do this, the composer/*technology* relationship

[1] Elizabeth Le Guin, *Boccherini's Body: An Essay in Carnal Musicology* (Berkeley, CA: University of California Press, 2006).
[2] Most of the potential collaborators discussed in this thesis will be musical performers, but collaborators could include teachers, peers, audiences, and so on.

also had to be understood. This led to a hypothesis: *The use of tools by composers shapes the cognitive processes of composition, even when those tools are absent.* Framed as the following research question, this hypothesis is explored in this thesis through both theory and practice in order to understand the role of absent tools and performers in the compositional process.

Research Questions

- **What is the role of absent compositional tools in the cognitive processes of musical composition?**

While the above is the central question of this thesis, it can be broken down into smaller questions for the sake of clarity, as follows.

1) What is the role of *present* compositional tools in the cognitive processes of musical composition?

Through analysing and synthesising existing work on tools, technology, and creativity, and applying this to composition, answering this question will provide a bedrock from which to build answers to the other questions. In recent decades, theorists, including those in anthropology, cognitive science, philosophy of mind, literature studies, architecture, mathematics, and music have started to take a 'post-Cartesian' approach to understanding the function and constitution of the mind. 'Post-Cartesian' in this context refers to theories which move beyond the Cartesian separation of mind and body. This follows work by 20th century phenomenologists who sought to understand the role of the body and tools in thinking and being in the world. There have also been numerous empirical studies which provide evidence for the validity of these approaches. All these can serve to provide an understanding of musical composition as an embodied process which is connected to the environment – both material and social - of the composer.

2) How might the use of tools in the past be integrated into the competencies of a composer?

Developing these theories to consider the importance of *absent* tools is the next step. 'Absence' in these cases can mean tools which are remembered, imagined, or a combination of both – and virtual tools provide an additional blurring of the boundaries between presence and absence. Answering this question requires the development of a conceptual framework, 'Integrated Tool Competency', which is done through Chapter Six of the thesis. This provides a means to understand how absent compositional tools function in the cognitive processes of musical composition.

a) How might the experiences of working with performers be similarly integrated?

Applying the concept of Integrated Tool Competency to understanding absent *performers* will provide a means to understanding the relationship between composer and absent/remembered/virtual performer. This also requires some exploration of the role of *present* performers.

i) What does this mean for the relationship between composer and performer?

This is the question which initially inspired this research. By extending the Integrated Tool Competency concept and combining this with existing work on empathy and social cognition, it becomes possible to develop an understanding of how composers and performers relate across time.

The exploration of this research question, divided into sub-questions as detailed, leads to a central hypothesis regarding the use of tools by composers, and an extension of that hypothesis into a second hypothesis regarding the relationship between composer and performer. These two hypotheses are stated below.

Hypotheses

The use of tools by composers shapes the cognitive processes of composition, even when those tools are absent. This is due to the integration of the experience of using those tools.

The experience of working with performers shapes the cognitive processes of composition, even when those performers are absent. This has a substantial impact on how the relationship between composer and performer should be considered.

A note on COVID-19, and the impact on the thesis.

Before discussing the methodology by which these hypotheses were reached, and the structure which the thesis takes, it is important to note the impact of COVID-19 on this research. Firstly, lockdown restrictions meant the cancellation of concerts, conferences, and workshops. As such, the majority of the compositions in the portfolio were written in the absence of real performers and recorded using virtual performers, which has limited some of the intended insights and outputs from those compositions. However, these processes have produced their own unique insights.

Secondly, my own COVID-19 symptoms (so-called 'long COVID') severely limited my capacity to work during nearly all of 2020 and a large portion of 2021. These limitations have affected the compositional decisions made during the PhD research. Certain things which would have been fascinating to explore during the pandemic (for example, collaborating online with performers) had to be passed over. Similarly, some ideas for compositional work had to be postponed until after the completion of the thesis, where otherwise these would have been explored during the writing of the thesis and insights applied where relevant. Nevertheless, overcoming these limitations has provided interesting insights into the role of tools, technology, and the body in the compositional process.[3]

Most importantly, the use of technology in the compositions went far beyond the initial proposal for the research, producing incredibly useful insights. Being required to undertake the compositional portion of the thesis in different ways than planned has therefore produced useful results which may not have been produced by following the initial research plan. The

[3] See this article written for the Royal Musical Association student blog for more on this, if interested. https://www.rma.ac.uk/2021/05/31/long-haul-composition-and-digital-crutches-how-i-used-the-virtual-performers-of-the-digital-age-to-overcome-the-impact-od-post-covid-19-syndrome-long-covid-and-lockdown-restrictions/ (or search 'Long-haul composition'). This article was used as the basis for parts of Chapter Eight.

theoretical portion of the thesis also had to be streamlined in response to both the practical circumstances and the changes to the composition portfolio. In the end, despite the limitations caused by COVID-19, this project has resulted in a thesis which thoroughly explores the principal research question with potentially transformative results.

Methodology

This thesis explores both theory and practice, and both elements are essential. The balance between theory and practice is an inversion of many PhDs in composition, where the research question tends to focus on how certain research perspectives can impact compositional practice. Unlike most PhDs involving compositions, in this thesis the compositions support and contribute to the theoretical ideas, rather than the other way round. There is therefore a more even balance between text and music, with the former being more substantive than for many doctorates in composition.

Theoretical Analysis, Synthesis, and Argument

Through active engagement with various theories, the use of thought experiments, and analysis of practice, two hypotheses are generated and tested in this thesis. The use of a reflective practitioner approach aids in the development of these ideas. Models for understanding the cognitive processes of musical composition are tested theoretically and practically, towards the development of an understanding of the role of tools and performers in composition.

Part of the contribution of this thesis is in its synthesis of existing thought from divergent areas, and novel application of this thought to composition. Relevant work has been done by theorists and philosophers, but also in empirical studies and experiments which have produced results which support the arguments being made in this thesis. The function of Part One is therefore to refine, synthesise, and apply these theories to demonstrate their importance for composition. The main contribution of the thesis is to then develop these ideas further in Part Two, to provide an answer to the research question above.

In summary, one central hypothesis - that absent compositional tools can affect the cognitive processes of composition - is proposed in the thesis. Through thought experiments and theoretical analysis, the boundaries of this hypothesis and related ideas have begun to be tested, including through the generation of a second hypothesis – that absent performers can also affect the cognitive processes of composition, and that this is essential to understanding the relationship between composer and performer - and this work will continue beyond the thesis. These hypotheses explain certain aspects of the process of composition in a unique way, and fill a gap in the literature, while also raising interesting questions which are just beginning to be explored in this thesis.

Compositional Practice

The processes of composing and recording the pieces in the portfolio are explored, in terms of the ideas discussed in the thesis, in a musical commentary. Each of the pieces has a certain element of the research question(s) to which it relates – be that influence and intertextuality, tools and technology, working with co-present performers, the role of imagined or remembered performers, and so on. Therefore, their primary contribution is in the analysis of the process of their composition and recording as a means to advance a general understanding of the cognitive processes of musical composition. These pieces belong to the tradition of notated music, with a focus on colour, chromaticism, complexity, and the potentials of instruments.[4] They thus also contribute to compositional practice through continuing to develop this approach to aesthetic and technical concerns without allying themselves with a particular 'school'. There are many ensembles performing works by past and present composers who relate to this approach,[5] and it is hoped that these and future pieces can continue to reach audiences through performances and recordings. It is also worth adding that while this might be where the practice is situated, the ideas they elucidate in this thesis by no means exclude other musical practices, or, indeed, creative practices outside music.

[4] Three major composers who immediately come to mind are Olivier Messiaen, Pierre Boulez, and Tōru Takemitsu. Of course, the list is endless, and there are many composers amongst my peers and mentors whose work is incredibly inspiring, but these seem at this point the most 'efficient' list of names to help situate the included compositions.

[5] For example, BCMG, Britten Pears Contemporary Ensemble, Ensemble intercontemporain, Ensemble 10/10, rarescale, the Arditti Quartet, LSO, BBC SO, BBC Singers, and so on.

A key practical investigation is into the role that digital technology could play in compositional practice, through the perspective of the role of tools in cognition. Digital technology became a greater part of the composition portfolio than initially envisaged, and yet these insights became the most useful. These investigations demonstrate the lessons which can be learned from understanding the potentials and limitations of digital technology, both in terms of compositional practice and the ideas regarding cognition discussed in the rest of the thesis. This means that, as has been stated above, the process of creating the recordings is just as much a part of the practical element of the thesis as the composition of the pieces and the creation of the written scores. The recordings are not only included so that the piece can be heard, though of course that is valuable in itself. They are an essential part of the practical element of the thesis.

Key concepts

Part One of this thesis focuses on the relevant literature, and unpacking, synthesising, and applying this literature to composition. However, certain concepts are essential throughout, and so are briefly described here as they pertain to the thesis. There is also an extended glossary at the end of the document.

Offloading: The idea that we can 'offload' certain aspects of cognitive processes onto things 'outside the head' permeates the various theories on which this thesis is based – whether this is through making use of external memory aids, interacting with the environment (for example, moving scrabble tiles around to find a word, rather than trying to do this task purely in the head), relying on embodied gesture or feedback, and so on. This offloading eases the cognitive load of certain tasks.

Parity Principle: the 'parity principle': '[i]f, as we confront some task, a part of the world functions as a process which, *were it done in the head*, we would have no hesitation in recognizing as part of the cognitive process, then that part of the world *is* (so we claim) part of the cognitive process.'[6] This is one of the core arguments for the validity of considering things external to the brain as essential parts of thinking and being in the world.

[6] Andy Clark and David Chalmers. 'The Extended Mind', *Analysis* 58, no. 1 (1998): 7–19 (14).

Transparent Technology: Also called 'smooth-coping', this is the idea that a technology can become so integrated into the relevant cognitive process that it becomes invisible-in-use. This is very much related to Heidegger's conception of *Readiness-to-hand (Zuhandenheit).*

Sensori-/ideomotor phenomena: sensorimotor refers to systems of bodily engagement with the world – ideomotor to internalised versions of those systems.

Process: The term 'process' is often used when discussing compositional practice as a term for the set of compositional techniques, theoretical approaches, and aesthetic approaches which a composer might use to produce a work.[7] However, throughout this thesis, the word 'process' is primarily used to refer to specific cognitive processes at a higher level of resolution. For example, the process of notating a certain part, or manipulating a certain piece of musical material, or using the skill of audiation to 'hear' the music which is being written. This relates much more closely to the discussion of cognitive processes in the relevant literature.

Absent: This thesis presents a blurring of the boundaries between 'absent' and 'present'. While the thesis argues that an 'absent' tool might become ready-to-hand in the same way as a 'present' tool. it is nevertheless useful linguistically to define absence as opposed to presence. As such, the word 'absent' is used throughout the thesis to mean something (a tool, a performer), which is not physically co-present with the agent in question.

Structure of thesis

The composition portfolio includes recordings and scores of four main pieces:

- *Emergence//Overture, for large orchestra including 12 soloists*
- *des colombes et des crocodiles…, for string orchestra*
- *symmetry I, 'resonance', for solo piano*
- *symmetry II, 'dare mighty things', for 20 string players*

[7] Where the phrase 'the compositional process' is used in this thesis, it is close to this definition, but more generalised rather than relating to a specific composer.

While these pieces can be listened to at any time for an understanding of the compositional practice which forms part of this thesis, it is essential that each piece is listened to at the point when it is discussed in the musical commentary (Chapters Six and Eight). Relevant parts of the score are included as musical examples in the body of the text, but the complete scores for *Emergence//Overture, des colombes et des crocodiles…,* and *symmetry I* are included for perusal, along with a partial transcription of *symmetry II.*

The research questions are tackled in two ways – theory and practice – and the written portion of the thesis is also split into two broad parts. Part One describes and analyses the relevant theoretical and empirical research in 4E cognition, cognitive science, phenomenology, and musicology (Chapters Two, Three, and Four); and then synthesises and applies this research to paint a picture of how we might view the cognitive processes of musical composition (Chapter Five).

Exploring this literature in the context of the research questions reveals some key gaps:

1) The 4E theories which underpin this research focus almost exclusively on co-present tools/people when considering relevant cognitive processes.
2) Where there is a temporal dimension, this is offloaded, so to speak, onto cultural artefacts and signifiers. While this 'ratcheting'[8] is important, it is not the whole story as far as this thesis is concerned.
3) Where these ideas have been applied in musicology (and, in fact, in general pedagogical research), this has largely been focused on *embodiment*, ignoring the other 'E's.
4) Where *musical composition* has been explored through these lenses, these same three gaps are evident.
5) 'Internality' is still seen as the *default* understanding of cognition. Theorists seem to argue 'see, this is the same as internal reasoning' as evidence for the use of an external tool or the body as part of a cognitive process. However, seeing *external* (distributed, embodied, extended) cognition as the *default*, and trying to explain

[8] Michael Tomasello, *The Cultural Origins of Human Cognition* (Cambridge, MA: Harvard University Press, 2001).

internal cognition through a bottom-up approach built from an externalist understanding could be incredibly fruitful.

Part Two breaks further conceptual ground by dealing with these issues. It does this through the proposal of the first hypothesis stated above, as a way of understanding the role of absent tools in composition, and then applying this to understanding the relationship between composer and absent performer, leading to the second hypothesis also stated above. Essentially, this second part of the thesis first argues for an understanding of the role of absent tools in the relevant cognitive processes of composition (Chapter Seven), through the development of the concept of 'Integrated Tool Competency'. This concept, and relevant research on social cognition, empathy, and the sensorimotor/ideomotor phenomenon, is then applied (Chapter Nine) to answer the question raised by *Boccherini's Body*: what is the relationship between composer and absent performer, how does it function, and what influence does it have on the creation of a musical work?[9] Another essential element of Part Two is the musical commentary (Chapters Six and Eight), which discusses the contribution of insights gained from the process of composing and recording the included portfolio.

Dissemination

The ideas developed in this thesis have been presented at six conferences:

- 'Embodied Cognition in the VLE: exploring the challenges of embodied knowledge acquisition in virtual learning environments', presented at *Future of Interdisciplinary Teaching and Learning @ The OU Online Conference* (2022, June).

- 'Integrated Tool Competency in the Compositional Process', presented at *the 57th RMA Annual Conference, Newcastle University, Newcastle* (2021, September).

- 'The Cognitive Role of Computers in the Future of Musical Composition: A Revolution in Instance or in Kind?'', presented at *RESFEST, Birmingham City University, Birmingham* (2019, July).

[9] However defined. See discussion on page 48.

- ‘A Materialist Workman Blames His Tools?’, presented at *Music, Humans and Machines, Orpheus Instituut, Ghent* (2019, June).

- ‘Towards Empathetic Embodiment’, presented *at Realities and Fantasies, Amsterdam School for Cultural Analysis, Amsterdam*. (2019, April).

- ‘Scores and Sketchbooks as Cognitive Artefacts’, presented at *CARU conference, Oxford Brookes University, Oxford* (2018, December).

The initial articulation of the ideas in Chapter Nine was published in the *Journal of Interdisciplinary Musicology* as ‘Empathetic Embodiment in the Compositional Process: A 4E Perspective on the Relationship between Composer and Performer’.[10]
A version of Chapter Seven is under review for publication in the *Journal of the Royal Musical Association* as ‘Integrated Tool Competency in Musical Composition: A 4E Perspective on the Cognitive Role of Absent Compositional Tools’.

The pieces in the portfolio have been presented at composition workshops including by the Birmingham Contemporary Music Group (BCMG) and published online.

Conclusion to the Introduction

This thesis aims, through a combination of theoretical analysis and compositional practice, to address a major concern in the study of musical composition. Understanding the impact of the relationships which composers have with the tools and technology of composition, and with the collaborators with whom they work, has the potential to not only reshape how we consider composers and the act of composition, but also how we understand creative cognition more generally. Exploring these issues through the lens of musical composition also provides unique insights into the post-Cartesian theories which underpin this research.

[10] Michael Boyle, ‘Empathetic Embodiment in the Compositional Process: A 4E Perspective on the Relationship between Composer and Performer’, *Journal of Interdisciplinary Music Studies,* 10 (2020), 59-72.

PART ONE: HINTERLANDS

CHAPTER TWO: The 4 ‘E’s, and some other letters.

The principal areas of study which feed into this thesis can be separated into three broad categories: phenomenology, ‘4E’ cognition, and musicological engagement with these theories. This first part of the thesis begins by briefly exploring writings by 20th-century phenomenologists. These demonstrate the first stirrings in Western thought of a consideration of body and world as central to thought and being – a move away from the Cartesian duality of mind and world. This is followed by an in-depth exploration of the 4 ‘E’s (embodied, embedded, enacted, and extended) of externalist theories of cognition, and the related concepts of distributed cognition and Material Engagement Theory. Chapter Two then explores empathy and social cognition and the role of tools and technology in thought, in the context of the previously discussed areas of study.

Then, in Chapter Three, the discussion moves to explicitly musical literature – exploring musicological applications of the previously discussed ideas. Firstly, musicological perspectives on imagination are explored, along with general theories of imagination. Secondly, Actor Network Theory and its application to music is discussed. Thirdly, applications of theories of mind to music are reviewed. The penultimate section introduces the important phenomenon of ‘audiation’ (or, directed musical imagery), and how various researchers have approached this. Finally, there is a section concerning composers, tools, and influence, which serves to situate the composition portfolio. This also acts as a place to include literature on or by composers or about compositional tools which does not fit elsewhere – for example, studies of compositional tools which do not take an externalist approach. While most of the compositional work considered in this thesis is that of the attached composition portfolio, there are some speculative examples of these ideas in the work of other composers, to further strengthen the *general* case for the cognitive processes of composition which the thesis is making.

Phenomenology and early post-Cartesian theorising

The seeds of much of the thinking which underpins this thesis can be found in mid-20th century phenomenology. Maurice Merleau-Ponty made significant steps towards describing the importance of the body in being, sociality, and thought.[1] Gilbert Ryle was among the first 20th century post-Cartesian philosophers. He referred to the Cartesian duality of mind and body as 'the dogma of the ghost in the machine.'[2] Lev Vygotsky, in 1962, extended the concept of mediation in human-environment interaction to the use of signs as well as 'cognitive tools', which is markedly relevant for the ideas discussed in this thesis.[3] Edmund Husserl noted that humans 'are "animate organisms", sensorially and emotionally attuned to our surroundings'.[4] Essentially: information is available for use in the environment due to an understanding of embodied engagement *with* that environment. Mark Rowlands sums up Husserl's view like this: 'Your sense of holding a bottle is made up of these anticipations of how your experience would change if you were to perform certain types of action.'[5] Martin Heidegger wrote extensively about the role of technology and objects in being and thought. Relevant essays to this thesis have been edited by David Farrell Krell into a collection with the (perhaps tongue-in-cheek) title of *Basic Writings*.[6]

Graham Harman's work, taking perspectives from Heidegger and from Bruno Latour, provides fascinating perspectives on the importance of objects in thought.[7] These ideas about the agency of objects, and the importance of networks and 'interaction', relate closely to the themes of 4E cognition, creativity, and the role of music in culture which are central to this thesis. Ingold's wide ranging essays touch on issues of bio-culturo-environmental feedback and interaction, and anthropological perspectives on phenomenological concerns relevant

[1] Maurice Merleau-Ponty, *Phénoménologie de la Perception* (Paris, FR: Éditions Gallimard, 1945).
[2] Gilbert Ryle, *The Concept of Mind* (Chicago, IL: The University of Chicago Press, 1949), 32; 35; 50.
[3] Lev Vygotsky, *Thought and Language* (Cambridge, MA: MIT Press, 1962).
[4] Harry Mallgrave, 'Enculturation, Sociality, and the Built Environment', *Architecture and Empathy*, eds. Vittorio Gallese, Juhani Pallasmaa, Harry Mallgrave, and Sarah Robinson (Tapio Wirkkala-Rut Bryk Foundation, 2015), 20-41 (29).
[5] Mark Rowlands, 'Enactivism and the Extended Mind', *Topoi*, 28, no. 1 (2009), 53–62 (55).
[6] Martin Heidegger, *Basic Writings*, ed. David Farrell Krell (London, UK: Routledge).
[7] Graham Harman, *Prince of Networks: Bruno Latour and Metaphysics* (re.press, 2009); Graham Harman, 'Technology, Objects and Things in Heidegger', *Cambridge Journal of Economics*, 34, no. 1 (2010), 17–25; Graham Harman, *Tool-Being: Heidegger and the Metaphysics of Objects* (Chicago, IL: Open Court, 2011). Latour's idea of 'Actor Network Theory' as it relates to music will be discussed later in this chapter.

here.[8] Gieser follows Ingold in seeing cultural knowledge as embodied rather than discursive, and approaches apprenticeship learning from this phenomenological approach.[9]

The link to phenomenology continues throughout much of Part One of this thesis – in fact, a large number of cited articles come from the journal *Phenomenology and the Cognitive Sciences*. Phenomenology, then, provides the basis for understanding the role of the body and tools in thought. The idea within cognitive science and philosophy of mind that cognition could be best considered as embodied, and extended through use of tools and environmental support, grew and developed through the late 90s and into the 21st century.

The scientist and educator Richard Feynman said, in an interview with Charles Weiner in 1996, that his work wasn't just done in his head: 'the paper isn't a record, not really. It's working. You have to do the work on the paper and this is the paper, okay?'[10] This could be seen to signal the turning point when externalist, post-Cartesian theories which see the mind as varyingly embodied, embedded, extended, and enacted begin to be more widely explored.[11]

While these 4 'E's - which became known collectively as '4E cognition' - often overlap or even contradict each other,[12] looking at each separately is a useful conceit for clarity's sake. They will be explored in the following order: Embodied, Embedded, Enacted, Extended; and this will be followed by sections on 'Distributed' cognition as a related and almost synonymous concept, and the concept of 'Material Engagement Theory'.

[8] Tim Ingold, *The Perception of the Environment: Essays on Livelihood, Dwelling and Skill* (London, UK: Routledge, 2000).
[9] Thorsten Gieser, 'Embodiment, Emotion and Empathy: A Phenomenological Approach to Apprenticeship Learning,' *Anthropological Theory*, 8, no. 3 (2008), 299–318.
[10] James Gleick, *Genius: The Life and Science of Richard Feynman* (California: California Institute of Technology Press, 1992), 409.
[11] For a useful overview, see Mark Rowlands, *The New Science of the Mind: From Extended Mind to Embodied Phenomenology*, (Cambridge, MA: MIT Press, 2010).
[12] Julian Kiverstein and Andy Clark, 'Introduction: Mind Embodied, Embedded, Enacted: One Church or Many?' *Topoi*, 28 (2009), 1–7.

Embodied Cognition

Theories of embodied cognition argue that 'cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and [these] are themselves embedded in a more encompassing biological, psychological, and cultural context.'[13] George Lakoff's and Mark Johnson's seminal book, following the latter's *The Body in the Mind,* shows how much of a challenge the embodied view is to a whole range of established modes of thinking about the mind.[14] As Lawrence Shapiro argues: 'Flesh matters'.[15] Shapiro's *Embodied Cognition* further shows how embodied cognition departs from 'standard' cognitive science.[16] Anthony Chemero has also discussed the radical nature of embodiment as a means to understand cognition.[17] For a collection of seminal essays on embodied cognition, see Shapiro's Routledge Companion.[18] For the purposes of this thesis, an understanding of embodied cognition is primarily useful as a pre-requisite for interaction with tools and the environment, and also as a basis for understanding social cognition and empathy, rather than as a theory of the cognitive processes of musical composition in its own right. However, of all the 'post-Cartesian' areas of study relevant to this thesis, embodiment is the one which has had the biggest impact on musicology, and so is also important from that perspective. Considering both its use in wider theorising, and its impact on musicology, embodied cognition is explored in depth here.

Francisco J. Varela, Evan Thompson, and Eleanor Rosch demonstrate how enacted, embodied cognition links to various schools of thought, again showing the link between embodied cognitive science and phenomenology.[19] Andy Clark's *Supersizing the Mind* also shows how an embodied understanding of cognition links to other 'Es'.[20] Shaun Gallagher's *How the Body Shapes the Mind* explores gesture, the body schema (a concept that will return

[13] Francisco J. Varela, Evan Thompson, and Eleanor Rosch, *The Embodied Mind, revised edition: Cognitive Science and Human Experience* (Cambridge, MA: MIT Press, 2017), 173.
[14] George Lakoff and Mark Johnson, *Philosophy in The Flesh: The Embodied Mind and its Challenge to Western Thought* (New York, NY: Basic Books, 1999); Mark Johnson, *The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason* (Chicago, IL: University of Chicago Press, 1990).
[15] Lawrence Shapiro, 'Flesh Matters: The Body in Cognition', *Mind & Language*, 34, no. 1 (2019), 3–20.
[16] Lawrence Shapiro, *Embodied Cognition* (London, UK: Routledge, 2019).
[17] Anthony P. Chemero, *Radical Embodied Cognitive Science* (Cambridge, MA: MIT Press, 2011).
[18] Lawrence Shapiro, *The Routledge Handbook of Embodied Cognition*. (London, UK: Routledge, 2014).
[19] Varela, Thompson, and Rosch, *The Embodied Mind*.
[20] Andy Clark, *Supersizing the Mind: Embodiment, Action, and Cognitive Extension* (Oxford: Oxford University Press, 2008c).

later) and the interactive nature of mind.[21] These books show how embodiment is often taken as a departure point for understanding the role of other things external to the 'mind' in cognition, supporting the approach taken in this thesis.

Antoni Gomila and Paco Calvo have argued for an integration of embodied understandings of the mind and cognitive science.[22] Julian Kiverstein and Mark Miller also argue for an embodied approach to neuroscience, claiming that looking at only specific parts of the brain without taking into full account the wider organism is an error.[23] As Shapiro argues in *Embodied Cognition*, these links to empirical science are important, as they provide further weight to the thesis that the body constitutes part of the mind.

George Lakoff and Rafael Núñez's exploration of mathematics and the embodied mind is important for this project, as mathematics and music are so linked, in process and often in public perception, and the spatial metaphors inherent to both are important to understand.[24] We are, after all, spatial, bodily creatures, good at frisbee but bad at logic.[25] Other studies of specific creative acts in terms of embodiment include Sarah Robinson and Juhani Pallasmaa's study of how embodied understandings of cognition, backed up by neuroscientific developments, might impact the future of architectural design.[26] Peter Garratt's *Embodied Mind in Literature and Culture* is interesting from the perspective of applications of these theories to creativity and the impacts of creative output on wider culture.[27] This idea of a

[21] Shaun Gallagher, *How the Body Shapes the Mind*. (Gloucester, UK: Clarendon Press, 2006).
[22] Antoni Gomila and Paco Calvo, 'Directions for an Embodied Cognitive Science: Toward an Integrated Approach', *Handbook of Cognitive Science*, ed. Paco Calvo & Antoni Gomila (London, UK: Elsevier, 2008), 1-25.
[23] Julian Kiverstein and Mark Miller, 'The Embodied Brain: Towards a Radical Embodied Cognitive Neuroscience', *Frontiers in Human Neuroscience*, 9 (2015).
[24] George Lakoff and Rafael E. Núñez. *Where Mathematics Come From: How the Embodied Mind Brings Mathematics into Being* (New York, NY: Basic Books, 2000); see also Stanislas Dehaene, *The Number Sense: How the Mind Creates Mathematics, Revised and Updated Edition* (Oxford: Oxford University Press, 2011); Rafael Núñez, 'Mathematical Idea Analysis: What Embodied Cognitive Science Can Say about the Human Nature of Mathematics', *Proceedings of the Conference of the International Group for the Psychology of Mathematics Education* (2000). https://eric.ed.gov/?id=ED466734; Rafael Núñez, 'Do Real Numbers Really Move? Language, Thought, and Gesture: The Embodied Cognitive Foundations of Mathematics', *18 Unconventional Essays on the Nature of Mathematics*, ed. Reuben Hersh (London, UK: Springer, 2006), 160-181.
[25] Andy Clark, *Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence* (Oxford: Oxford University Press, 2004), 5; 75.
[26] Sarah Robinson and Juhani Pallasmaa, *Mind in Architecture: Neuroscience, Embodiment, and the Future of Design*. (Cambridge, MA: MIT Press, 2015). See also Juhani Pallasmaa, *The Thinking Hand: Existential and Embodied Wisdom in Architecture* (Oxford: John Wiley & Sons, 2009).
[27] Peter Garratt, (2016), *The Cognitive Humanities: Embodied Mind in Literature and Culture*, (London, UK: Springer, 2016).

feedback loop between mind and world is one which 4E theories consistently return to, and one which is essential to the arguments made in this thesis.

Alva Noë demonstrates the biological underpinnings of why we are 'not our brains.'[28] Again, it is important to point out that the idea that cognition is profoundly embodied appears to be largely backed up by empirical studies. These productive links between science and philosophy have been a crucial aspect of research into 4E cognition. For example, Somogy Varga and Detlef Heck (a philosopher and a neurobiologist respectively) show how an understanding of respiration has implications for the embodied cognition model. They argue that their specific example of how *respiration* influences cognition, in a bottom-up way through modulating neural synchronisation in specific cognitive processes, may function as a *general* model for how the body influences cognitive processes.[29] As an aside, anyone reading this thesis will likely be interested to know (or may well already know) that when people sing together in choirs, their heartbeats synchronise.[30]

Michelle Maiese demonstrates not just the importance of embodiment in cognition, but of *emotion* as a regulating factor – something born out in empirical psychology.[31] She argues that understanding is always partially 'constituted and informed' by 'needs, interests, and desires'.[32] This 'affective framing', for Maiese, is the selection of a 'handful of sand to call the world. This 'caring contoured map' allows the harnessing of motivation in support of various cross-temporal behavioural tasks.[33] She argues that the embodied nature of this phenomenon is that 'feelings of bodily "grabbiness" such as heart rate focus our attention.'[34] Georg Northoff also discusses emotions and appraisal from an embodied perspective.[35]

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[28] Alva Noë, *Out of Our Heads: Why You Are Not Your Brain, and Other Lessons From the Biology of Consciousness* (New York, NY: Hill & Wang, 2009).
[29] Somogy Varga and Detlef H. Heck, 'Rhythms of the Body, Rhythms of the Brain: Respiration, Neural Oscillations, and Embodied Cognition', *Consciousness and Cognition,* 56 (2017), 77-90.
[30] Björn Vickhoff, Helge Malmgren, Rickard Åström, Gunnar Nyberg, Seth-Reino Ekström, Mathias Engwall, Johan Snygg, Michael Nilsson, and Rebecka Jörnsten. "Music structure determines heart rate variability of singers." *Frontiers in psychology* 4 (2013): 334. What this means for how choristers *think* about the music being sung is perhaps something to be explored in a future study.
[31] Michelle Maiese, *Embodiment, Emotion, and Cognition* (London, UK: Springer, 2010).
[32] Ibid., 119.
[33] Ibid., 120.
[34] Ibid. 139. This relates again to the choristers' heartbeat synchronicity described by Björn Vickhoff et al.
[35] Georg Northoff, 'Is Appraisal 'Embodied' and 'Embedded'? A Neurophilosophical Investigation of Emotions', *Journal of Consciousness Studies*, 15, no. 5 (2008), 68–99.

Cedric Galetzka further discusses how meaning-making and the answers to the problems of meaning-making can be found in embodied cognition.[36]

In pedagogy, embodiment is widely studied. Iris Laner has explored the links between phenomenology and enacted/embodied cognition, and the impacts this might have on understanding how people engage with ideas.[37] Denis Francesconi and Massimiliano Tarozzi have similarly explored the intersection of phenomenology and embodied cognition in pedagogy.[38] Mia Perry and Carmen Medina have explored the potentials of embodiment for general pedagogy.[39] Núñez and colleagues have also discussed how the embodied nature of mathematics is important for mathematical pedagogy.[40] Prajakt Pande also proposes an extended model for understanding external representations in science.[41] Lin Zhu has explored the importance of embodiment for translation education.[42] This can be linked to Shapiro's exploration of linguistics as influencing thought about embodiment. Wayne Bowman has argued that 'when the learner experiences motion, timbre, and rhythm, sense, perception, action, and conception are mutually informative, and structurally linked to one another.'[43] This is particularly clear when exploring an explicitly physical topic such as musical performance.

Martha Alibali and Mitchell Nathan have observed the use of gestures by learners when approaching a new mathematical concept, before they are able to articulate it.[44] They demonstrate how students often point to the specific numbers within an equation when

[36] Cedric Galetzka, 'The Story So Far: How Embodied Cognition Advances Our Understanding of Meaning-Making', *Frontiers in Psychology*, 8, 1315 (2017). See also Robert A. Wilson, 'Meaning Making and the Mind of the Externalist', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 167-188.
[37] Iris Laner, 'Reflective Interventions: Enactivism and Phenomenology on Ways of Bringing the Body into Intellectual Engagement', *Phenomenology and the Cognitive Sciences*, 20, no. 3 (2021), 443–461.
[38] Denis Francesconi and Massimiliano Tarozzi, 'Embodied Education: A Convergence of Phenomenological Pedagogy and Embodiment', *Studia Phaenomenologica*, 12 (2012), 263–288.
[39] Mia Perry and Carmen Medina, 'Embodiment and Performance in Pedagogy Research: Investigating the Possibility of the Body in Curriculum Experience', *Journal of Curriculum Theorizing*, 27, no. 3 (2011), 3.
[40] Rafael Núñez, R. E., Edwards, L. D., & Filipe Matos, J. (1999). Embodied cognition as grounding for situatedness and context in mathematics education. *Educational Studies in Mathematics*, *39*(1), 45–65.
[41] Prajakt Pande, 'Learning and Expertise with Scientific External Representations: An Embodied and Extended Cognition Model', *Phenomenology and the Cognitive Sciences*, 20 (2020), 463-482.
[42] Lin Zhu, 'An Embodied Cognition Perspective on Translation Education: Philosophy and Pedagogy', *Perspectives*, 26, no. 1 (2018), 135–151.
[43] Wayne Bowman, 'Cognition and the Body: Perspectives from Music Education', *Knowing Bodies, Moving Minds.* (Dordrecht: Springer, 2004), 29-50 (36); see also Andrea Schiavio and Dylan van der Schyff, '4E Music Pedagogy and the Principles of Self-Organization', *Behavioral Sciences* 8, no. 8 (2018), 72.
[44] Martha Alibali and Mitchell Nathan, 'Embodiment in Mathematics Teaching and Learning: Evidence from Learners' and Teachers' Gestures', *Journal of the Learning Sciences,* 21 (2012), 247 - 286.

explaining their answer. This allows for intervention by the instructor, as it shows how the student has derived the answer. David Tall has explored the use of computer programs that allow visual representations to be manipulated through sight and hand-movement. He found that students normally intimidated by complex, subtle mathematical concepts spontaneously engaged in discussion of their intricacies.[45] These two studies of mathematics show the pedagogical implications of creating an embodied link between a problem and its solution, and the potential of digital technology for this purpose. One of the potential impacts of this thesis is on how we should consider compositional pedagogy, something supported by these examples from mathematics.

Embedded Cognition

The term 'Embedded Cognition' groups theories which see cognition as *embedded* in the environment. Terms such as 'scaffolding' are also relevant. J. Kevin O'Regan in 1992 discussed the world as an 'outside memory' when perceiving visual information, which is an early 'embedded' account of memory.[46] John Haugeland wrote in 1993 about cognition as embodied and embedded (these two 'Es' are often connected).[47] An early paper in the field of artificial cognition is Kirsh's 'the intelligent use of space', which has become a seminal text when considering embodied/embedded approaches to understanding cognition.[48] If the tools of composition are not just means to record existing thoughts, but have a part to play in forming those thoughts, this has ramifications for how we understand musical creativity and the environments in which this creativity takes place.

Joel Krueger explores the role of music *as* a tool, as a means of scaffolding various experiences, especially emotional consciousness.[49] He argues that the affordances which music grants mean that acts of musicking grant access to novel emotional experiences. This article is useful for two reasons. Firstly, it is focused on music, in contrast to the largely

[45] David Tall, 'Using Technology to Support an Embodied Approach to Learning Concepts in Mathematics', paper presented at a Summer School at Nafplion, Greece (2003).
[46] J. Kevin O'Regan, 'Solving the 'Real' Mysteries of Visual Perception: The World as an Outside Memory', *Canadian Journal of Psychology/Revue Canadienne de Psychologie*, 46, no. 3 (1992), 461–488.
[47] John Haugeland, 'Mind Embodied and Embedded', *Mind and Cognition: 1993 International Symposium,* eds. Yu-Houng H. Houng and J. Ho (Nanking, Academica Sinica, 1993), 233-267.
[48] David Kirsh, 'The Intelligent Use of Space', *Artificial Intelligence*, 73, no. 1 (1995), 31–68.
[49] Joel Krueger, 'Affordances and the Musically Extended Mind', *Frontiers in Psychology*, 4 (2014).

extramusical literature explored in this chapter. Secondly, it focuses on the concept of 'affordance'. Affordance is an important concept for the ideas discussed here. James Gibson proposed the concept in the mid-20th century, crystalising the argument in 1979.[50] He argued that 'the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. […. Affordance] refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment.'[51] In 4E approaches to cognitive science, the term is often used to discuss specifically *cognitive* affordances found in the external world.

Tarja Knuuttila discusses the role of the extended /embedded mind in scientific models, and the role of imagination (and conceptions of imagination) and fiction in these models.[52] He argues that

> '[t]he imaginary accounts focusing on imagined-objects are bound to approach modelling as a primarily mental activity, and the activity of using external representational means as that of merely (partially) describing the mental content of scientists. In contrast, the artifactual account renders visible how the characteristics of the various representational tools used in model construction enable and shape scientific imagination, also delimiting what can be thought of.'

For Knuuttila, then, tools are influencing the scientific imagination, just as the scientific imagination is developing the tool. This is a co-constitutive feedback loop the likes of which are discussed later in this chapter. The distinction here between 'real' and 'imagined' objects is an interesting one, and when it comes to real and imagined *musical* objects, this thesis will perhaps show how the real and imagined versions of these objects interact.

Wheeler's book, *Reconstructing the Cognitive World,* breaks down the paradigm shift in the cognitive sciences caused by externalist accounts of the mind.[53] He combines analysis of Heidegger with embodied and embedded approaches to understanding cognition, including

[50] James Gibson, *The Ecological Approach to Visual Perception* (Boulder, CA: Taylor & Francis, 1979).
[51] Ibid., 127.
[52] Tarja Knuuttila, 'Imagination Extended and Embedded: Artifactual Versus Fictional Accounts of Models', *Synthese*, 198 (2017), 5077-97.
[53] Michael Wheeler, *Reconstructing the Cognitive World: The Next Step* (Cambridge, MA: MIT Press, 2005).

exploring debates as to whether cognition is computation or not. He also uses examples from AI research, which - as is noted throughout this thesis - is an area which has provided much food for thought when it comes to post-Cartesian theorising about the constitution of the mind. For Wheeler, Heideggerian analysis is a 'conceptual glue' that is particularly useful when discussing externalist theories of the mind. This has certainly proven true in thinking through the concepts contained in this thesis.

Kim Sterelny argues for a niche construction model as a useful model for understanding interaction with mind and world, with extended mind as a limited case of these niches.[54] Michael Wheeler and Clark further explore cognitive niche construction.[55] Karola Stotz similarly argues that people construct cognitive-developmental 'niches'.[56] Pim Haselajer and colleagues take a cognitive neuroscience approach to understanding how the brain makes use of its body and environment.[57] As Clark puts it, we build worlds to think in.[58] Laura Malinin's focus on place in a 4E context, especially in terms of creativity, is also useful for the ideas discussed in this thesis.[59] She observes that architectural settings are often designed with creativity in mind (for example office spaces, meeting rooms, libraries), This can be applied to thus situating 'the composer' in 'place'. Musical creativity, as this thesis will argue, does not just take place in a cognitively useful environment, but changes and develops that environment so that it is a better place in which to create music. The concept developed in this thesis, that this re-configures the competencies of composers (i.e., that this embeddedness has impact through time, and not just through the continued existence of re-configured environments) builds on these studies, which largely focus on the present.

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[54] Kim Sterelny, 'Social Intelligence, Human Intelligence and Niche Construction', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 362, no. 1480 (2007), 719-730. The link to social cognition here is interesting and will become relevant later. For an evolutionary perspective, see also Kim Sterelny, 'Thought in a Hostile World: The Evolution of Human Cognition', *Philosophy and Phenomenological Research*, 74, no. 2 (2007), 476–497. For a related study regarding extreme environments influencing creativity, see Kathryn Hays, Cris Kubli, and Roger Malina, 'Creativity and Cognition in Extreme Environments: The Space Arts as a Case Study', *Frontiers in Psychology*, 11 (2020).

[55] Michael Wheeler and Andy Clark, 'Culture, Embodiment and Genes: Unravelling the Triple Helix', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363, no. 1509 (2008), 3563–3575.

[56] Karola Stotz, 'Human Nature and Cognitive-Developmental Niche Construction', *Phenomenology and the Cognitive Sciences*, 9, no. 4 (2010), 483–501.

[57] Pim Haselager, Jelle van Dijk, Iris van Rooij, 'A Lazy Brain? Embodied Embedded Cognition and Cognitive Neuroscience', *Handbook of Cognitive Science*, ed. Paco. Calvo & Antoni Gomila (London, UK: Elsevier, 2008), 273-290.

[58] Clark, *Natural-Born Cyborgs*, 59.

[59] Laura H. Malinin, 'Creative Practices Embodied, Embedded, and Enacted in Architectural Settings: Toward an Ecological Model of Creativity', *Frontiers in Psychology*, 6 (2016). See also Laura H. Malinin, 'How Radical Is Embodied Creativity? Implications of 4E Approaches for Creativity Research and Teaching', *Frontiers in Psychology*, 10 (2019).

Enacted Cognition

Enacted cognition refers to the idea that agents 'think through doing'. In reference to visual perception, O'Regan and Noë argue that 'seeing is not a simple occurrence; it is a rich, exploratory activity within a certain environment and with certain sensory apparatus, drawing on a number of heterogeneous capacities.'[60] Essentially, seeing is not a passive experience, but an *enacted* process of interaction with the world. In their following paper, the argument is simplified further. 'Seeing is something we *do*, not something that happens in our brains (even though, of course, a lot goes on in the brain when we see).'[61] Noë further explores the importance of action in perception, arguing that (and this relates to Rowland's reading of Husserl cited above) '[o]ur relation to the unseen bits of [an object] is mediated by patterns of sensorimotor contingency.'[62] 'To encounter its visual potential is thus to encounter its actual shape.'[63] The idea that perception is something active and engaged with the full embodied being of the agent in question is important,[64] especially when we consider, in Part Two of this thesis, what influence those sensorimotor experiences might have on *future* cognitive processes.

While O'Regan and Noë focus on visual perception, enacted cognition perspectives have been applied to many areas of study. Brian Irwin draws on ideas from Merleau-Ponty to create an enactivist account of abstract words as affordances for action.[65] Cuffari discusses narrative, embodiment and enaction.[66] Rachel Wood and Susan Stuart discuss mirror neurons, enactivism, and the phenomenon of phantom limbs – they advance the idea that there is a link between self-other mappings (the role of mirror neurons most commonly discussed) and the persistence of the subjective experience of part of the body that is no longer objectively there

[60] J. Kevin O'Regan and Alva Noë, 'A Sensorimotor Account of Vision and Visual Consciousness', *Behavioral and Brain Sciences,* 24, no. 5 (2001), 939-1031. See also Joel Krueger, 'Seeing Mind in Action', *Phenomenology and the Cognitive Sciences,* 11, no. 2 (2012), 149–173.
[61] J. Kevin O'Regan and Alva Noë, 'What is it Like to See: A Sensorimotor Theory of Perceptual Experience', *Synthese,* 129, no. 1 (2002), 79-103 (80). My own emphasis.
[62] Alva Noë, *Action in Perception* (Cambridge, MA: MIT Press, 2004), 67.
[63] Ibid., 63.
[64] A very clear (and unconscious) example is that of 'saccades', or the rapid movements the eye makes to effectively perceive a scene when not tracking a moving object.
[65] Brian A. Irwin, 'An Enactivist Account of Abstract Words: Lessons from Merleau-Ponty. *Phenomenology and the Cognitive Sciences,* 16, no. 1 (2017), 133–153.
[66] Elena Cuffari, 'Gestural Sense-making: Hand Gestures as Intersubjective Linguistic Enactments', *Phenomenology and the Cognitive Sciences,* 11, no. 4 (2012), 599–622; Elena Cuffari, 'Yanna B. Popova, Stories, Meaning, and Experience: Narrativity and Enaction', *Phenomenology and the Cognitive Sciences,* 16, no. 1 (2017), 181–185.

– an important link to *absence* which will become important in Part Two of the thesis.[67] Evan Thompson and Mog Stapleton discuss the differences between enactive and extended approaches to sense-making, and, importantly, the difference between incorporation and extension in the body-mind-environment relation.[68]

The sensorimotor and ideomotor phenomena mentioned in this section will be explored in more depth in the Part Two of the thesis, where they become markedly relevant to understanding how composers might integrate tools into their cognitive competencies. There are also numerous enacted cognition approaches to understanding social cognition and empathy, which will be explored in the upcoming section.

Extended Cognition

The extended mind hypothesis – which argues that parts of the world can constitute parts of mental processes – is essential for the approach this thesis is taking. The extended mind hypothesis was initially made by Andy Clark and David Chalmers in their seminal article, 'The Extended Mind'. They include a thought experiment, about Otto, who has Alzheimer's disease, and Inga, who does not. Both Otto and Inga wish to get to a museum. Inga thinks for a moment, remembers the route to the museum, then goes to the museum. Otto instead uses a notebook, where he has written down the route to the museum. He checks the notebook for a moment, then goes to the museum. Their argument is that when an external object, such as a notebook, functions in the same way as a process inside the head, it should be considered equally cognitive. That is, Otto checking his notebook for a moment should be considered as equally cognitive as Inga thinking for a moment. This example of Otto and Inga (outside and inside), leads to the 'parity principle': '[i]f, as we confront some task, a part of the world functions as a process which, *were it done in the head*, we would have no hesitation in recognizing as part of the cognitive process, then that part of the world *is* (so we claim) part of the cognitive process.'[69] Susan Hurley rightly argues that there are many varieties of

[67] Rachel Wood and Susan A. J. Stuart, 'Aplasic Phantoms and the Mirror Neuron System: An Enactive, Developmental Perspective', *Phenomenology and the Cognitive Sciences*, 8, no. 4 (2009), 487–504; See also Marc Jeannerod, *The Cognitive Neuroscience of Action*, (London, UK: John Wiley & Sons, 1997).
[68] Evan Thompson and Mog Stapleton, 'Making Sense of Sense-Making: Reflections on Enactive and Extended Mind Theories', *Topoi*, 28, no. 1 (2009), 23–30.
[69] Andy Clark and David Chalmers. 'The Extended Mind', *Analysis* 58, no. 1 (1998): 7–19 (14).

externalism,[70] and all are somewhat relevant for this thesis, but perhaps extended cognition is the most important.

Clark has continually developed the ideas found in 'The Extended Mind', always with a focus on technology.[71] Richard Menary later edited a collection of essays, including ones critical of the Extended Mind thesis.[72] In one of these essays, John Sutton looks at exograms (external symbols) and the 'civilising process' in the context of the extended mind. He posits that these symbols live cognitive lives, with histories of being part of minds. As part of the article, he contrasts two 'waves' of Extended Cognition and points to a third.[73] It is worth taking a moment to discuss these three 'waves' of the extended cognition hypothesis. Kevin Ryan and Andrea Schiavio describe the three waves as follows:[74]

The first wave:

> focuses on 'functionalist accounts of mind that held that the body and environment may be a constitutive part of cognition insofar as they play the right sorts of functional role for the cognitive.' This is the version posited by Clark and Chalmers as discussed above, and still provides the foundation for thinking about extended cognition.

The second wave:

> focuses on 'how external objects and processes internal to the organism can be integrated without necessarily postulating an inherent isomorphism between internal and external'.[75] Essentially the second wave progresses the 'parity principle' and acknowledges that external and internal processes may be considered to function differently, or take on different roles, without denying *either* process its rightful place in the consideration of 'the cognitive'.

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[70] Susan Hurley, 'The Varieties of Externalism', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 101-153.
[71] Andy Clark, *Natural-Born Cyborgs;* Andy Clark, *Supersizing the Mind;* Andy Clark, 'Memento's Revenge: The Extended Mind, Extended', *The Extended Mind,* ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 43-66; Andy Clark, 'Finding the Mind', *Philosophical Studies*, 152, no. 3 (2011), 447–461.
[72] Richard Menary, *The Extended Mind* (Cambridge, MA: MIT Press, 2010a).
[73] John Sutton, 'Exograms and Interdisciplinarity: History, the Extended Mind, and the Civilizing Process', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 189-225.
[74] Ryan and Schiavio, 'Extended Musicking, Extended Mind, Extended Agency', 9-10.
[75] Note that these integrations are integrations of *present* objects.

And the third wave:

> focuses on 'the specific dynamics and temporal components that were lacking in many examples in the first two waves.' The dynamic, recursive nature of cognition is implied by much work in 4E cognition, but the third wave of extended cognition perhaps moves that to the forefront.

So, just as there are four overlapping 'E's within the externalist pantheon, within the extended mind debate there are at least three overlapping waves of thought. The third wave is the first place where attempts to discuss the *temporality* of cognitive extension are being made, and the focus on *absence* in this thesis could be a valuable contribution to this line of thinking, which still argues for cultural objects (and the changes an agent might make to those objects which then remain through time) and scaffolding (similar to embedded approaches and MET, which will be discussed later) as the primary form that this temporality takes. There is also a thread of *agency* running through 2nd and 3rd wave approaches, and this might deal with the issue of distinction between the conscious agent and the various things and processes they might use and integrate through their cognitive lives.

Terry Horgan and Uriah Kriegel explore the phenomenological roots of the extended mind, further demonstrating the links between these mid-20th century ideas and the 4E theories which have so impacted cognitive science.[76] Importantly, they discuss *intent* as a crucial aspect of using external tools in cognition. This links with an argument made by Bruno Latour, whose Actor Network Theory will be discussed later, that we 'retain cognitive competencies only when we subscribe to the relevant equipment.'[77] The importance which intent might play in these concepts will also be discussed at various other points in this thesis.

Fred Adams and Ken Aizawa are prominent critics of 4E approaches, especially the extended mind thesis.[78] Their arguments, and responses by Andy Clark and others, have produced

[76] Terry Horgan and Uriah Kriegel, 'Phenomenal Intentionality Meets the Extended Mind', *The Monist, 91*, no. 2 (2008), 347–373.
[77] Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory*, (Oxford: Oxford University Press, 2005), 210. Latour sadly passed away just before the submission of this thesis. His work will no doubt continue to have a substantial impact on the actor-networks of politics, philosophy, and science; and his influence on how I think about things (in both meanings of that phrase), even when not explicitly stated in this document, cannot be understated.
[78] Ken Aizawa, 'Clark on Language, Cognition, and Extended Cognition', *Andy Clark and His Critics,* ed. Matteo Colombo, Elizabeth Irvine, & Mog Stapleton (Oxford: Oxford University Press, 2019), 32-43; Fred

valuable insights into what might constitute the mind. These and other critical responses were collated in a book, *Andy Clark and His Critics*.[79] Adams and Aizawa argue that there is a coupling-constitution fallacy, that 'we cannot assume that casually coupling a process X to cognitive process Y is sufficient to make X a cognitive process'[80]. This is answered by Clark,[81] and Don Ross and James Ladyman.[82] Effectively the responses argue that the important claim of the extended mind thesis is not that external things can be cognitive in their own right, but that external things can form *part* of the cognitive process in question – that they can in certain circumstances be considered as a *constituent part* of that process in the same way that we would have no problem considering neurons in the brain as *part* of those processes. Adams has made further criticism of embodied cognition.[83] See also a more personal response to the implications of the extended mind by Don Ihde, who 'doesn't want to be a cyborg'.[84] David Ludwig's account of extended cognition is also a critical one – he argues that by counting external resources as cognitive, suddenly everyone 'knows' everything on Wikipedia.[85] Proponents of the extended mind hypothesis would likely respond that it is the permanence, accessibility, and possibility of interaction with (or lack thereof) a given repository of knowledge which would tip the scales in favour of it being 'known' or not. This relates to Richard Menary's response to Adams/Aizawa's criticism of the extended mind, where he argues that 'it is not the notebook that is important, it is Otto's capacity to write down and retrieve information as written sentences that matters. This might be in a

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Adams, 'Embodied Cognition', *Phenomenology and the Cognitive Sciences*, 19, no. 4 (2010), 619-628; Fred Adams and Ken Aizawa, 'The Value of Cognitivism in Thinking about Extended Cognition', *Phenomenology and the Cognitive Sciences*, 9, no. 4 (2010b), 579–603; Zed Adams and Chauncey Maher, 'Cognitive Spread: Under What Conditions Does the Mind Extend Beyond the Body?', *European Journal of Philosophy*, 23, no. 3 (2015), 420–438.

[79] Matteo Colombo, Elizabeth Irvine, & Mog Stapleton, *Andy Clark and His Critics* (Oxford: Oxford University Press, 2019).

[80] Fred Adams and Ken Aizawa, 'Defending the Bounds of Cognition', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010a), 67–81.

[81] Andy Clark, 'Coupling, Constitution, the Cognitive Kind: A Reply to Adams and Aizawa. *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 81-99. Clark also defended the extended mind in Andy Clark, 'Curing Cognitive Hiccups: A Defense of The Extended Mind', *The Journal of Philosophy*, 104 (2007), 163–192.

[82] Don Ross and James Ladyman, 'The Alleged Coupling-Constitution Fallacy and Mature Sciences', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 155–166.

[83] Fred Adams, 'Embodied Cognition', *Phenomenology and the Cognitive Sciences*, 19, no. 4 (2010), 619-628.

[84] Don Ihde, 'Aging: I don't want to be a cyborg!', *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008), 397–404.

[85] David Ludwig, 'Extended Cognition and the Explosion of Knowledge', *Philosophical Psychology*, 28, no. 3 (2015), 355–368.

notebook, or it might be in some other medium.'[86] This last argument relates to the concepts of affordance and intent discussed elsewhere in this chapter.

John Preston discusses the question of epistemic credit in the extended mind thesis – if objects form part of a cognitive process, do they take 'credit' for knowledge produced?[87] Similarly, when talking about responsibility, Mason Cash argues that in an extended mind context 'individuals are merely one of many possible loci of cognition action and responsibility.'[88] The question of to what degree the objects involved in musical creativity should be considered *responsible* for its process and results is certainly raised by the ideas discussed in this thesis, so it is important to note that these ideas have been tackled by the above articles. There are also numerous studies on more substantial ethical dilemmas raised by the extended mind thesis, which are only tangentially relevant here.[89]

Menary has explored how the manipulation and creation of written vehicles is part of our cognition and memory.[90] Dirk Van Hulle's work in literature studies, specifically on Beckett from a 'post-cognitivist' approach, and on the extended mind and drafts (including how characters understand these processes) is useful in that they show how these approaches can both illuminate and be illuminated by a study of a specific art form, and how those artforms

[86] Richard Menary, 'The Holy Grail of Cognitivism: A Response to Adams and Aizawa', *Phenomenology and the Cognitive Sciences*, 9, no. 4 (2010b), 605–618 (610).
[87] John Preston, 'The Extended Mind, the Concept of Belief, and Epistemic Credit', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010a), 355-369.
[88] Mason Cash, 'Extended Cognition, Personal Responsibility, and Relational Autonomy. *Phenomenology and the Cognitive Sciences*, 9, no. 4 (2010), 645–671.
[89] Adam Carter and Orestis Palermos, 'Is Having Your Computer Compromised a Personal Assault? The Ethics of Extended Cognition', *Journal of the American Philosophical Association*, 2, no. 4 (2016), 542–560; Richard Heersmink, 'Extended Mind and Cognitive Enhancement: Moral Aspects of Cognitive Artifacts', *Phenomenology and the Cognitive Sciences*, 16, no. 1 (2017b), 17–32; Pierre Cassou-Noguès, 'The Social Impact and the Intrusive Dimension of Enhancement', *Phenomenology and the Cognitive Sciences*, 16, no. 1 (2017), 75–89; John Protevi, 'Affect, Agency and Responsibility: The Act of Killing in the Age of Cyborgs,' *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008), 405–413; Daniel Qaurooni and Hamid Ekbia, 'The "Enhanced" Warrior: Drone Warfare and the Problematics of Separation. *Phenomenology and the Cognitive Sciences*, 16, no. 1 (2017), 53–73; Jan-Hendrik Heinrichs, (2020) 'Artificial Intelligence in Extended Minds: Intrapersonal Diffusion of Responsibility and Legal Multiple Personality', *Technology, Anthropology, and Dimensions of Responsibility*, ed. Birgit Beck and Michael Kühler (Stuttgart, DL: J.B. Metzler, 2020), 159-176; F. Allan Hanson, 'The Anachronism of Moral Individualism and the Responsibility of Extended Agency', *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008), 415–424.
[90] Richard Menary, 'Writing as Thinking', *Language Sciences*, 29, no. 5 (2007), 621–632. It is interesting to consider Linda Flower and John Richard Hayes, 'A Cognitive Process Theory of Writing', *College Composition and Communication*, 32, no. 4 (1981), 365–387; which was published a quarter of a century earlier, as anticipating these ideas.

can integrate them.[91] In *Modern Manuscripts* he explores the development of literary texts through the lens of the extended mind, showing how marginalia and revisions can be seen as cognitive interaction with paper during the creative process.[92] He has also focused on digital editing, which could be productively applied to understanding musical notation software.[93] Along with Nixon he discusses the creative function of Samuel Beckett's extensive influences.[94] This could be related to musical work such as Luciano Berio's Sinfonia,[95] and is interesting from the perspective of influence and intertextuality. He further explores the 'work in progress' in the work of James Joyce.[96] Marcelle Frieman has also explored these ideas.[97] These papers show the importance of drafting, revision, the material with which the writer works. Applying cognitive research to a creative writing disciplinary approach can 'make visible' the experience, even the mind, of the writer-at-work. This closely relates to the approach that this thesis is taking.

Distributed Cognition

Distributed cognition could be seen as synonymous with embedded cognition; but distributed perhaps implies not just *scaffolding* but *constituting*. An embedded account might be something like 'the mind makes use of environmental support to ease the cognitive load of certain tasks', and a distributed account something like 'the cognitive processes of certain tasks are distributed across the environment'. This is not as radical as the extended mind claim above, but certainly goes further than the embedded argument.[98] Edwin Hutchin's *Cognition in the Wild* is one of the earliest works which point towards this stage of externalist

[91] Dirk Van Hulle, 'The Extended Mind and Multiple Drafts: Beckett's Models of the Mind and the Postcognitivist Paradigm', *Samuel Beckett Today / Aujourd'hui*, 24, no. 1 (2012), 277–290.
[92] Dirk Van Hulle, *Modern Manuscripts: The Extended Mind and Creative Undoing from Darwin to Beckett and Beyond* (London, UK: Bloomsbury, 2020).
[93] Dirk Van Hulle, 'The Stuff of Fiction: Digital Editing, Multiple Drafts and the Extended Mind', *Textual Cultures*, 8, no. 1 (2013), 23–37.
[94] Dirk Van Hulle and Mark Nixon, *Samuel Beckett's Library*. (Cambridge, UK: Cambridge University Press, 2013).
[95] Luciano Berio, *Sinfonia, for orchestra and eight amplified voices* (1968-69). Not least because Beckett is quoted in the piece!
[96] Dirk Van Hulle, *James Joyce's 'Work in Progress': Pre-Book Publications of Finnegans Wake Fragments*. (London, UK: Routledge, 2016).
66[97] Marcelle Freiman, 'The Art of Drafting and Revision: Extended Mind in Creative Writing', *New Writing*, 12, no. 1 (2015), 48–66.
[98] For a similar discussion see Kim Sterelny, 'Minds: Extended or Scaffolded?', *Phenomenology and the Cognitive Sciences*, 9, no. 4 (2010), 465–481.

theorising.[99] This is also used as the basis for much work in Material Engagement Theory, discussed in the next section.

Evelyn Tribble has explored the role of distributed cognition in the performance of Shakespeare in the Globe Theatre, specifically with regards to memory.[100] She has further explored 'cognitive ecologies' in relation to memory, with Nicholas Keene and, with John Sutton, explored how this would be useful for Shakespeare studies.[101] While the idea of distributing memory onto the environment is important for its own sake, these studies are also fascinating for the purposes of this thesis due to their *specific* application to a very narrow field of art (in this case, performance of Shakespeare), yet the *general* applicability of their results. This is what this thesis is attempting to achieve for musical composition and the externalist theories which are being used to better understand it.

Kourken Michaelean and Sutton show how distributed cognition impacts the study of memory.[102] Richard Heersmink also explores the ways in which extended memory affects personal identity.[103] This is important when we consider the huge hinterlands of influence and experience behind any musical activity. Sutton further explores what distributed cognition might teach us about the materiality of memory.[104] Along with other colleagues in a later paper, he also discusses 'socially distributed remembering',[105] specifically how memory is distributed across society. This focus on material culture, touched upon in previous sections, leads to the discussion of 'Material Engagement Theory', a field of anthropology arguably

[99] Edwin Hutchins, *Cognition in the Wild* (Cambridge, MA: MIT Press, 1995). This is related, conceptually and chronologically, to Kirsch, 'Intelligent Use of Space' and Clark and Chalmers, 'The Extended Mind'.
[100] Evelyn Tribble, 'Distributing Cognition in the Globe' *Shakespeare Quarterly*, 56, no. 2 (2005), 135–155; Evelyn Tribble, *Cognition in the Globe: Attention and Memory in Shakespeare's Theatre* (London, UK: Palgrave Macmillan, 2011).
[101] Evelyn Tribble and Nicholas Keene, *Cognitive Ecologies and the History of Remembering* (London, UK: Palgrave Macmillan, 2011); Evelyn Tribble and John Sutton, 'Minds In and Out of Time: Memory, Embodied Skill, Anachronism, and Performance, *Textual Practice*, 26, no. 4 (2012), 587-607.
[102] Kourken Michaelian and John Sutton, 'Distributed Cognition and Memory Research: History and Current Directions', *Review of Philosophy and Psychology*, 4, no. 1 (2013), 1–24.
[103] Richard Heersmink, 'Distributed Selves: Personal Identity and Extended Memory Systems', *Synthese*, 194, no. 8 (2017a), 3135–3151. Heersmink has also explored integration of minds and technology, which will be more relevant later. See Richard Heersmink, 'Embodied Tools, Cognitive Tools and Brain-Computer Interfaces', *Neuroethics*, 6, no. 1 (2013), 207–219.
[104] John Sutton, 'Material Agency, Skills and History: Distributed Cognition and the Archaeology of Memory', *Material Agency: Towards a Non-Anthropocentric Approach*, eds. Carl Knappett and Lambros Malafouris, (London, UK: Springer, 2008), 37-55.
[105] John Sutton, Celia B. Harris, Paul G. Keil, and Amanda J. Barnier, 'The Psychology of Memory, Extended Cognition, and Socially Distributed Remembering', *Phenomenology and the Cognitive Sciences*, 9 (2010), 521–560.

led by Lambros Malafouris, Colin Renfrew, and Edwin Hutchins, which focuses precisely on the importance of engaging with materials in thought.

Material Engagement Theory

Material Engagement Theory is an anthropological perspective which emphasises the way that artefacts shape (and are shaped by) culture and thought. Hutchins' seminal *Cognition in the Wild*, mentioned above in relation to distributed cognition, can be seen as the foundation of Material Engagement Theory, and links to the above distributed/embedded/extended views of the mind, and to phenomenological theories which argue for the importance of objects to mind and world.[106] Malafouris' work in Material Engagement Theory is particularly important for this thesis.[107] His collection with Renfrew provides a solid backdrop for arguing for the cognitive role of tools in musical creativity. He states plainly that the Material Engagement Theory perspective 'recasts the boundaries of the mind'.[108] With Carl Knappett, he also discusses the agency of objects that this implies.[109]

MET largely deals with how minds interact with and change objects and the environment when thinking. Where it deals with human agents, it focuses on the present. Where it focuses on the past and future, which is a core aspect of the theory, it focuses on recursive interaction between people and things. This is incredibly important, but it does not focus specifically on how these 'things' change people in their absence. However, this is often *implied*, or can be read as such, when phrases such as 'how things shape the mind' are used. Ian Hodder, for example, discusses the two-way street of the connection between humans and things. For Hodder, humans 'get caught in a double bind, depending on things that depend on

[106] Edwin Hutchins, *Cognition in the Wild* (Cambridge, MA: MIT Press, 1995). See also this much later chapter: Edwin Hutchins, 'Imagining the Cognitive Life of Things', *The Cognitive Life of Things: Recasting the Boundaries of the Mind*, eds. Lambros Malafouris and Colin Renfrew (Cambridge, UK: McDonald Institute for Archaeological Research, 2010).
[107] Lambros Malafouris, *How Things Shape the Mind* (Cambridge, MA: MIT Press, 2013); Lambros Malafouris, 'Mind and Material Engagement', *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 1–17.
[108] Lambros Malafouris and Colin Renfrew, *The Cognitive Life of Things: Recasting the Boundaries of the Mind* (Cambridge, UK: McDonald Institute for Archaeological Research, 2010).
[109] Carl Knappett and Lambros Malafouris, *Material Agency: Towards a Non-Anthropocentric Approach*, (London, UK: Springer, 2008).

humans'.[110] Francesco Parisi, as a further example, discusses the co-constitutive loop between humans and things over time – by focusing on incorporation and temporality.[111] Ben Jeffares takes a similarly long ranging view of tool use and cognition from prehistory to today.[112] Where the thesis goes further is in focusing explicitly on competencies which are present *in the absence* of tools.

In terms of studies of specific creative acts through a Material Engagement Theory framework, Paul March undertook a self-observing study on clay, following from Malafouris' exploration of that particular craft.[113] Tom Froese explores how a Material Engagement Theory approach has been supported by recent evidence as to how neolithic cave paintings evolved over time – implying a continual interaction with the 'finished' work, not a splurging of creative thought onto the wall.[114] Woodward's paper builds an account of painting that can be read as expressing the encultured and historical manipulation of paint as an expressive material in itself; an action rendered visible that expresses the historical emergence of mind. Following a Material Engagement Theory approach, he argues that paintings can provide clues to the historical specificity of the mind that crosses the 'lifeworld' of human action; the technological, phenomenological, philosophical, material, and social conditions underpinning the creation of a painted mark.[115]

Erik Rietveld and colleagues argue that one implication of Material Engagement Theory, along with the Skilled Intentionality Framework, is that there are affordances allowed for by society in relation to trusting strangers.[116] These affordances may be developed within said

[110] Ian Hodder, 'The Entanglements of Humans and Things: A Long-Term View', *New Literary History*. 45, no. 1 (2014), 19-36.
[111] Francesco Parisi, 'Temporality and Metaplasticity: Facing Extension and Incorporation Through Material Engagement Theory. *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 205–221.
[112] Ben Jeffares, 'The Co-Evolution of Tools and Minds: Cognition and Material Culture in the Hominin Lineage', *Phenomenology and the Cognitive Sciences*, 9, no. 4 (2010), 503–520.
[113] Paul Louis March, 'Playing with Clay and the Uncertainty of Agency: A Material Engagement Theory Perspective', *Phenomenology and the Cognitive Sciences*, 18 (no. 1 (2019), 133–151. For an interdisciplinary approach to materiality in creativity, see Kerry Chappell, Lindsay Hetherington, Hermione Ruck Keene, Heather Wren, Angelos Alexopoulos, Oded Ben-Horin, Kim Nikolopoulos, Janne Robberstad, Sofoklis Sotiriou, and Bogner Franz, 'Dialogue and Materiality/Embodiment in Science|arts Creative Pedagogy: Their Role and Manifestation', *Thinking Skills and Creativity*, 31 (2019), 296-322.
[114] Tom Froese, 'Making Sense of the Chronology of Paleolithic Cave Painting from the Perspective of Material Engagement Theory, *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 91–112.
[115] Martyn Woodward, 'Metaplasticity Rendered Visible in Paint: How Matter 'Matters' in the Lifeworld of Human Action', *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 113–132. (124).
[116] Erik Rietveld, Ronald Rietveld, and Janno Martens, 'Trusted Strangers: Social Affordances for Social Cohesion', *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 299–316.

social environment or in a previous but related social environment. As a case study, they argue that '[certain structures in the New Amsterdam Park] will provide landscapes of social affordances; possibilities for social interaction provided by the environment.' This perhaps slightly tangential study does provide a transition point to the following chapter, which discusses empathy and social cognition. In the context of the ideas discussed so far, this is essential to the final part of the thesis.

This chapter has served to outline the post-Cartesian theories which provide the best route towards understanding the role of things 'outside the head' in cognition. It has explored the 4 often overlapping 'E's, as well as distributed cognition and Material Engagement Theory, and shown how much of this thinking is built upon the work of 20th century phenomenologists. This helps set the stage for tackling the first sub-research question (what is the role of present tools in the cognitive processes of musical composition?). This understanding is essential to then develop these theories towards providing an answer for the main research question of this thesis: what is the role of absent tools in the cognitive processes of composition?

CHAPTER THREE: Social Cognition and Technology.

In order to situate later discussions about the relationship between composer and performer, it is important to understand existing theories on empathy. As Nivedita Gangopadhya notes, '[c]ontemporary theories of social cognition disagree extensively about how to characterise the psychological, cognitive, and neural processes enabling a form of 'immediate' (i.e. non-theoretical, non-inferential) understanding of another's mental states.'[1] This distinction between 'theoretical' and 'immediate' understandings is important. It is therefore necessary to explore relevant theories of empathy and social cognition, which may well overlap or even compete, in preparation for applying these ideas to understanding the cognitive processes of musical composition. There are two particularly important ideas for this thesis. Firstly, that the mental states of others are accessible in the environment. Secondly, that the embodied understanding of the embodied nature of others, or 'intercorporeality', is essential to empathy and social cognition. The following chapter explores work which relates to these two ideas, and work which explores social cognition and empathy in relation to the ideas discussed in the previous chapter. It then closes by discussing art, language, and technology in the same contexts.

Simulation Theory, Interaction Theory, Direct Perception Theory and 'Theory Theory'

There are multiple theories which can be brought to bear when discussing empathy and understanding the mental states of others. Four of the most prominent are Simulation Theory, Interaction Theory, Direct Perception Theory and Theory Theory. Simulation Theory argues that most empathy comes from basic neural mechanisms to do with processing witnessed bodily action.[2] Interaction Theory further sees empathy as embedded in the dynamic interaction between body, mind and world , and more fully states that emotions of others are *accessible in the environment*, as they are embodied in voice, gesture, facial expression and

[1] Nivedita Gangopadhyay, 'Introduction: Embodiment and Empathy, Current Debates in Social Cognition' *Topoi*, 33, no. 1 (2014), 117–127.
[2] See Vittorio Gallese (2003). The Roots of Empathy: The Shared Manifold Hypothesis and the Neural Basis of Intersubjectivity. *Psychopathology*, *36*(4), 171–180.

other tangible aspects of emotion.[3] In the introduction to the issue of *Phenomenology and the Cognitive Sciences* on empathy, Rasmus Thybo Jensen and Dermot Moran describe Direct Perception as a perspective which 'claims that perception can provide the perceiver with knowledge of other minds without the perceiver relying on any actual theorising or simulation and without the observational judgement receiving its epistemic status as knowledge because of a *potential* inferential justification'.[4] This is a step beyond Interaction Theory but they largely overlap. All three of these theories are opposed to Theory Theory, which suggests that a top-down, conscious understanding of what it means to 'be' another agent is a prerequisite for empathy.[5]

Vittorio Gallese describes empathy as not dependent on linguistic/mentalist abilities but on the relational nature of our understanding of the world, focusing on the mirror neuron system.[6] Similarly, John Michael has examined mirror neuron systems and simulation.[7] Leonhard Schilbach makes a distinction between online and offline social cognition,[8] and discusses the 'simulationist vs theorist' debate, and the evidence for both, in terms of social cognition. Matthew Ratcliffe also explores 'empathy without simulation'.[9] Joel Krueger challenges the 'theory of mind' paradigm, by looking at an extended/embedded perspective on social cognition. He argues that extended social cognition implies that things from the 'inner' lives of others are accessible in the outside world – and that therefore some mental

[3] See Shaun Gallagher, 'Understanding Others: Embodied Social Cognition', *Handbook of Cognitive Science*, ed. Paco. Calvo & Antoni Gomila (London, UK: Elsevier, 2008), 437-452; Tom Froese and Shaun Gallagher. "Getting Interaction Theory (IT) Together: Integrating Developmental, Phenomenological, Enactive, and Dynamical Approaches to Social Interaction." *Interaction Studies* 13, no. 3 (2012): 436-468.
[4] Rasmus Thybo Jensen and Dermot Moran, 'Introduction: Intersubjectivity and Empathy', *Phenomenology and the Cognitive Sciences*, 11, no. 2 (2012), 125–133 (127).
[5] See Amy Coplan, 'Understanding Empathy: Its Features and Effects', *Empathy: Philosophical and Psychological Perspectives*, eds. Amy Coplan and Peter Goldie (Oxford: Oxford University Press, 2011), 2–18; James R. O'Shea, 'The 'Theory' of Mind and the Aims of Sellars' Original Myth of Jones', *Phenomenology and the Cognitive Sciences*, 11, no. 2 (2012), 175–204.
[6] Vittorio Gallese, 'The Roots of Empathy: The Shared Manifold Hypothesis and the Neural Basis of Intersubjectivity', *Psychopathology*, 36, no. 4 (2003), 171–180; Vittorio Gallese and Alvin Goldman, 'Mirror Neurons and the Simulation Theory of Mind-Reading, *Trends in Cognitive Sciences*, 2, no. 12 (1998), 493–501. The mirror neuron system is a huge topic, so here it is simply stated alongside other relevant theories. Interested readers should see Gallese's work as a starting point.
[7] John Michael, 'Mirror Systems and Simulation: A Neo-Empiricist Interpretation', *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 565–582.
[8] Leonhard Schilbach, 'On the Relationship of Online and Offline Social Cognition', *Frontiers in Human Neuroscience*, 8 (2014).
[9] Matthew Ratcliffe, 'Empathy Without Simulation', *Imagination and Social Perspectives: Approaches from Phenomenology and Psychopathology*, eds. Michela Summa, Thomas Fuchs, and Luca Vanzago (London, UK: Routledge, 2018), 199-220.

states are not internal, but directly accessible by others.[10] For the purposes of this thesis, these theories all point to the same important idea: When working closely with others, agents have access *in the environment* to the mental states of these others, allowing for collaboration at multiple levels of complexity.

Embodied Social Cognition

The development by 21st century theorists of Maurice Merleau-Ponty's concept of 'intercorporeality' (intercorporéité) - or the embodied interaction between self and other - is useful here. Shogo Tanaka develops this concept to see it as a theory of social cognition. He contests Theory-Theory and Simulation Theory as *both* missing an embodied dimension, further complicating the debate around theories of empathy.[11] This shows the importance of bringing multiple different theoretical approaches to bear when considering an issue as complex as empathy, social cognition, or, indeed, the role of technology in creative thought.

Christian Meyer and Ulrich van Wedelstaedt further explore this idea as a theory for understanding sociality.[12] They argue that these approaches see individual action as the 'product of interaction between organisms and their others' and see embodied understandings as 'preconceptual'.[13] Gail Weiss has similarly taken a relationship-based, intercorporeal approach to understanding being in the world, as have Renee Eli and Thomas Csordas.[14] Carrie Noland explores the embodied nature of culture, especially through gestures.[15] Joshua Shepherd takes a similarly embodied/enactive approach to social cognition and

[10] Joel Krueger, 'Extended Cognition and the Space of Social Interaction. *Consciousness and Cognition*, 20, no. 3 (2011), 643–657.
[11] Shogo Tanaka, 'Intercorporeality as a Theory of Social Cognition, *Theory & Psychology*, 25, no. 4 (2015), 455–472.
[12] Christian Meyer and Ulrich van Wedelstaedt, *Moving Bodies in Interaction – Interacting Bodies in Motion: Intercorporeality, Interkinesthesia, and Enaction in Sports*. (Amsterdam, NL: John Benjamins Publishing Company, 2017).
[13] Christian Meyer, Jürgen Streeck, J. Scott Jordan, *Intercorporeality: Emerging Socialities in Interaction* (Oxford: Oxford University Press, 2017), xv.
[14] Gail Weiss, *Body Images: Embodiment as Intercorporeality* (London, UK: Routledge, 2013); Renee Eli, 'Intercorporeality: An Invitation to Being in the Human-Body-Nature Relationship', *Journal of Conscious Evolution*, 9 (2018); Thomas J. Csordas, 'Intersubjectivity and Intercorporeality', *Subjectivity*, 22, no. 1 (2008), 110–121.
[15] Carrie Noland, *Agency and Embodiment: Performing Gestures/Producing Culture* (Cambridge, MA: Harvard University Press, 2010).

mindreading/empathy,[16] while J. Robert Thompson is critical of embodied accounts of social cognition, arguing that they may be incorrect based on developmental timelines.[17] Karine Jospe and colleagues have explored the embodied nature of empathy in terms of facial expression recognition, and Tom Froese and Thomas Fuchs push this further in discussing the 'extended body' in social cognition.[18]

The collection *Embodiment, Enaction, and Culture: Investigating the Constitution of the Shared World* explores the importance of the shared (social) world from an embodied/enactive point of view.[19] Dan Zahavi further argues for the importance of embodiment for empathy, with reference to many theories of empathy.[20] With John Michael, Zahavi explores further 4E perspectives on empathy, attempting to move beyond both the Theory Theory and Simulation Theory paradigms.[21] Douglas Robinson similarly talks about the extended mind and embodiment in the context of sociality.[22] Marc Slors, however, argues that symbiotic cognition, related to 'distributed' cognition, is a better idea for how social cognition works than extended cognition.[23] These debates are clearly ongoing, yet, from the perspective of the post-Cartesian theories discussed throughout this chapter and Chapter Two, offloading social cognition (such as understanding the mental states of others) onto the environment must be an essential part of the functioning of sociality. Similarly, the sensorimotor and ideomotor phenomena, as will be discussed in more depth later, provide an enacted perspective on understanding others - related to Merleau-Ponty's intercorporeality -

[16] Joshua Shepherd, 'Action, Mindreading and Embodied Social Cognition', *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 507–518.
[17] J. Robert Thompson, 'Implicit Mindreading and Embodied Cognition', *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 449–466.
[18] Tom Froese and Thomas Fuchs, 'The Extended Body: A Case Study in the Neurophenomenology of Social Interaction, *Phenomenology and the Cognitive Sciences*, 11, no. 2 (2012), 205–235.
[19] Christopher Durt, Thomas Fuchs, and Christian Tewes, *Embodiment, Enaction, and Culture: Investigating the Constitution of the Shared World* (Cambridge, MA: MIT Press, 2017). See also the special issue of *Phenomenology and the Cognitive Sciences*, the editorial of which lays out some of the issues arising from 'traditional' computational views of social cognition. Ezequiel Di Paolo, 'Editorial: The Social and Enactive Mind', *Phenomenology and the Cognitive Sciences*, 8, no. 4, 409–415.
[20] Dan Zahavi, 'Empathy, Embodiment and Interpersonal Understanding: From Lipps to Schutz', *Inquiry*, 53, no. 3 (2010), 285–306.
[21] Dan Zahavi and John Michael, 'Beyond Mirroring: 4E Perspectives on Empathy', *The Oxford Handbook of 4E Cognition*, eds. Albert Newen, Leon De Bruin, and Shaun Gallagher (Oxford: Oxford University Press, 2018), 589–606.
[22] Douglas Robinson, *Feeling Extended: Sociality as Extended Body-Becoming-Mind* (Cambridge, MA: MIT Press, 2013).
[23] Marc Slors, 'Symbiotic Cognition as an Alternative for Socially Extended Cognition', *Philosophical Psychology*, 32, no. 8 (2019), 1179–1203.

and this will be important for understanding the relationship between composer and performer.

4E Social Cognition and Intent

There are numerous post-Cartesian perspectives which move beyond purely looking at *embodiment* as a means to understand social cognition. Edwin Hutchins demonstrates the distributed cognition perspective on human interaction – that minds distribute across other minds, as well as through technology.[24] Alexander Aston combines an enactivist approach with MET to explore the means by which communities self-organise, critiquing traditional theory of mind approaches in the process.[25] Chris Goldsworthy has explored how researchers in biomedical labs have to navigate 'multiple cognitive worlds within their day-to-day practices', through an MET and enactive lens.[26] Tadeusz Zawidzki argues that we shape each other's minds in order to make them easier to understand, and that this mutual 'mindshaping' is what distinguishes human social cognition/empathy from that of other animals.[27]

The importance of intent becomes particularly relevant when considering *creative* cognition, where influence and motivation will collide with practical necessity. This is explored here as discussion of intent so often relates to theories of social cognition. Zawidzki argues that the 'intentional stance' perspective from Daniel Dennett meshes with Embodied Social Cognition, in that both assume social cognition is possible without metapsychology – he relates this to empirical work in psychology, again linking philosophy and science.[28] Maiese argues that affective framing, or the way that agents use emotion to guide cognition, plays an

[24] Edwin Hutchins, 'The Distributed Cognition Perspective on Human Interaction', *Roots of Human Sociality*, eds. Stephen C. Levinson and Nicholas J. Enfield (London, UK: Routledge, 2006), 375-398.
[25] Alexander Aston, 'Metaplasticity and the Boundaries of Social Cognition: Exploring Scalar Transformations in Social Interaction and Intersubjectivity', *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 65–89. For a critical take on enactive approaches to social interactions, see Mitchell Herschbach, 'On the Role of Social Interaction in Social Cognition: A Mechanistic Alternative to Enactivism', *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 467–486.
[26] Chris Goldsworthy, 'The Effect of Dynamic Social Material Conditions on Cognition in the Biomedical Research Laboratory, *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 241–257 (241).
[27] Tadeusz Wieslaw Zawidzki, *Mindshaping: A New Framework for Understanding Human Social Cognition*. (Cambridge, MA: MIT Press, 2013).
[28] Tadeusz Wieslaw Zawidzki, 'Unlikely Allies: Embodied Social Cognition and the Intentional Stance', *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 487–506.

integral role in social cognition.[29] Peter-Paul Verbeek discusses *composite* intentionality - that intentionality might be mediated through technological artifacts.[30] Holger Lyre similarly shows how extended cognition fits into theories of social cognition and shared intent,[31] which links to the work done by Jessica Witt and colleagues about the impact of intent on the cognitive results of tool-use, which will be discussed later.[32]

Art and Language

While the above literature focuses on social cognition, the embodied, empathetic connections felt with works of art (and *through* art, similar to Le Guin's connection to Boccherini)[33] are explored by David Freedberg and Vittorio Gallese.[34] They note a further connection with Merleau-Ponty's work in these ideas, that not only is there a sense of physical involvement with the *subject* of the work of art (a tension in response to tension in a sculpture, for example), but also with the *artist's physicality*, by understanding, for example, how a particular brushstroke would have been produced physically. Referencing empirical studies of the mirror neuron system, they argue that 'it stands to reason that a similar motor simulation process can be induced by the observation of still images of actions in works of art. It is not surprising that felt physical responses to works of art are so often located in the part of the body that is shown to be engaged in purposive physical actions.'[35] With reference to the artist's physicality, in relation to Jackson Pollock's paintings, they argue that '[t]he gestures that are only implicit in the marks on these works of art are corporeally felt by their spectators.'[36] These ideas, then, have something to say about an audience's relationship to art and artist, as well as the relationship that the artist might have with their tools and

[29] Maiese, *Embodiment, Emotion, and Cognition*, 150.
[30] Peter-Paul Verbeek, 'Cyborg Intentionality: Rethinking the Phenomenology of Human-Technology Relations', *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008), 387–395. See also Latour, *Reassembling the Social*¸ 210.
[31] Holger Lyre, 'Socially Extended Cognition and Shared Intentionality', *Frontiers in Psychology*, 9 (2018).
[32] Jessica K. Witt, Dennis R. Proffitt, and William Epstein, 'Tool Use Affects Perceived Distance, But Only When You Intend to Use It', *Journal of Experimental Psychology Human Perception & Performance,* 31, no. 5 (2005), 880–888.
[33] Le Guin, *Boccherini's Body*
[34] David Freedberg and Vittorio Gallese, 'Motion, Emotion and Empathy in Esthetic Experience', *Trends in Cognitive Sciences,* 11, no. 5 (2007), 197-203.
[35] Ibid., 200.
[36] Ibid., 199. This is related to a work by the artist Gilberto Zorio entitled *Terracotta Circle* (1969), in which he had delineated the boundaries of his physicality by marking the potential reach of his arms by a ring of terracotta, his height by a suspended block, and so on. Compared to a representative sculpture of a person, it is surprisingly large and provides an interesting perspective on the 'actual size' of a human being.

collaborators. Composers and musicians are not mentioned, evidencing the importance of applying these theories to musical creativity before developing them.

Sergeiy Sandler's idea of 're-enactment' in language is also important. He reviews experimental literature which has found that 'understanding actions involves their embodied simulation.' He then argues that 're-enactment - the *overt embodied simulation of actions and practices* within utterances - makes it possible to forge an integrated extended cognition account of linguistic meaning.'[37] This, along with the theories of empathy and social cognition discussed above, is an important link to the ideas discussed in Part Two of this thesis, along with the theories of empathy discussed above.

Technology, Transparency, and its Impact

Phenomenology from Merleau-Ponty to Heidegger to Ingold; Hutchins', Malafouris' and Renfew's Materially Engaged culture; Clark's cyborgs. There is one central thing at the heart of all these perspectives – tools and technology. Particularly important for this thesis is the idea of 'transparent technology'. Transparency, very much related to – and sometimes used synonymously with - 'readiness-to-hand' (*Zuhandenheit*),[38] is a key idea in post-Cartesian theories cited above. Transparency is the idea that a technology can become so much a part of an agent's cognitive apparatus that it becomes invisible in use. That is to say, the cognitive process ceases to be 'interaction with tool while trying to solve the problem' and instead simply becomes 'trying to solve the problem,' because the tool is so integrated into the cognitive system. This goes for anything which has thus disappeared from view, from pen and paper to a tennis racket to prosthetics to cybernetic enhancement. Clark defines transparent tools as 'tools whose use and functioning have become so deeply dovetailed to the biological system that the […] problem solving system just *is* the composite of the biological system and these nonbiological tools.'[39] He further notes that for tools to become

[37] Sergeiy Sandler, 'Reenactment: An Embodied Cognition Approach to Meaning and Linguistic Content', *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 583–598.
[38] Heidegger, *Sein und Zeit / Being and Time*, 98.
[39] Clark, *Natural-Born Cyborgs*, 2004, 37.

transparent, training and practice may be needed. That is, it is a quality of the agent-tool relationship, not just the tool itself.[40]

The 'Demonstration of the Transition from Ready-to-Hand to Unready-at-Hand' by Dobromir Dotov, Lin Nie, and Anthony Chemero makes an empirical attempt to explore Heidegger's ideas regarding technology and transparency, ideas which have had considerable impact on philosophy of mind, AI, and cognitive science. Their experiments support the Heideggerian claim that '[w]hen humans are smoothly coping with entities ready-to-hand, they see through their tools to focus on the task they are using those tools to complete. When that coping is disrupted by a temporary malfunction, humans can no longer see through the malfunctioning tool and experience it as unready-to-hand.'[41] This implies that technology requires a level of competency in its use and consistency in its function to become 'transparent', which will become important in Part Two of this thesis. Peter Jones and colleagues performed a similarly useful empirical study regarding haptic interfaces in the context of rescue missions – and the importance of the haptic 'guide robot' (inspired by guide dogs) becoming *transparent technology.*[42]

Niels Johannsen explores how technology and interaction with technology is a continual process, relating to the discussion of Material Engagement Theory in Chapter One.[43] This is also explored by Verbeek, mentioned above in relation to intentionality.[44] Felix Riede and colleagues discuss the importance of play objects in cognitive evolution and innovation.[45] Menary explores integration of things into the extended mind.[46] These articles and books demonstrate how technology impacts culture which impacts minds which then create

[40] Ibid., 38.
[41] Dobromir G. Dotov, Lin Nie, and Anthony Chemero, 'A Demonstration of the Transition from Ready-to-Hand to Unready-to-Hand', *PLOS ONE*, 5, no. 3 (2010), e9433 (8).
[42] Peter Jones, Ayan Ghosh, Jacques Penders, and Heath Reed, 'Towards Human Technology Symbiosis in the Haptic Mode', conference paper presented at *International Conference on Communication, Media, Technology and Design* (2013).
[43] Niels Nørkjær Johannsen, 'Technological Conceptualization: Cognition on the Shoulders of History', *The Cognitive Life of Things: Recasting the Boundaries of the Mind,* eds. Lambros Malafouris and Colin Renfrew (Cambridge, UK: McDonald Institute for Archaeological Research, 2010), 59-69.
[44] Peter-Paul Verbeek, 'Cyborg Intentionality: Rethinking the Phenomenology of Human-Technology Relations', *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008), 387–395.
[45] Felix Riede, Niels N. Johannsen, Anders Högberg, April Nowell, and Marlize Lombard, 'The Role of Play Objects and Object Play in Human Cognitive Evolution and Innovation. *Evolutionary Anthropology: Issues, News, and Reviews*, 27, no. 1 (2018), 46-59.
[46] Richard Menary, 'Cognitive Integration and the Extended Mind', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010e), 226-243.

technology. This adds a level of temporality to the ideas discussed so far. However, in these writings, the impact of tool-use is offloaded onto the surrounding culture, rather than being integrated into the being of the agent in question, as this thesis is attempting to describe.

In terms of physical motions and feedback specifically, sensori-/ideomotor phenomena are particularly important for considering the role of tools in shaping cognition. J. Kevin O'Regan and Alva Noë have explored these phenomena in terms of perception,[47] Kai Kaspar, Sabine König, and colleagues have explored sensorimotor contingencies, showing that participants gained improved competencies spatial perception and navigation strategies through the use of a vibrating belt – eventually becoming transparent.[48] In analysing the long-term effects of this sensory augmentation, they found that, for their participants, 'the increase of quantitative perceptual changes over time and qualitative perceptual are compatible with the theory of sensorimotor contingencies'.[49] This is a useful piece of empirical evidence whose findings could be transferred to arguing for the role that technology can play in changing the cognitive competencies of a composer.

Lucila Cardinali and colleagues have explored the ways that tool use changes the internal body schema.[50] 'The effects produced by tool-use were not ephemeral, and persisted (*at least*) [their parentheses, my emphasis] for the duration of the post-tool sessions (~10-15 min).' This dynamic updating of body morphology was also shown to be functional, in that it

[47] J. Kevin O'Regan and Alva Noë, 'What is it Like to See: A Sensorimotor Theory of Perceptual Experience', *Synthese,* 129, no. 1 (2002), 79-103.
[48] Kai Kaspar, Sabine König, Jessika Schwandt, and Peter König, 'The Experience of New Sensorimotor Contingencies by Sensory Augmentation', *Consciousness and Cognition*, 28 (2014), 47–63.
[49] Sabine U. König, Frank Schumann, Johannes Keyser, Caspar Goeke, Carina Krause, Susan Wache, Aleksey Lytochkin, Manuel Ebert, Vincent Brunsch, Basil Wahn, Kai Kaspar, Saskia K. Nagel, Tobias Meilinger, Heinrich Bülthoff, Thomas Wolbers, Christian Büchel, and Peter König, 'Learning New Sensorimotor Contingencies: Effects of Long-Term Use of Sensory Augmentation on the Brain and Conscious Perception' *PLOS ONE*, 11, no. 12, e0166647 (2016).
[50] Lucilla Cardinali, Francesca Frassinetti, Claudio Brozzoli, Christian Urquizar, Alice C Roy, and Alessandro Famè, 'Tool-use Induces Morphological Updating of the Body Schema', *Current Biology*, 19, no. 12 (2009). See also Angelo Maravita and Atsushi Iriki, 'Tools for the Body (Schema)', *Trends in Cognitive Sciences*, 8, no. 2 (2004), 79–86; Anna Berti and Francesca Frassinetti, 'When Far Becomes Near: Remapping of Space by Tool Use, *Journal of Cognitive Neuroscience,* 12, no. 3 (2000), 415–420; Maurizio Gentilucci, Alice Roy, and Silvia Stefanini, 'Grasping an Object Naturally or With a Tool: Are These Tasks Guided by a Common Motor Representation?', *Experimental Brain Research,* 157, no. 4 (2004), 496-506; Alessandro Farnè, Atsushi Iriki, and Elisabetta Làdavas, 'Shaping Multisensory Action–Space With Tools: Evidence From Patients With Cross-Modal Extinction', *Neuropsychologia,* 43 (2005), 238–248; Marie Martel, Lucilla Cardinalli, Giorga Bertonati, Christophe Jouffrais, Livio Finos, Alessandro Famè, and Alice C Roy, 'Somatosensory-guided Tool Use Modifies Arm Representation for Action', Scientific Reports, 9; Marie Martel, Lucilla Cardinalli, Alessandro Famè, and Alice C Roy, 'Tool-use: An Open Window into Body Representation and its Plasticity', Cognitive Neuropsychology, 33, no. 1-2 (2016), 81-101.

did not hamper control of related bodily movements (in this case, grasping with the hand). The participants felt that they had extended reach even after the tool which gave them that reach was gone. Witt and colleagues discovered that intent matters for this kind of updating.[51] The idea that tool use might mediate access to the body schema is also explored by the same research group.[52] Additionally, Francis Willett and colleagues have shown that brain-computer-interfaces that work on interpreting bodily action (including bodily action remembered/integrated but no longer possible) have a high success rate.[53] These are some of the few existing sources which really delve into the role of tools *after* the moment of their use – something which is critical to this thesis. Jon Bird and colleagues, including Andy Clark, have examined the use of mediation technologies to investigate the extended mind, but this was from the perspective of tools used in the present.[54]

There is one more relevant study which could help towards understanding the role of absent tools in the compositional process, but it is not a study of composers, or even of humans. In 1997, Roger Thompson, David Oden, and Sarah Boysen performed a study on chimpanzees (*Pan troglodytes*),[55] which focused on developing their capacity to understand and identify second-order difference.[56] The chimps were taught to identify the difference between differences using coloured plastic tokens: one token which they would place next to pairs with the same difference (A/A and C/C), and another token which they would place next to the more different difference (B/B and D/E). The salient point for the purposes of this thesis is not that they learned to identify second-order differences through using these tokens, but

[51] Witt et al, 'Tool Use Affects Perceived Distance'.
[52] Lucilla Cardinali, Claudio Brozzoli, Christian Urquizar, Alice Roy, and Alessandro Famè, 'When Action is Not Enough: Tool-use Reveals Tactile-Dependent Access to Body Schema', *Neuropsychologia,* 49 (2011), 3750-3757.
[53] Francis R. Willett, Donald T. Avansino, Leigh R. Hochberg, Jaimie M. Henderson, and Krishna V. Shenoy, 'High-Performance Brain-to-Text Communication Via Handwriting', *Nature,* 593, no. 7858 (2021), 249–254. For an exploration of schema theory from the perspective of someone involved in Extended Cognition research, see Marc Leman, *Music and Schema Theory: Cognitive Foundations of Systematic Musicology*. Springer Science & Business Media, 2012).
[54] Jon Bird, Simon Holland, Paul Marshall, Yvonne Rogers, and Andy Clark, 'Feel the Force: Using Tactile Technologies to Investigate the Extended Mind', *DAP 08,* (2008), 1-4.
[55] Roger K. R. Thompson, David L. Oden and Sarah T. Boysen, 'Language-Naïve Chimpanzees (Pan troglodytes) Judge Relations Between Relations in a Conceptual Matching-to-Sample Task', *Journal of Experimental Psychology: Animal Behaviour Processes,* 23, no. 1 (1997), 31-51. For a specifically 4E exploration of animal cognition see Hilton F. Japyassú and Kevin N Laland, 'Extended Spider Cognition', *Animal Cognition*, 20, no. 3 (2017), 375–395.
[56] Second-order difference refers to a difference between differences. The difference between A and A is the same as the difference between C and C, but different than the difference between D and E.

that they retained this new cognitive competency in their absence. This was a competency absent in chimps who had never used tokens.

The researchers suggest that the chimps now have internal representations of these tokens, which allow them to then perform the task of recognising second-order difference, even in the absence of the actual, physical tokens.[57] Similarly, Richard Wilson examined studies on a Bonobo chimp (*Pan paniscus*) named Kanzi, contending that Kanzi had reconfigured his capacities for belief through use of a symbol board, which, again, he retained in absence of this tool.[58] This is further evidence for the argument that it is the ability to create *new* tools, to engineer our cognitive environment,[59] which allows for the undertaking of complex, long-term cognitive processes - for example, musical composition – and (as will be argued in Chapter Seven) the development of related competencies. These studies provide some evidence for the mechanisms by which the use of cognitive tools may extend our *cognitive* 'reach' beyond the moment of their use, essential for the main hypothesis of this thesis.

This chapter has served to show that the accessibility of mental states in the environment, along with intercorporeality and related ideas, is an important facet of social cognition, and is therefore essential to understanding the role of a *physically present* performer in the cognitive processes of musical composition. Understanding how these experiences of mental states being present in the environment are integrated is an important part of understanding the role of the *absent* performer in composition, along with theories also discussed here about how agents theorise the mental states of others. Intent has also been identified as a crucial aspect of cognition, often through the lens of social cognition. These sections on social cognition and empathy therefore provide an essential background to Chapters Five and Nine of this thesis, which seek to answer the research questions related to the relationship between composer and performer. Along with the discussion of the relationship empathy has with art and language, and the impact that an agent's relationship with technology might have, this chapter has built upon the previous chapter to form the foundation for the contributions this

[57] This study was cited by Andy Clark in *Natural-Born Cyborgs* (70-72) which is in the bibliography of a huge number of articles and books concerned with extended cognition published since, but few seem to have grappled with the significance of the 'internalised, external token' when considering more complex cognitive pursuits, such as creating a work of art.
[58] Robert A. Wilson, *Boundaries of the Mind: The Individual in the Fragile Sciences: Cognition* (New York: Cambridge University Press, 2004); Richard A. Wilson, 'Meaning Making and the Mind of the Externalist', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 167-188 (180).
[59] Clark, *Supersizing the Mind*, 59; Latour, *Reassembling the Social*, 210.

thesis will make in Chapter Five and Part Two. However, there is one final area of literature which needs to be explored: that of musicological approaches to the ideas discussed thus far.

CHAPTER FOUR: Music, Mind, and Creativity.

This chapter serves to situate the above literature, as much as possible, within existing musicological and music-related work. It explores relevant musicological studies of imagination, intertextuality, and music and the mind, followed by a crucial section on musical imagery. In doing so, certain gaps are revealed, some of which begin to be dealt with in the next chapter. The chapter then closes with a discussion of composers, tools, and influence, particularly where these things have been discussed in terms which do not explicitly relate to the literature in the previous two chapters, but which are still useful in understanding the role of technology in the compositional process.

Imagination

Hugo Riemann wrote early in the last century that '[t]he process of notating an artistic creation as well as the sounding performance of the work are merely expedients to transplant musical experiences from the composer's imagination into the imagination of the musical listener.'[1] Similarly, Eduard Hanslick writes about *Phantasie*, that '[a] musical piece emerges from the Phantasie of the artist for the Phantasie of the listener.'[2] Composers have echoed these ideas. Aaron Copland states that 'the listener […] must […] relive in his own mind the completed revelation of the composer's thought.'[3] Kate Covington quotes Robert Schumann: 'He is a good musician, who understands the music without the score, and the score without the music. The ear should not need the eye, the eye should not need the (outward) ear.'[4] The tools of composition (including even performers), then, are seen as mediators at best, and there is a sense that the musicologists of the early 20th century wished that musical ideas, arriving fully formed in a composer's head, could be translated directly from composer to listener without any such tools.

[1] Riemann, Hugo. "Ideen zu einer 'Lehre von den Ton Vorstellungen'." Jahrbuch der Musikbibliothek Peters 21/22: 1-26. 1914/15 Translated by Robert Wason and Elizabeth Marvin as "Ideas for a Study 'On the Imagination of Tone'." Journal of Music Theory 36, no. 1 (1992): 81-117 (82).
[2] Eduard Hanslick, *Vom Musikalisch-Schönen*, Translated by Lee Rothfarb and Christoph Landerer, as 'Eduard Hanslick's On the Musically Beautiful: A New Translation' (Oxford: Oxford University Press, 1854/2018), 5-6.
[3] Aaron Copland, *Music and Imagination* (Harvard: Harvard University Press, 1980), 2.
[4] Kate Covington, 'The Mind's Ear: I Hear Music and No One Is Performing', *College Music Symposium*, 45 (2005), 25–41 (25). She further notes that Schumann suggests to composers, 'do it all with your brain' (26).

The writings of Nicholas Cook demonstrate the recent developments in musicological thought with regards to the theories of mind discussed above - from the perspectives expressed in the quotes in the previous paragraph, with tools and bodies relegated to being simply intermediaries, to the idea of musical activity as embodied, networked, and even extended.[5] *Music, Imagination, and Culture*, which was published in 1990, uses the word 'body' five times, only once referring to a physical body (the other instances referring to bodies of work, knowledge, and so on), and this the physical body of a potter, not a musician.[6] In contrast, *Music as Creative Practice*, published in 2018, mentions the word 'body' 27 times, including 'instruments are extensions of the body',[7] 'the performing body',[8] 'the extent to which human cognition […] is grounded in bodily experience';[9] and has an entire section on the extended musical mind.[10]

Maria Koukoti and Lambros Malafouris have explored the materiality of imagination: imagination not as a kind of decontextualized mental processing of internal representations, but as a situated dynamic sculpting of heterogeneous resources and processes (both internal and external).[11] Ludger Van Dijk and Erik Rietfeld have similarly discussed imagination's seemingly 'representational' nature, and therefore how it can be seen as an opening up of larger-scale possibilities for action (or, in other words, affordances) and that indeterminacy and simultaneity can be seen as marks of imagination. They do this in the context of architects working on a large-scale installation.[12] Juhani Pallasmaa has explored embodiment, imagination, and empathy in the context of architecture and architectural practice.[13] So, there

[5] Nicholas Cook, *Music, Imagination, and Culture* (Oxford: Oxford University Press, 1990); Nicholas Cook, *Beyond the Score: Music as Performance*. (Oxford: Oxford University Press, 2013).
Nicholas Cook, *Music as Creative Practice*. (Oxford: Oxford University Press, 2018).
[6] Cook, *Music, Imagination, and Culture*, 2. This is an interesting foreshadowing of Malafouris' exploration of Material Engagement Theory through the example of a potter at the wheel. Lambros Malafouris, 'At the Potter's Wheel: An Argument for Material Agency', *Material Agency: Towards a Non-Anthropocentric Approach*, ed. Carl Knappett and Lambros Malafouris (Boston, MA: Springer, 2008), 19-36.
[7] Cook, *Music as Creative Practice*, 114.
[8] *Ibid.*, 117.
[9] *Ibid.*, 21.
[10] *Ibid*., 117-127.
[11] Maria Koukouti and Lambros Malafouris, 'Material Imagination: An Anthropological Perspective', *The Cambridge Handbook of the Imagination*, ed. Anna Abraham (Cambridge: Cambridge University Press, 2020), 30–46.
[12] Ludger van Dijk and Erik Rietveld, 'Situated Imagination', *Phenomenology and the Cognitive Sciences* (2020).
[13] Juhani Pallasmaa, 'Empathic and Embodied Imagination: Intuiting Experience and Life in Architecture', *Architecture and Empathy*, eds. Vittorio Gallese, Juhani Pallasmaa, Harry Mallgrave, and Sarah Robinson (Tapio Wirkkala-Rut Bryk Foundation, 2015), 4-19.

have been '4E+' attempts to describe imagination, but it is certainly an area where more work needs to be done, and especially when it comes to music.

Despite the exceptions cited above, studies of imagination do not tend to approach these ideas from an externalist perspective. Imagination, after all, seems to be the most 'internal' phenomenon of human experience. *The Oxford Handbook of Sound and Imagination*, for example, has only three explicitly externalist chapters out of 70.[14] Anna Abraham's *Cambridge Companion to the Imagination* shows how broad the approaches to imagination are, across the humanities.[15] Hans-Georg Moeller and Andrew Whitehead explore cross-cultural perspectives on imagination, drawing parallels and contrasts, and showing that there are an infinite number of ways to approach the study of imagination and ways imagination can be understood.[16]

In terms of music more generally, the edited collection *Musical Imaginations* takes a similarly broad view of how to understand 'imagination'.[17] A more recent example is Alan Taylor's recent book, which explores musical imagination, collaboration, and meaning making – this focus on *collaboration* when trying to break new ground in musicology can be seen throughout this chapter.[18] Lydia Goehr's *The Imaginary Museum* offers a compelling perspective on how composers and musical works are perceived culturally and created through culture, and how works influence each other and themselves.[19] This provides a useful segue to a brief discussion of what could be meant by a musical 'work' in the context of this

[14] Ulrik Volgsten, 'Fantasy Control: Implications for Distributed Imagination and Affect Attunements in Music and Sound', *The Oxford Handbook of Sound and Imagination, vol. 1*, ed. Mark Grimshaw-Aagaard, Mads Walther-Hansen and Martin Knakkergaard (Oxford: Oxford University Press, 2019), 229-250; Duby, 'Affordances in Real, Virtual, and Imaginary Musical Performance'; Justin Christensen, 'Improvisation: An Ideal Display of Embodied Imagination', *The Oxford Handbook of Sound and Imagination, vol. 2*, ed. Mark Grimshaw-Aagaard, Mads Walther-Hansen and Martin Knakkergaard (Oxford: Oxford University Press, 2019), 15-36.

[15] Anna Abraham, *The Cambridge Handbook of the Imagination* (Cambridge, UK: Cambridge University Press, 2020).

[16] Hans-Georg Moeller and Andrew K. Whitehead, *Imagination: Cross-Cultural Philosophical Analyses* (London, UK: Bloomsbury Publishing, 2018).

[17] David Hargreaves, Dorothy Miell, and Raymond MacDonald, *Musical Imaginations: Multidisciplinary Perspectives on Creativity, Performance and Perception* (Oxford: Oxford University Press, 2011); David Hargreaves, Jonathan James Hargreaves, and Adrian C. North, 'Imagination and Creativity in Musical Listening', *Musical Imaginations: Multidisciplinary Perspectives on Creativity, Performance and Perception*, eds. David Hargreaves, Dorothy Miell, and Raymond MacDonald (Oxford: Oxford University Press, 2011), 156-172.

[18] Alan Taylor, *The Imagination of Experiences: Musical Invention, Collaboration, and the Making of Meanings* (London, UK: Routledge, 2021).

[19] Lydia Goehr, *The Imaginary Museum of Musical Works: An Essay in the Philosophy of Music: An Essay in the Philosophy of Music* (Gloucester, UK: Clarendon Press, 1992).

thesis, which does not pick sides in the ongoing debate, but nevertheless could be seen to lean towards certain perspectives.

The Musical Work

The initial inspiration for this research, Le Guin's discussion of Boccherini's cello works, does comes from a perspective of considering works as complete and existing in the score, but one which muddies the waters by pointing to the importance of performance in their creation. The arguments made in this thesis, focusing on the *processes* of musical composition, and the feedback loop between composer, performer, and technology, present or absent (the similar role of the audience remains to be explored in future research), may imply a certain perspective, that the work is in the process – but the fact that the pieces were written towards a goal of a finished *thing* seem to lead to another perspective – that of the work existing as the score, perhaps with many versions (different performances, recordings), and this is further muddied by the fact that it is the *recording* of *symmetry II* which is the 'finished work' as far as the thesis is concerned. There is one additional point that does seem worth making here. In practical terms, when considering the processes of musical composition as discussed in this thesis a 'work', in the mind of a composer, may be a goal which guides the processes of composition in a certain direction (see also later discussions of intent and affective framing) and therefore in itself becomes a tool.

Regardless, the most important thing to point out is that different musical traditions, or even different idioms within the same tradition, may have different views of the musical work. As discussed elsewhere, the thesis uses examples based on the idioms of the included composition portfolio, without being exclusive of other musical idioms or traditions (or indeed exclusive to only music). So, while the contents of the thesis could be read as placing it somewhere along the multi-dimensional axes of 'the work is the performance', 'the work is the recording', 'the work is the score', 'the work is the process, from start to finish, from initial idea to audience reception', 'the work continues to evolve after being "completed", picking up new significance over time', 'the work exists in its relationship to other works in the same tradition', or even 'the work is none of these things, but one or more of them may

be considered a *close approximation* of the work *qua* work', this thesis ultimately remains agnostic on the point of what constitutes a musical work.[20]

Actor Network Theory and Intertextuality

Actor Network Theory (ANT) as posited by Bruno Latour is another useful and related framework for understanding the role of connection in generating ideas and culture.[21] ANT sees actors as being best understood as a locus in a network. For Latour, when considering a scientific breakthrough, for example, it is not just the scientist that should be considered, but also the surrounding lab equipment, coffee mugs, radiators, computers, colleagues, papers, pens, lighting fixtures, telephones, nametags, and so on.[22] A useful musical example might be this one, by Charles Kronengold, as cited by Born and Barry:[23]

> The harpsichord is a perfect example of the Latourian non-human actor: it's [sic] a node in networks that include people, texts, bits of discourse, social conventions, institutions, objects, and spaces … [and is entangled] with pop, rock, jazz, and Western art music, record companies, and universities [as well as] materials science,

[20] On a personal note, and thus unsuited to the main text, I will say that it seems to me that to call something a 'work' implies the creation of a permanent artefact – be that a score or a recording – even if that artefact is then used to produce multiple different artistic events, such as in the case of a musical score having multiple performances. A 'performance of a work' seems a legitimate thing to say and this is also true of theatre, despite there often being *more* changes and interpretations between different theatre productions of a play than different performances of most notated musical works. The fact that an expert musician can read and understand a score *without* a performance (though, of course, with competencies built from an experience of and understanding of musical performance) further points to *the score* as a valid place for 'the work' to be situated. We have no problem considering a painting an artistic work, regardless of the embodied, extended processes which go into its creation, the intertextual network within which it sits, or the multiple ways said work may be presented, displayed, and understood by audiences. While as a musician I am often in favour of musical exceptionalism, it does seem odd to plant a flag so firmly in the camp of 'the work is in the performance', when surely that is an *aspect* of the work, not the work *in totalis*, and an aspect which is more or less important depending on the musical tradition being discussed. As to whether the score or recording of a work is the work itself, or simply a representation of the work itself (is there a platonic ideal of the work to which the score merely aspires?), I plead the right to have not yet formed an opinion.

[21] Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005). See Tara Fenwick and Richard Edwards, *Actor-Network-Theory in Education* (London, UK: Routledge, 2010) for an application to pedagogy.

[22] These 'Latourian litanies' were certainly in vogue in the early 21st century.

[23] Georgina Born and Andrew Barry, 'Music, Mediation Theories and Actor-Network Theory', *Contemporary Music Review*, 37, nos. 5-6 (2018), 443–487.

> freight-delivery services, political protests, American high-school students, and do-it-yourself culture.[24]

ANT has been further explored in musicology by scholars such as Christopher Haworth, who writes about non-human actors in the music of Xenakis and Cage,[25] and Benjamin Piekut, who has actively responded to criticisms of ANTs applicability to music.[26] Harman's development of ANT, along with Heideggerian analysis, into an exploration of the agency of objects also provides food for thought.[27]

The idea of ANT relates to the perhaps slightly less radical notion of intertextuality. Michael Klein's seminal *Intertextuality in Western Art Music* explores how the multivariate connections which might be discussed in an ANT context are indispensable for understanding the musical 'work'.[28] The newly released *Intertextuality in Music* demonstrates the staying power of the idea of intertextuality in musicology.[29] The discussion of the piece *des colombes et des crocodiles…* in Chapter Six provides practical perspectives on this idea.

Examples of studies of intertextuality in music include Jennifer Shaw, who has explored intertextuality in the work of Arnold Schonberg.[30] Robert Hatten also approaches this topic, claiming that viewing the musical work simply as a text and applying intertextual approaches is not the ideal way of understanding music through intertextuality.[31] Alessandro Miani takes a linguistic approach to intertextuality in music.[32] James Bunch's PhD thesis explores

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[24] Charles Kronengold, 'Harpsichords (and People) at the Limits of Mediation Theory', *Contemporary Music Review*, 37, nos. 5-6 (2018), 575-605 (577).
[25] Christopher Haworth, 'Protentions and Retentions of Xenakis and Cage: Nonhuman Actors, Genre and Time in Microsound', *Contemporary Music Review*, 37, nos. 5-6 (2018), 606–625.
[26] Benjamin Piekut, 'Actor-Networks in Music History: Clarifications and Critiques', *Twentieth-Century Music*, 11 (2014), 191–215.
[27] Harman, *Prince of Networks.*
[28] Michael Leslie Klein, *Intertextuality in Western Art Music* (Bloomington, IN: Indiana University Press, 2005).
[29] Violetta Kostka, Paulo F. de Castro, and William A. Everett, *Intertextuality in Music: Dialogic Composition*. (London, UK: Routledge, 2021).
[30] Jennifer Shaw, 'Arnold Schoenberg and the Intertextuality of Composing and Performance', *Context: Journal of Music Research*, 31 (2006), 109-121.
[31] Robert S. Hatten, 'The Place of Intertextuality in Music Studies', *The American Journal of Semiotics*, 3, no. 4 (2008), 69–82.
[32] Alessandro Miani, 'A Language-Based Approach to Music and Intertextuality', *From Modernism to Postmodernism: Between Universal and Local,* eds. Gregor Pompe, Katarina Bogunović Hočevar, and Nejc Sukljan (2016), 267–277.

intertextuality in the work of Sciarrino, whose markedly physical compositional process is itself relevant to the ideas discussed in the thesis.[33]

Music Cognition and Collaboration

Studies of music in 4E contexts generally focus on *present* and/or *physical* aspects of external cognitive tools and structures. Performance and improvisation have been widely studied,[34] and here the co-presence of fellow performers and the physicality of instrumental playing make the connection to general 4E arguments clear, even when not explicitly stated. There are also studies focused on the role of music itself, rather than the things involved in its creation, in certain cognitive processes (i.e., musical affordances). For example, there are studies exploring the affordances offered by music in day-to-day life,[35] and even music in infancy.[36] Dylan van der Schyff also discusses the embodied nature of musical emotion for 'bio-cognitive organisation', when looking at music as a tool in itself.[37] This can be linked to the work on emotion and empathy discussed in the previous chapter.[38]

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[33] James Bunch, *A Polyphony of the Mind: Intertextuality in the Music of Salvatore Sciarrino* (PhD. dissertation, University of Illinois, 2016).

[34] See David Borgo, 'Strange Loops of Attention, Awareness, Action, and Affect in Musical Improvisation', *Music and Consciousness 2: Worlds, Practices, Modalities*, ed. Ruth Herbert, David Clarke and Eric Clarke (Oxford: Oxford University Press, 2019), 113-24; Simon Høffding, 'Performative Passivity: Lessons on Phenomenology and the Extended Musical Mind with the Danish String Quartet', *Music and Consciousness 2: Worlds, Practices, Modalities*, ed. Ruth Herbert, David Clarke and Eric Clarke (Oxford: Oxford University Press, 2019), 127-42; Simon Høffding and Torben Snekkestad, 'Inner and Outer Ears: Enacting Agential Systems in Music Improvisation', *Philosophy of Improvisation : Interdisciplinary Perspectives on Theory and Practice, ed.* Susanne Ravn, Simon Høffding and James McGuirk (London: Routledge, 2021), 161-182; Marc Duby, 'Affordances in Real, Virtual, and Imaginary Musical Performance', *The Oxford Handbook of Sound and Imagination, vol. 2*, ed. Mark Grimshaw-Aagaard, Mads Walther-Hansen and Martin Knakkergaard (Oxford: Oxford University Press, 2019), 97-116; Justin Christensen, 'Improvisation: An Ideal Display of Embodied Imagination', *The Oxford Handbook of Sound and Imagination, vol. 2*, ed. Mark Grimshaw-Aagaard, Mads Walther-Hansen and Martin Knakkergaard (Oxford: Oxford University Press, 2019), 15-36.

[35] Joel Krueger, 'Affordances and the Musically Extended Mind', *Frontiers in Psychology*, 4 (2014); Joel Krueger, 'Music as Affective Scaffolding', *Music and Consciousness 2: Worlds, Practices, Modalities*, ed. Ruth Herbert, David Clarke and Eric Clarke (Oxford, Oxford University Press, 2019c), 55-70. We can also consider the role of music as a memory aid, for example in the alphabet song.

[36] Andrea Schiavio, Dylan van der Schyff, Silke Kruse-Weber and Renee Timmers, 'When the Sound Becomes the Goal: 4E Cognition and Teleomusicality in Early Infancy', *Frontiers in Psychology,* 8 (2017), 10.3389/fpsyg.2017.01585.

[37] Dylan van der Schyff, 'Emotion, Embodied Mind and the Therapeutic Aspects of Musical Experience in Everyday Life', *Approaches: Music Therapy & Special Music Education*, 5 (2013), 50–58. See also Joel Krueger, 'Music as Affective Scaffolding', *Music and Consciousness 2: Worlds, Practices, Modalities*, ed. Ruth Herbert, David Clarke and Eric Clarke (Oxford, Oxford University Press, 2019c), 55-70.

[38] Maiese, *Embodiment, Emotion, and Cognition*; Northoff, 'Is Appraisal "Embodied" and "Embedded"?'.

Mark Reybrouck has recently taken an enactivist approach to understanding musical sense-making as a process facilitated by interaction between mind, body, and musical stimuli.[39] Here Reybrouck also considers the important distinction between musical stimuli *in absentia* and *in praesentia* - though in smaller timescales than are being dealt with here - with regards to musical experience and how to understand music as a 'temporal art'[40] from an enacted cognition perspective. Where the processes of musical composition have been explored through an 'externalist' lens, this has primarily been from the perspective of collaboration,[41] and through embodiment,[42] which is only one of the 4 'E's (although, as Kevin Ryan and Andrea Schiavio note, the mind extending through the body is a crucial aspect of the 'second wave' of the Extended Mind Thesis),[43] and collaboration.

Reybrouck also sees music listening as an adaptive behaviour, rather than a passive experience. He discusses the in-time/outside-of-time dichotomy in terms of musical experience – seeing musical experience again as an active process. The potter at the wheel, used as an example by Malafouris, is also a productive analogy for understanding creative processes as a feedback loop between creator and created, rather than the unidirectional process which might be the traditional view.[44] Nicolas Donin and Jacques Thereau explore the problem of *long-term* creative cognition.[45] This relates to Reybrouck's interrogation of musical *experience* as being hugely influenced due to music being a temporal art.[46] These glimpses at a temporal approach are important for the arguments made in Part Two of this thesis.

[39] Mark Reybrouck, *Musical Sense-Making: Enaction, Experience, and Computation* (New York: Routledge, 2021).
[40] Ibid., 59.
[41] See e.g., Karlin Love and Margaret S. Barrett. 'Learning to Collaborate in Code: Negotiating the Score in a Symphony Orchestra Composers' School'. *Collaborative Creative Thought and Practice in Music*, ed. Margaret S. Barrett (London: Ashgate Publishing, 2016), 49–64. The line between collaboration and interpretation can probably be drawn where there are multiple instances of feedback between composer and performer.
[42] See e.g., Paul Craenen, *Composing under the Skin: The Music-Making Body at the Composer's Desk* (Leuven: Leuven University Press, 2014); Zvonimir Zagy, *Embodiment of Musical Creativity: The Cognitive and Performative Causality of Musical Composition* (London: Routledge, 2016).
[43] Kevin Ryan and Andrea Schiavio, 'Extended Musicking, Extended Mind, Extended Agency'.
[44] Lambros Malafouris, 'At the Potter's Wheel: An Argument for Material Agency', *Material Agency: Towards a Non-Anthropocentric Approach*, eds. Carl Knappett and Lambros Malafouris, (London, UK: Springer, 2008), 19-36.
[45] Nicolas Donin and Jacques Theureau, 'Theoretical and Methodological Issues Related to Long Term Creative Cognition: The Case of Musical Composition, *Cognition, Technology & Work*, 9, no. 4 (2007), 233–251.
[46] Reybrouck, 'Experience as Cognition'.

Phenomenological approaches to understanding music are many and varied. As mentioned earlier in this chapter, phenomenology has many links with the theories in philosophy of mind and cognitive science which are discussed in this thesis. In 1969, Philip Batstone discussed viewing musical analysis as phenomenology, opening the door for phenomenological approaches to understanding music.[47] Ihde, in 1976, explored *Phenomenologies of Sound,*[48] and later pursued work in embodiment and technology which mesh with the other literature discussed here.[49] David Clarke takes a phenomenological approach to music and time, following Husserl.[50] Margaret Chatterjee further discusses these approaches to time in music.[51] Georg Boenn provides another phenomenological perspective on the analysis of musical processes/aesthetics, examining Husserl's conception of internal time-consciousness.[52] Mark Reybrouck raises similar issues to do with time in music perception – arguing for the distinction between musical phenomena *in praesentia* and *in absentia* and the importance of understanding this when considering music as a temporal art form.[53] This has parallels with how we must consider composition – of a particular work and as a career – as taking place in time, and the implications of this. Paul Roe's PhD thesis considers a phenomenological approach to understanding collaboration in contemporary composition, with practical examples.[54] Simon Høffding's book on musical absorption takes a phenomenological approach through a case study.[55] David Clarke and Eric Clarke's *Music and Consciousness* also has many chapters which touch on perspectives of music and the mind.[56]

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[47] Philip Batstone, 'Musical Analysis as Phenomenology', *Perspectives of New Music*, 7, no. 2 (1969), 94–110.
[48] Don Ihde, *Listening and Voice: Phenomenologies of Sound, 2nd edition* (Albany, NY: State University of New York Press, 1976/2007).
[49] Don Ihde, *Technology and the Lifeworld: From Garden to Earth* (Champaign and Urbana, IN: University of Illinois Press, 1990); Don Ihde, *Bodies in Technology* (Minneapolis, MN: University of Minnesota Press, 2002).
[50] David Clarke, 'Music, Phenomenology, Time Consciousness: Meditations after Husserl', *Music and Consciousness: Philosophical, Psychological, and Cultural Perspectives*, ed. Eric Clarke (Oxford: Oxford University Press, 2011), 1-28.
[51] Margaret Chatterjee, 'Towards a Phenomenology of Time-Consciousness in Music', *Diogenes*, 19, no. 74 (1971), 49–56.
[52] Georg Boenn, 'The Importance of Husserl's Phenomenology of Internal Time-Consciousness for Music Analysis and Composition', conference paper presented at the *International Computer Music Conference, ICMC* (2008).
[53] Mark Reybrouck, *Musical Sense-Making*
[54] Paul Roe, *A Phenomenology of Collaboration in Contemporary Composition and Performance* (PhD thesis, Technology University Dublin, 2007).
[55] Simon Høffding, *A Phenomenology of Musical Absorption* (London, UK: Springer, 2018); This idea is then crystallised in Simon Høffding, 'Performative Passivity: Lessons on Phenomenology and the Extended Musical Mind with the Danish String Quartet', *Music and Consciousness 2: Worlds, Practices, Modalities*, ed. Ruth Herbert, David Clarke and Eric Clarke (Oxford: Oxford University Press, 2019), 127-42.
[56] David Clarke and Eric Clarke, *Music and Consciousness: Philosophical, Psychological, and Cultural Perspectives* (Oxford: Oxford University Press, 2011).

Eric Clarke and Mark Doffman have explored distributed creativity in music.[57] Vittorio Gallese and colleagues discuss creativity, imagination, and embodied simulation in 'Architecture and Empathy'[58] The concept of 'Dynamical Systems Theory' is explored by Schyff and colleagues as a way of understanding embodiment and musical creativity.[59] Schyff and Schiavio also apply embodied and enacted approaches to the study of the evolution of human musicality, which can be linked to Material Engagement Theory perspectives on the materiality of human cognitive development through time.[60] Relatedly, Jonathan de Souza has explored the role of instruments and 'music-at-hand' in musical cognition, discussing everything from bone flutes to pianos to electronic instruments, always looking at *bodily* interaction with *present* tools.[61]

This leads to discussions related explicitly to musical collaboration. Margaret Barrett's *Collaborative Creative Thought and Practice in Music* explores the importance of collaboration in creative music making,[62] leaving the door wide open for an exploration of the role of these collaborations when collaborators are absent or remembered (or virtual). Karlin Love and Barrett further explore the role of collaboration in musical pedagogy by studying the role of the score in composition workshops.[63] David Borgo examines the dynamic, recursive processes found in musical improvisation from the perspective of theories including embodied and enactive cognition.[64] Ashley Walton and colleagues have also

[57] Eric Clarke and Mark Doffman, *Distributed Creativity: Collaboration and Improvisation in Contemporary Music* (Oxford: Oxford University Press, 2017).
[58] Vittorio Gallese, Juhani Pallasmaa, Harry Mallgrave, and Sarah Robinson, *Architecture and Empathy* (Tapio Wirkkala-Rut Bryk Foundation, 2015).
[59] Dylan van der Schyff, Andrea Schiavio, Ashley Walton, Valerio Velardo, and Anthony Chemero, 'Musical Creativity and the Embodied Mind: Exploring the Possibilities of 4E Cognition and Dynamical Systems Theory', *Music & Science*, 1 (2018).
[60] Dylan van der Schyff and Andrea Schiavio, 'Evolutionary Musicology Meets Embodied Cognition: Biocultural Coevolution and the Enactive Origins of Human Musicality', *Frontiers in Neuroscience*, 11 (2017).
[61] Jonathan de Souza, *Music at Hand: Instruments, Bodies, and Cognition*, (Oxford: Oxford University Press, 2017).
[62] Margaret S. Barrett, *Collaborative Creative Thought and Practice in Music*, (London, UK: Routledge, 2016. See also Ian Cross, Felicity Laurence, and Tal-Chen Rabinowitch, 'Empathy and Creativity in Group Musical Practices: Towards a Concept of Empathic Creativity', *The Oxford Handbook of Music Education, Volume 2,* eds. Gary E. McPherson, and Graham F. Welch (Oxford: Oxford University Press, 2012).
[63] Karlin Love and Margaret S. Barrett. 'Learning to Collaborate in Code: Negotiating the Score in a Symphony Orchestra Composers' School', *Collaborative Creative Thought and Practice in Music*, ed. Margaret S. Barrett (London: Ashgate Publishing, 2016), 49–64.
[64] David Borgo, 'Strange Loops of Attention, Awareness, Action, and Affect in Musical Improvisation', *Music and Consciousness 2: Worlds, Practices, Modalities*, ed. Ruth Herbert, David Clarke and Eric Clarke (Oxford: Oxford University Press, 2019).

studied musical improvisation from an embodied perspective.[65] Adam Linson and Eric Clarke explore distributed cognition in group improvisation.[66] Similarly, Murphy McCaleb explores the importance of embodied knowledge when playing as an ensemble.[67] Andrea Schiavio and Schyff's approach to understanding 4E theories in music, focusing on the idea of 'autopoiesis' (self-flourishing) in relation to emergent dynamics in developing musically, is one of the few examples of pedagogical approaches which do not stop at the 'embodiment' barrier.[68] It is clear, however, that most of these studies relate to improvisation, collaboration, and performance –and focus on situations where the tools or collaborators are co-present. The idea of absence is not studied at all - hence the importance of Part Two of this thesis. Crucially, even these studies of *present* tools do not focus on composition.

There are some exceptions to this latter point, however. Zvonomir Nagy has explored embodied creative space in terms of music (and this can be related to work by Malinin mentioned above, which observes that many spaces are designed with creativity in mind).[69] This 'spacialisation' of musical thought can be related to Lakoff and Nunez's work in mathematics.[70] Anthony Gilbert argues that, when it comes to music, 'notions of space are a common metaphor'.[71] Nagy's *Embodiment of Musical Creativity* is a major work in approaches to understand the embodied nature of musical creativity.[72] Paul Craenen has taken a practice-based approach to understanding composition as an embodied process.[73] Ulla Pohjaranno has taken a similarly practice-based approach to understanding 4E perspectives

[65] Ashley E. Walton, Michael J. Richardson, Peter Langland-Hassan, and Anthony Chemero, 'Improvisation and the Self-Organization of Multiple Musical Bodies', *Frontiers in Psychology,* 6 2015, 6 (2015), 313.
[66] Adam Linson and Eric Clarke, 'Distributed Cognition, Ecological Theory and Group Improvisation', *Distributed Creativity: Collaboration and Improvisation in Contemporary Music,* eds. Eric Clarke and Mark Doffman (Oxford: Oxford University Press, 2017), 52-69.
[67] J. Murphy McCaleb, *Embodied Knowledge in Ensemble Performance* (London, UK: Routledge, 2017).
[68] Andrea Schiavio and Dylan van der Schyff, '4E Music Pedagogy and the Principles of Self-organization', *Behavioral Sciences* 8, no. 8 (2018), 72.
[69] Zvonimir Nagy, 'Music and Embodied Creative Space', *Journal of Genius and Eminence*, 4 (2020), 64–74.
[70] Lakoff and Núñez. *Where Mathematics Come From*; Núñez, 'Mathematical Idea Analysis: What Embodied Cognitive Science Can Say about the Human Nature of Mathematics'; Rafael Núñez, 'Do Real Numbers Really Move?'.
[71] Anthony Gilbert, 'Musical Space: A Composer's View', *Critical Inquiry*, 7, no. 3 (1981), 605–611. See also Gieser, 'Embodiment, Emotion, and Empathy'; Ingold, *The Perception of the Environment*.
[72] Zvonimir Nagy, *Embodiment of Musical Creativity: The Cognitive and Performative Causality of Musical Composition* (London, UK: Routledge, 2016); Malinin, 'Creative Practices Embodied, Embedded, and Enacted in Architectural Settings.'
[73] Paul Craenan, *Composing under the Skin: The Music-making Body at the Composer's Desk,* (Leuven: Leuven University Press, 2014).

on musical creativity.[74] In this thesis, however, while it is certainly hoped that the practice is of high quality, the role of the practice is to inform the theory, rather than the other way round.

Applied Musical Imagery, or Audiation

Audiation is a skilled application of musical imagery – often called 'the mind's ear', in parallel to the mind's eye. It describes the ability to accurately imagine sounds in response to some stimulus, be it a score, a gesture, a creative idea, and so on. Audiation is crucial to the arguments made in this thesis. This is due to the primacy placed upon it in traditional views of musical thought and creativity, as explored in the opening to this chapter, despite it having, as will be argued here and in Chapter Seven, a markedly material, embodied nature. The dynamic nature of Musical Imagery is explored by Freya Bailes, who observes that studies of musical imagery emphasise cognitive 'process rather than product'.[75] Bailes and Laura Bishop explore audiation as a part of the creative processes of music making.[76] Simon Høffding and Torben Snekkestad have explored audiation and feedback in improvisation, through a distributed cognition lens, exploring how the lines between internal and external can blend, and again implying that audiation is important for understanding this.[77] Andrea Schiavio, Damiano Menin, and Jakub Matyja focus on embodied simulation in music perception, exploring how listeners 'mirror' acts implied by the music.[78] Warren Brodsky and colleagues studied how notation, mental representation, and audiation might link.[79] These

[74] Ulla Pohjannoro, 'Embodiment in Composition: 4E Theoretical Considerations and Empirical Evidence from a Case Study', *Musicae Scientiae*, (2020); Ulla Pohjannoro, 'Mind the Body: Materiality and Physicality in a Composer's Thinking Process', *Psychology of Music,* 50, no. 4 (2022), 1169-83.
[75] Freya Bailes, 'Musical Imagery and the Temporality of Consciousness', *Music and Consciousness 2: Worlds, Practices, Modalities,* ed. Ruth Herbert, David Clarke, Eric Clarke (Oxford: Oxford University Press, 2019), 271–285.
[76] Freya Bailes and Laura Bishop, 'Musical Imagery in the Creative Process', *The Act of Musical Composition,* ed. Dave Collins (London, UK: Routledge, 2012). See also Margaret Elizabeth Moore, *Imagination and the Mind's Ear* (PhD thesis, Temple University, 2010).
[77] Simon Høffding and Torben Snekkestad, 'Inner and Outer Ears: Enacting Agential Systems in Music Improvisation', *Philosophy of Improvisation: Interdisciplinary Perspectives on Theory and Practice,* eds. Susanne Ravn, Simon Høffding, James McGuirk (London, UK: Routledge, 2021).
[78] Andrea Schiavio, Damiano Menin, and Jakub Ryszard Matyja, 'Music in the Flesh: Embodied Simulation in Musical Understanding', *Psychomusicology: Music, Mind and Brain,* 24 (2015), 340-343.
[79] Warren Brodsky, Yoav Kessler, Bat-Sheva Rubinstein, Jane Ginsborg and Avishai Henik. 'The Mental Representation of Music Notation: Notational Audiation'. *Journal of Experimental Psychology: Human Perception and Performance* 34, no. 2 (2008), 427–45.

studies provide an essential background to considerations made in the following chapter and in Part Two about the role of the tools and collaborators surrounding the composer.

Rolf Inge Godøy has explored the role of imagined actions in producing imagined sounds.[80] His edited collection on musical imagery with Harald Jørgensen contains many useful insights across its chapters.[81] These ideas are essential to the 'Integrated Tool Competency' conceptual framework proposed in Chapter Seven. Other specific studies of the role of gesture in musical imagery include Mariko Mikumo's demonstration that enacting the gestures of piano playing aided with melody recall;[82] and Bruno Repp and Günther Knoblich's discovery that *deceptive* performed or observed keyboard actions, not related to the heard pitches, negatively impacted pitch recognition skills.[83] This latter study implies that participants normally used these gestures and interactions to help identify pitches. One study of expert classical performers found that they scored lower on aural pitch replication tests than non-experts due to 'over-reliance' on notation, which could imply that gestural reference is more useful to audiation than the kind of expertise a performer will have with musical notation.[84]

Many studies in brain imaging and cognitive neuroscience have been done regarding musical imagery. Robert Zatorre and colleagues have used PET scans to investigate musical imagery,[85] and Martin Schürmann and colleagues attempted to use neuro-imaging techniques

[80] Rolf Inge Godøy, 'Imagined Action, Excitation, and Resonance', *Musical Imagery,* ed. Rolf Inge Godøy and Harald Jørgensen (Amsterdam: Swets and Zeitlinger, 2001), 237-250.
[81] Rolf Inge Godøy and Harald Jørgensen, *Musical Imagery,* (London, UK: Routledge, 2012).
[82] Mariko Mikumo, 'Motor Encoding Strategy for Pitches of Melodies', *Music Perception: An Interdisciplinary Journal,* 12 (1994), 175-97.
[83] Bruno H Repp and Günther Knoblich, 'Performed or Observed Keyboard Actions Affect Pianists' Judgements of Relative Pitch', *Quarterly Journal of Experimental Psychology,* 62 (2009), 2156-2170.
[84] Christopher Corcoran and Neta Spiro, 'Score-dependency: Over-reliance on Performing Music from Notation Reduces Aural Pitch Replication Skills', *Journal of Interdisciplinary Music Studies,* 10 (2020), 73-98. However, see Laura Bishop et. al, 'Musical Expertise and the Ability to Imagine Loudness', for a study which did find a correlation between musical expertise and certain aspects of audiation in the absence of tools. It is also worth noting that performers deal with notation in a unidirectional way (from written note to sounding pitch) as compared to composers, which may have caused this interesting result. Additionally, performers can always expect to have notation available when performing, reducing the need for competencies in its absence.
[85] Robert J. Zatorre, Andrea R. Halpern, David W. Perry, Ernst Meyer, and Alan C. Evans, 'Hearing in the Mind's Ear: A PET Investigation of Musical Imagery and Perception', *Journal of Cognitive Neuroscience,* 8, no. 1 (1996), 29–46; Robert J. Zatorre, Andrea R. Halpern, David W. Perry, Ernst Meyer, and Alan C. Evans, 'Mental Concerts: Musical Imagery and Auditory Cortex', *Neuron,* 47 (2005), 9-12.

to discover where audiation occurs in the brain.[86] Laura Bishop and colleagues explored the ability to imagine loudness in the context of musical expertise.[87]

Edwin Gordon has done a considerable amount of work on audiation from a pedagogical perspective.[88] Bruno Adolphe's book, *The Mind's Ear*, offers practical exercises for students wishing to improve their skills in audiation. The book uses the idea of the 'imagined performer' as an exercise.[89] This is interesting in the context of Chapter Nine, where the 'imagined performer' is argued to be crucial for the cognitive processes of composition.

Composers, Tools, and Influence

Much material exists on the use of computer technology for score and sound production and teaching, but this often has a practical basis, rather than focusing on impacts for an understanding of the compositional process.[90] Daniel Walzer, for example, has explored the impacts of DAW-based teaching of music,[91] and provided a guide for teaching through a software-based methodology.[92] Christopher Dobrian explores virtual instruments from the point of view of aesthetics.[93] Adria Hoffman and Bruce Carter look at how a 'virtual composer-in-residence' could be useful for musical pedagogy.[94] Andrew Johnston and colleagues' work on virtual instrument interface design shows the importance that is placed

[86] Martin Schürmann, Tommi Raij, Nobuya Fujiki, and Riitta Hari, 'Mind's Ear in a Musician: Where and When in the Brain', *NeuroImage*, 16, no. 2 (2002), 434–440.
[87] Laura Bishop, Freya Bailes, and Roger T. Dean, 'Musical Expertise and the Ability to Imagine Loudness', *PLOS ONE* 8, no. 2, e56052 (2013).
[88] Edwin E. Gordon, 'Research Studies in Audiation: I', *Bulletin of the Council for Research in Music Education, 84* (1985), 34–50; Edwin E. Gordon, 'All about Audiation and Music Aptitudes', *Music Educators Journal*, 86, no. 2 (1999), 41–44.
[89] Bruce Adolphe, *The Mind's Ear: Exercises for Improving the Musical Imagination for Performers, Composers, and Listeners* (Oxford: Oxford University Press, 2013).
[90] See, for example, Samuel Bennett, *Computer Orchestration: Tips and Tricks*. PC Publishing, 2009). Interestingly (dare I say worryingly?) the advertising for this book includes a promise that 'little or no musical notation knowledge is needed' to create 'realistic sounding' orchestrations.
[91] Daniel Walzer, 'Blurred Lines: Practical and Theoretical Implications of a DAW-based Pedagogy', *Journal of Music, Technology & Education*, 13, no. 1 (2020), 79-94.
[92] Daniel Walzer, 'Software-Based Scoring and Sound Design: An Introductory Guide for Music Technology Instruction', *Music Educators Journal*, 103, no. 1 (2016), 19–26.
[93] Christopher Dobrian, 'Aesthetic Considerations in the Use of "Virtual" Music Instruments', *Proceedings of the Workshop on Current Research Directions in Computer Music* (2001).
[94] Adria R. Hoffman and Bruce A. Carter, 'A Virtual Composer in Every Classroom', *Music Educators Journal*, 99, no. 3 (2013), 59–62.

on playing, interactivity, feedback, and so on.[95] The role of technology in assisting in score-based musical practice has also been explored.[96]

There are some studies which can be related to the ideas in the previous chapters. Jeff Pressing and others have discussed the experience of performed sound in virtual spaces.[97] Thor Magnusson discusses 'epistemic tools' (tools for producing knowledge) and extends this to include digital instruments.[98] Mark Marrington, like Magnusson, explores the role of Digital Audio Workstations (DAWs) as mediators in musical composition from a phenomenological perspective.[99]Simon Holland and colleague's edited collection on music and human-computer interaction demonstrates the wealth of practical and theoretical implications of the use of modern music technologies.[100] Stephen Dillon and Andrew Brown have explored the 'meaningful relationships' accessed through the use of virtual instruments and ensembles.[101]

Peter Simons has written about the issues thrown up by computer composition, with reference to Husserl and Ingarden, and the idea of the 'work' itself.[102] Robert Strachan's exploration of sonic technologies provides a good example of music technology being studied in musicology.[103] Adam Parkinson explores the affordances offered by computer performance.[104] Ian Macchiusi has pointed to the importance of 'the visual' when working

[95] Andrew Johnston, Linda Candy, Ernest Edmonds, 'Designing and Evaluating Virtual Musical Instruments: Facilitating Conversational User Interaction', *Design Studies*, 29, no. 6 (2008), 556–571.
[96] See, for example, Ed Hughes, Alice Eldridge, and Chris Kiefer, 'Syncphonia: Understanding the Value of Participatory Design in Developing Music Technology to Support Musical Ensembles That Use Notation', *Journal of Music Technology & Education*, 13, no. 1 (2020), 57–77.
[97] Jeff Pressing, 'Some Perspectives on Performed Sound and Music in Virtual Environments', *Presence: Teleoperators and Virtual Environments*, 6, no. 4 (1997), 482–503.
[98] Thor Magnusson, *Epistemic Tools: The Phenomenology of Digital Musical Instruments* (PhD thesis, University of Sussex, 2009a); Magnusson, 'Of Epistemic Tools'.
[99] Mark Marrington 'Experiencing Musical Composition in the DAW: The Software Interface as Mediator of the Musical Ideal', *Proceedings of the 6th Art of Record Production Conference* (2010), 1-8.
[100] Simon Holland, Katie Wilkie, Paul Mulholland, and Allan Seago, *Music and Human-Computer Interaction* (London, UK: Springer, 2013).
[101] Stephen C. Dillon and Andrew R. Brown, 'Access to Meaningful Relationships Through Virtual Instruments and Ensembles', *Proceedings of the ISME Commission for Community Music Activity: CMA XII Harmonizing the Diversity that is Community Musical Activity* (2010), 33-36.
[102] Peter M. Simons, 'Computer Composition and Works of Music: Variation on A Theme of Ingarden', *Journal of the British Society for Phenomenology*, 19, no. 2 (1988), 141–154.
[103] Robert Strachan, *Sonic Technologies: Popular Music, Digital Culture and the Creative Process* (London, UK: Bloomsbury, 2017).
[104] Adam Parkinson, 'Embodied Listening, Affordances and Performing with Computers', *Proceedings of ICMC '13* (2013), 162-168.

with digital audio workstations.[105] Geoffrey Wilson has explored his own practice in terms of integrating virtual instruments into compositional practice.[106] Paul Ramshaw asks whether music production should be considered composition.[107] Joshua Banks Mailman has attempted to explore phenomenology, technology, and embodiment in music through a practice-led approach.[108] James McDermott and colleagues present an interesting discussion about the 'ease of use' of musical technology and whether or not that is a good thing.[109] Exploring the role of compositional technology, from manuscript paper to Digital Audio Workstations (whether easy to use or not), is the next step for the thesis.

This chapter has demonstrated that there has been some post-Cartesian theorising in musicology, particularly in the past decade. These studies have largely focused on collaboration, performance, and influence. However, when considering some crucial aspects of the compositional process, such as musical imagination, there is still a leaning towards the traditional view of the tools of composition as merely expedients towards communication of a musical idea existing entirely in one's head. Musical imagery has been identified as an essential problem to tackle while trying to answer the central research question of this thesis: what is the role of absent tools in the cognitive processes of musical composition? Firstly, however, in order to answer the first sub-question (what is the role of present tools in the cognitive processes of musical composition?), the following chapter will apply the understandings developed through the previous three chapters to present a view of the composer at work, 'thinking through things', with compositional processes fundamentally rooted in materiality, embodiment, and the surrounding environment.

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[105] Ian Macchiusi, *'Knowing is Seeing': The Digital Audio Workstation and the Visualisation of Sound* (PhD thesis, York University (Toronto), 2017).
[106] Geoffrey Wilson, *An Autoethnography on Film Composition Practice: Integrating Virtual Instruments and the Live Performance Realisation within the DAW* (MA thesis, Masters, University of Huddersfield, 2018).
[107] Paul Ramshaw, 'Is Music Production now a Composition Process?' Paper presented at the *First Annual Conference on the Art of Record Production* (2006).
[108] Joshua Banks Mailman, 'Cybernetic Phenomenology of Music, Embodied Speculative Realism, and Aesthetics-Driven Techné for Spontaneous Audio-Visual Expression', *Perspectives of New Music*, 54, no. 1 (2016), 5–95.
[109] James McDermott, Toby Gifford, Anders Bouwer, and Mark Wagy 'Should Music Interaction Be Easy?', *Music and Human-Computer Interaction*, eds. Simon Holland, Katie Wilkie, Paul Mulholland, and Allan Seago (London, UK: Springer, 2013), 29-47. There is certainly a problem with certain music technologies where they are designed to be so easy to use that if you try to use them in an even *slightly* different way than intended, they become worse than any alternatives.

CHAPTER FIVE: The Composer at Work, Thinking Through Things.

To close Part One of this thesis, this short chapter will take the literature explored above and apply it to musical composition as closely as possible. It is worth noting here that the included musical practice, and therefore many of the related examples, is directly related to notated music written for future performance. However, the ideas developed in this thesis are applicable across a much broader range of musical practice, and even to other creative fields beyond music, and so this focus on notated music should not be seen as exclusionary, either practically or philosophically, but simply the lens through which the research questions are answered.

This chapter will therefore explore manuscript paper, emotion and gesture, instruments, performers, and digital technology. While, as mentioned in the previous chapter, there has been work which attempts this, this chapter attempts to draw a general conception of musical composition through all the relevant literature discussed so far. This means that in some cases it may go further than existing studies of composition, but without necessarily progressing the surrounding literature. It will serve, in combination with the previous chapters, as both a useful perspective on composition in itself, and as a solid foundation from which to build the arguments made in Part Two of the thesis.

Manuscript Paper

Nicholas Cook, in describing the materiality of Beethoven's compositional process, observes that 'as you pore over the sketchbooks, you have an almost visceral sense of Beethoven's pen digging into the fibrous, handmade paper as he struggled to give expression to some recalcitrant, half-formed idea.'[1] This is a compelling view of the score: as something to interact physically with, as something which forms part of a feedback loop, as something which, for a time, constitutes part of the cognitive processes of composition. In inscribing notes onto the paper with the pen, perhaps 'seeing through' both technologies so that they

[1] Nicholas Cook, *Music: A Very Short Introduction* (Oxford: Oxford University Press, 2000), 66-67.

become transparent in the pursuit of the musical goal, the composer may feel as though the music comes naturally. The composer enters into a feedback loop between the 'music-produced-so-far' and the 'music-yet-to-come'.[2] As Feynman said, 'you have to do the work on the paper.'

The notion of offloading - that objects in the environment can serve to ease the cognitive load of certain tasks - is important for current theories in cognition. A non-musical example would be physically re-arranging tiles when playing Scrabble to find a word, rather than simply doing so 'in the head'. What this means, for the composer working with manuscript paper and pen, is that the compositional environment provides opportunities for offloading. The musical 'text-produced-so-far' not only influences future musical thought, it also acts as an external memory source. When working on a complicated idea, the notation is not just a necessary record to instruct a future performer of the work, it is an essential part of the *working* memory of the composer when creating that section of music.[3]

As Husserl noted, humans are 'sensorially and emotionally attuned to our surroundings'. This means that composers, in working on manuscript paper, while they are *changing* that aspect of the environment, they are also then influenced by it. These influences may be subtle. For example, upon writing out one part, a composer might notice that one of the notes has a certain relationship to a note on a previous page or might relate to an understanding of the specific instrument (for example an open string on a guitar) – especially if this is during a process of orchestration where the pitches may have been written with a different instrument in mind initially. The notation on the stave goes from left to right temporally, from low to high in terms of pitch. This spatialisation of musical thought therefore allows for the piece to be understood outside real time, and thus the composition takes shape, in the most literal sense. If we are 'spatial, bodily creatures, good at frisbee but bad at logic', by placing the abstract in space, we make it concrete, malleable - solvable.[4]

So, if cognition indeed 'depends upon the kinds of experience that come from having a body',[5] then the cognitive processes involved in working with manuscript paper to complete

[2] Alva Noë, *Strange Tools: Art and Human Nature* (New York, NY: Hill and Wang, 2015).
[3] See e.g., Clark, *Natural-Born Cyborgs,* 73.
[4] See Lakoff and Núñez. *Where Mathematics Come From.*
[5] Varela, Thompson, and Rosch, *The Embodied Mind,* 173.

compositional tasks are not purely internal. These cognitive processes are not merely being recorded by writing them down, they involve the 'composing body'[6] in a number of ways. Once this material engagement with paper has taken place, the 'music-produced-so-far' is then present in the environment and affects the music-yet-to-be-produced.

There is also the case of other, existing, notated music. In pursuit of inspiration, composers can turn to the pile of scores on their desk and pore through the fossilised thought of other composers to see how they solved a similar problem. Whether physically present, remembered, or integrated, composers have access to a wealth of influences. This is explored in Chapter Six in the context of *des colombes et des crocodiles…*, which was inspired by the work of Beethoven in numerous ways. The way that agents use their environment to change themselves also has particular significance here.[7] As well as influences in the form of scores, composers may also take creative influence from their environment. As explored by Malinin, the *non-musical* environment may also be a potent source of inspiration, consciously or unconsciously.[8] Additionally, influence does not have to be limited to the same type of art – this is explored in Chapter Eight in the context of *symmetry I* and *symmetry II*.

Notation also goes some way to making *present* the absent eventual performers of the work – and this will be looked at in the final chapter. After all, as much as a score is a 'text', which interacts with and takes influence from the texts which surround it, it is also a set of physical instructions to performers, and most composition takes place in a space absent of the performers who will eventually interpret the work. This issue will be dealt with in the Part Two of the thesis.

Emotion and Gesture

There is another way the body may become engaged while working with notation to create music.[9] As Maiese has argued, choosing a 'handful of sand to call the world' allows for cognition and perception, where otherwise there would be too much data to process –

[6] See Craenen, *Composing Under the Skin.*
[7] E.g,. Noë, *Strange Tools*; Clark, *Supersizing the Mind.*
[8] Malinin, 'Creative Practices Embodied, Embedded, and Enacted in Architectural Settings'.
[9] There is a huge amount of *imagination* at play here too, but this will be explored in Part Two of the thesis – particularly relevant here is the idea of *necessary* competencies.

emotion, then, is another means by which we ease the cognitive load. As Kreuger has argued, music itself has a 'scaffolding' role when it comes to emotion,[10] and this must also be present when working on music. Here this scaffolding is perhaps in the form of guiding the composer's intent, in a recursive loop of embodied emotional feedback. This idea will be explored in more depth in Chapter Six, as it relates to competencies developed through the use of tools.

While gestures which directly relate to the actions of performance will be more relevant in Part Two of this thesis, gestures which might be termed *metaphorical gestures* are also an important part of certain cognitive processes of musical composition.[11] In imagining a rising gesture, for example, the composer might perform some action which has a 'rising' feel – the most obvious being raising the hand. These gestures have been observed in students trying to solve mathematical problems,[12] and given the oft-discussed links between music and mathematics, it seems reasonable to argue that this would also be the case for composers, at all stages of their development.

Instruments

An embodied engagement with absent instruments may well be an important part of the compositional process – such as acting out the motion of changing positions on a violin when writing a violin part. In these instances, the body is a *present* tool, but this will be explored in more depth in Part Two of the thesis when considering the *absent* nature of the instrument and performer in question. Instruments which are ready-to-hand, however, are an important compositional tool to discuss at this point.

When interacting with instruments there is a much more instantaneous and obvious connection between gesture and result, compared to either writing notes on a page or making the metaphorical gestures mentioned above. This could include testing out notated work-in-progress, or, in an improvisatory manner, working through some initial ideas. If the composer is also a performer, this may even include a complete 'performance' of the work.

[10] Krueger, 'Affordances and the Musically Extended Mind'.
[11] Metaphor in general, as a tool for composition rather than as an aspect of the work in question, could be a fruitful area for future study.
[12] Alibali and Nathan, 'Embodiment in Mathematics Teaching and Learning'.

Instruments, as 'epistemic tools',[13] function as repositories of musical information. In interacting with them, composers may update their body schema,[14] altering their perception of available sounds, and thus the way they think.

By interacting with the piano, the composer offloads cognitive work, as the process of audiation is offloaded to some degree onto the piano, and the sonorities of complex chords are made clear. This offloading will be compared to digital technology in a later section of this chapter. When using the piano to write a piece for different instrument(s), this feedback is limited in its accuracy, therefore still requiring other competencies to function in this way. The idea of necessary competencies for technological 'transparency' is discussed in the following chapter. But here we can take it as read that depending on the experience of the composer, the closeness of fit between composer and instrument may reach varying levels of transparency, with different impacts on the conscious experience of composition. Despite humans being 'primed in order to take part in hybrid cognition regimes,'[15] problems with using a tool can cause it to lose transparency – as Heidegger argued and Dotov and colleagues have shown empirically.[16] When interacting with an instrument as a tool of composition, then, the composer's individual skill level (and ability to extrapolate further musical ideas from what they are able to produce on the instrument) will likely influence the compositional choices made.[17]

Performers

When writing for a performer, notation and performance norms are essential: imagine if composers had to explain every aspect of performance *in totalis*. By understanding a score or instrumental part as a communication with, as well as a set of instructions for, a performer, the work is realised more appropriately and more easily. The connection with a present performer is one which can be described through the various theories of empathy explored in

[13] Magnusson, 'Of Epistemic Tools'; Reybrouck, 'Music Cognition and the Bodily Approach', de Souza, *Instruments at Hand*.
[14] Cardinali et al., Leman, *Music and Schema Theory*.
[15] Clark, *Natural-Born Cyborgs*, 86.
[16] Dotov et al., 'A Demonstration of the Transition from Ready-to-Hand to Unread-to-Hand'.
[17] In Chapter Six, the use of the voice to develop the skill of audiation is discussed, and this could also be considered an 'instrument' for this purpose.

the previous chapter. As has been explored by Love and Barrett, these acts of collaboration are an important part of compositional life.[18]

When working closely with a performer, trying out material and making suggestions, the composer has instant access to an empathetic understanding with the performer. It may also be that when working closely with a performer, unknown techniques, sounds or ways of realising material may come to light. Similarly, while a performer could potentially play a certain realisation of musical material or a certain musical gesture, they might suggest another, perhaps easier, way of doing a similar thing. It is also possible to draw a distinction between a) a performer declaring something impossible to play and the *composer* re-writing that part; and b) a performer declaring something impossible to play and suggesting a new part, perhaps with slightly different musical connotations. This 'creative offloading' is a potent form of cognitive offloading which crosses the boundaries into collaboration and shared creativity.

An example of this in practice came about during a workshop with the Birmingham Contemporary Music Group (BCMG). In pursuit of a certain sonority during a two-part heterophony between the woodwinds and strings, the harp part ended up being incredibly impractical. However, both the conductor and the harp player understood the intention of this section of the piece, and it was collaboratively decided which notes to remove from the harp part in order to retain the impact of the section. This demonstrates the role of present performers in the compositional process, as, had the impracticality of the harp part been clear before the workshop, it would have likely been changed in different ways. The value of this experience in *future* compositional work, on both a practical (writing better harp parts) and creative level - especially in situations where performers are absent - will become clear through the arguments made in the following chapters.

So, an instrument provides auditory feedback, but the performers who will perform the work provide not just this auditory feedback but *physical* and *intellectual* feedback. In a workshop or rehearsal situation, the physical actions and resulting sounds are ready-to-hand, as is any feedback about issues such as playability. In these latter situations, the performer becomes a collaborator, whose practical and artistic understanding (itself developed through a rich

[18] Love and Barrett, 'Learning to Collaborate in Code'.

musical life) is brought into the creative, problem solving 'network'. For a view of composition drawn from the literature in the previous chapters, this is only available to composers *when performers are present* – and, perhaps, when a composer is writing at the same instrument for which they are composing. As such, this view will be developed further in Part Two of the thesis.

Digital Technology

Eve Klein has explored in depth the ways in which virtual instruments 'imitate' real performers, and the fact that virtual instruments often 'capture' elements of real performance.[19] This shows the effort which has been made to make them a tool for 'acoustic' composition, rather than a separate tool in their own right. In an interview about virtual instruments, the film composer Hans Zimmer talks about having the players he knows at his fingertips – it is not 'just a string library, it is the actual players'.[20] This supports the claim that these instruments are 'virtual performers', rather than just sampled instruments. This links to the discussion of *absent* performers which will close the thesis.

It is worth noting that there has been a significant development in these virtual instruments, especially those intended for film composers. They have much more detail than individual techniques from a single input. Some of these 'virtual instruments' have actually captured detailed performances, more than just a single note played in a single way, and are then put into a package. There is also an emphasis on 'playability'. What this means is that a user can hold down a single note, or a chord, and this will trigger long, evolving performances – essentially some of the composition is already done. Similarly, pre-orchestrated instruments are common, where all the high woodwinds, for example, have been recorded with appropriate balancing and dovetailing. These start to blur the lines between composer and tool and raise the question as to where the 'epistemic credit'[21] lies for the resulting music. How different this is from quickly scribbling a '*crescendo con vibrato ad libitum'* above a semibreve on a piece of manuscript paper remains to be debated.

[19] Eve Klein, 'Feigning Humanity: Virtual Instruments, Simulation and Performativity', *IASPM Journal*, 6, no. 2 (2016), 22–48. See also Craig Ashley Morgan, *The Use of Virtual Instruments by Australian Screen Composers* (PhD thesis, University of Sydney, 2016) for a practical study.
[20] https://youtu.be/GDJeo67LqWA?t=94
[21] Preston, 'The Extended Mind, the Concept of Belief, and Epistemic Credit'.

Consider also digital writing, editing, and engraving of a musical score. In contrast to Nicholas Cook's description of 'Beethoven's pen digging into the fibrous, handmade paper' as 'no disembodied act',[22] digital score-writing feels almost immaterial. On one hand, Kirsh describes interacting with the video game Tetris to rotate a block, as opposed to imagining rotating the block, as a 'physical' act, and points out how the former is more efficient in finding a place for the block to fit.[23] This sets a precedent to see interaction with digital software along the same lines as interactions with other tools. On the other hand, there does seem to be less of a *physical* connection to the musical work when inputting notes digitally than when writing them onto paper. This disconnect could lead to a change in the way competencies are developed, given that the integration of physical actions and their results is an important aspect of this process, as discussed above.

Another contrast with writing on pen and paper is that digital notation software allows direct audio feedback, with the option to play back notes on input, to play back a section once it has been written, or a combination of the two. These auditory affordances open up the possibility of working in a constant feedback loop of editing and playback, more akin to a potter at the wheel than a traditional view of the compositional process.[24] While there may be a disconnect between physical actions and notation when working digitally, there is a *stronger* connection between notation and audio, at least while the tool is present, even without a well-developed 'mind's ear'.

Thor Magnusson notes how new digital instruments are designed with music theory in mind in a much more explicit way than traditionally.[25] Similarly, in reference to popular music, Strachan discusses how digital tools are designed to give a certain 'experience' in use – they are designed with transparency in mind.[26] From this perspective, the digital tools of

[22] Cook, *Music: A Very Short Introduction*, 67.
[23] Kirsh, 'The Intelligent Use of Space', 61-62.
[24] See Malafouris, 'At the Potter's Wheel'.
[25] Thor Magnusson, 'Of Epistemic Tools: Musical Instruments as Cognitive Extensions', *Organised Sound,* 14, no. 2 (August 2009): 168–76.
[26] Strachan, *Sonic Technologies,* 68; Although it is worth noting that this can mean that these tools become suddenly very opaque the moment a composer attempts to use them in a way for which they were not designed.

composition are a perfect example of how humans 'make the world smart so we can be dumb in peace'.[27]

A final example of digital tools is the 'piano roll' interface used to inscribe MIDI information in most DAWs.[28] These interfaces place notes as lines of a length representing duration, and a height representing pitch. Also, rather than having 7 steps in an octave, as on a stave, with accidentals used to achieve the other notes in the 12-note system, the piano roll has 12 subdivisions. These two factors of a) democratising pitches and b) representing rhythm through simple lines denoting duration, are examples of 'properties intrinsic to DAWs […] that have a fundamental bearing on what musicians and producers actually *do.*'[29]

Considering the feedback loop of editing and playback which was discussed above in terms of notation software, the piano roll interface makes working in this way far more intuitive and therefore more likely to involve transparency. It allows for the formation of a cognitive system in which, for experienced users, the software and its interfaces are completely 'seen-through' in the pursuit of the musical goal. Unlike with manuscript paper and pen, however, this is designed and built into the systems themselves. What this might mean for how we understand composition using this technology, and how this technology requires and generates different competencies from and in its users, is a key focus for Part Two of this thesis.

This chapter has presented an understanding, based on an application of the literature explored in the previous chapters, of musical composition as an embodied process which is connected to the environment - social and material - of the composer. However, through applying these theories to composition in this way, an objection has arisen:

> However compelling the 4E view might be, it does not explain how composition in the *absence* of the relevant tools or collaborators is possible. And it clearly is possible.

[27] John Sutton, 'Exograms and Interdisciplinarity: History, the Extended Mind, and the Civilizing Process', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 189-226 (194).
[28] Digital Audio Workstations are ubiquitous pieces of software for recording, editing, arranging, and rendering synthesised and recorded audio.
[29] Strachan, *Sonic Technologies,* 62.

Part Two will seek to answer this objection, taking as a foundation all that has been discussed in Part One. This will include analysis of the composition and recording of the included portfolio. In doing so, the hypotheses described in Chapter One will be tested, providing potential answers to the research question which motivates this thesis: What is the role of absent compositional tools in the cognitive processes of musical composition?

Conclusion to Part One

Part One has served to situate the research questions through exploring relevant literature. Key concepts include the sensorimotor and ideomotor systems, the 'parity principle', and 'transparent technology'. While it has also begun to answer the research questions, a number of key gaps in the surrounding literature have been identified:

1) The 4E theories which underpin this research focus almost exclusively on co-present tools/people when considering relevant cognitive processes.
2) Where there is a temporal dimension, this is offloaded, so to speak, onto cultural artefacts and signifiers. While this 'ratcheting'[30] is important, it is not the whole story as far as this thesis is concerned.
3) Where these ideas have been applied in musicology (and, in fact, in general pedagogical research), this has largely been focused on *embodiment*, ignoring the other 'E's.
4) Where *musical composition* has been explored through these lenses, these same three gaps are evident.
5) 'Internality' is still seen as the *default* understanding of cognition. Theorists seem to argue 'see, this is the same as internal reasoning' as evidence for the use of an external tool or the body as part of a cognitive process.

These issues are tackled in the second part of the thesis through the development and testing of the two hypotheses identified in Chapter One: Firstly, that the use of tools by composers shapes the cognitive processes of composition, even when those tools are absent. Secondly, that the experience of working with performers similarly shapes these processes.

[30] Michael Tomasello, *The Cultural Origins of Human Cognition* (Cambridge, MA: Harvard University Press, 2001).

PART TWO: FRONTIERS

This second part of the thesis will tackle the gaps in the literature, and the potential objection to a 4E understanding of the compositional process, towards the generation of the two hypotheses above. Given the importance of the insights gained through composing and recording the composition portfolio, Part Two begins with the first part of the musical commentary. It then develops the conceptual framework 'Integrated Tool Competency' as a way of understanding the role of absent tools in composition. This understanding can then, after the second part of the musical commentary provides relevant insights, be applied to understanding the relationship between composer and absent performer, thus making progress towards answering the research questions which motivate this thesis.

CHAPTER SIX: Musical Commentary, Part One; *Emergence//Overture* and *des colombes et des crocodiles…*

This commentary serves to ground the research in compositional practice, through examining the *process* of composing these musical works. As has been mentioned above, it is the insights gained from composing these pieces, and from being a practising composer, which are useful to the arguments made in this thesis. This is opposed to a traditional composition PhD, where a certain theoretical framework is usually explored in terms of how it *influences* or is *demonstrated in* the composition portfolio. In this case it is the analysis of the compositional process which influences the theoretical framework. It is advised to listen to the work in question before and after reading the relevant section, and to have the recording and score to hand while reading.

The largest contribution to practice from these pieces is in the novel use of digital technology within the tradition of notated music. Specific techniques used in the compositions, such as the lack of developmental characteristics in symmetry II, the chord rotations used in

Emergence//Overture, the use of modal centres in *des colombes et des crocodiles*, the detailed orchestration and performance directions and the use of stark contrasts and solo phrases in all the pieces, continue to develop these ideas in the ever-broadening context of the 21st century.[1] The specific approach to extramusical influence in symmetry I and II could also be explored further in a research project less focused on the *process* of musical composition and more on the results.

This chapter focuses on two pieces intended for 'real' performers, which were then recorded using virtual performers due to external circumstances. Thankfully, a number of important insights were gained from this process. Primarily, this section focuses on the recording process of the piece *Emergence//Overture*, for large orchestra and 12 soloists. The smaller piece, *des colombes et des crocodiles…,* for string orchestra, acts as a brief commentary on the role in the compositional process of influence, intertextuality, and the cognitive surroundings of the composer.

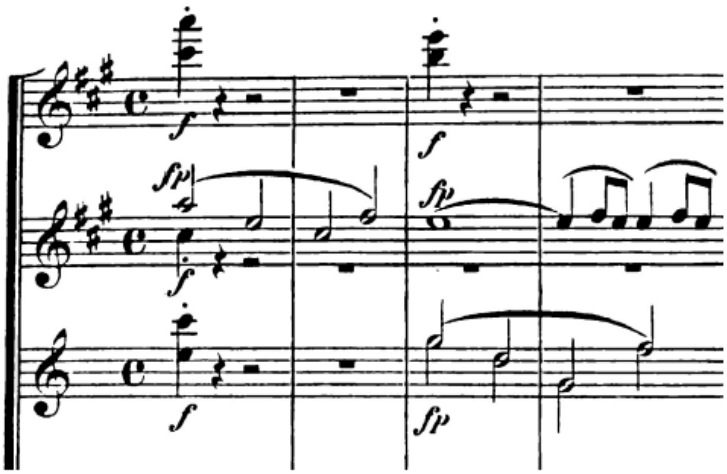
des colombes et des crocodiles…

Composed for string orchestra to celebrate Beethoven's 250th anniversary, *des colombes et des crocodiles…* takes its name from a critique by Guiseppe Calvini, a contemporary of Beethoven, who lamented - to paraphrase - that 'one doesn't know how to feel. The music of Beethoven harbours doves and crocodiles together!'[2] The role of Beethoven's music was not a typical, direct influence, due to the vast stylistic differences between his music and my own. The piece instead explores the contrasts described by Calvini, but in a contemporary context, through texture and dynamics. The primary influence of Beethoven, then, is second-hand – through attempting to create musical analogues to 'doves' and 'crocodiles'.

[1] Ideas which again relate to the three composers mentioned in the introduction: Messiaen, Boulez, and Takemitsu. On a personal note, unsuited to the main text, it seems to me important to continue to develop within the tradition of notated music for ensembles and soloists, even while continuing to push boundaries with electronics, improvisation, new instruments, and so on, and even (especially?) while celebrating the greater variety of musical offerings from completely outside the classical tradition both within and without conservatoire/concert hall/academic settings.

[2] *Après avoir pénétré l'âme d'une douce mélancolie, il la déchire aussitôt par un amas d'accords barbares. Il me semble voir renfermer ensemble des colombes et des crocodilles [sic].* Giovanni Giuseppe Cambini in *Les Tablettes de Polymni*, March 1811.

This piece can be used here as a brief commentary on the role of influence and intertextuality in the context of understanding the 'cognitive equipment' which surrounds a composer, and how this equipment influences compositional thought and re-shapes related competencies. The recording process of this piece was similar to that of the following piece explored in this commentary, *Emergence//Overture*, except it was much simpler due to the piece itself being less complex.[3] This recording process is important, and so is explored in the next section in detail.



Musical Example 1. The opening of Beethoven's 7th symphony, which provided the scaffolding for *des colombes et des crocodiles...*

While listening to Beethoven's music, the idea for the harmony of the piece became clear. The basis of its harmony is the first 8 notes of Beethoven's 7th symphony (see Musical Example 1), stretched to last for the duration of the piece. Each note provides a central point around which the various other musical elements are placed. Especially in the case of the arabesques, this functions in a similar way to some of Pierre Boulez's later works. What follows is an initial analysis of the work.

In the first section of the piece, the first note of Beethoven's 7th is extended through harmonics, in a bowed tremolando, in half the violins. The held notes, in the violas and the other violins are ornamented by quiet arabesques and trills. The first moment of contrast

[3] I also feel that the recording for *Emergence//Overture* is more effective. This may be because the complexity of the material and orchestration means the virtual performers have to do less 'heavy lifting', compared to in a simpler piece. I am still hopeful for a performance of *des colombes.*

comes with a dramatic entry of the lower strings. The arabesques become more frequent, until they build to a sudden, *forte* chord across the whole orchestra.

In the second section, the second note of Beethoven's 7th is held in half the violins and violas, while two solo violins play gestures on top of it. These are punctuated by *fortissimo* chords in the rest of the orchestra. The third section transitions to revolve around the third note of Beethoven's 7th, played using harmonics and fortified by small gestures. There is then a declamatory phrase played *forte* by the whole orchestra, before quiet harmonics are used to transition to the next section.

In the fourth section, the piece becomes pulsed for the first time, focusing on an ostinato based around the fourth note of Beethoven's 7th, which then, through a solo passage in the violin, transitions to the fifth note of the symphony, answered by swelling notes played across the orchestra in the fifth section of the piece.

The sixth section returns to a non-striated form, with harmonics and held notes, punctuated by arabesques, based around the sixth note of Beethoven's 7th. *Fortissimo* chords in the lower strings add dramatic contrast, and a solo in the viola leads to the penultimate section of the piece, which is based around the seventh note of the symphony. Here the note is played with a variety of techniques across most of the orchestra, while the violins play separate gestures above it. Two violas play a gesture in duet, leading to the eighth and final note of the opening melody of the 7th symphony. It is played very softly, surrounded by harmonics and quiet notes played *sul tasto,* to bring the piece to a close.

In terms of the immediate cognitive environment of the composer, the score for Beethoven's 7th acted as external memory and influence, an example of the 'ratcheting effect' described in Material Engagement Theory, while the expanded rendition of each note in *des colombes* then acted as 'music-produced-so-far', influencing the additional parts added to the piece, which give it its character. Therefore, both Beethoven's 7th symphony and '*des colombes*-in-progress' were, by the end of the compositional process, equally influential. The direct contribution of the intertextual influence of Beethoven is further demonstrated when listening to the recording of *des colombes* sped up 18-fold (included in the same folder as the original recording in the portfolio). In this sped up recording, the opening of the 7th symphony can be clearly heard. This demonstrates that Beethoven's music has provided scaffolding - an

allusion to cognitive scaffolding - for a very different kind of music, nevertheless descended from the same tradition.

Emergence//Overture for large orchestra including 12 soloists.

Emergence//Overture commences with a lone oboist on stage. As the oboe plays, other soloists join one by one, building a harmonically rich polyphonic texture. The soloists introduce every piece of musical material which is used for the rest of the piece. When all the soloists are present and playing, building to a crescendo, the orchestra enters and prepares to play. The soloists then play the role of 'leaders' of their sections, and similarly the rhythmic complexity is the purview of the conductor. The orchestra explores the opening material in contrasting sections of pulsed and un-pulsed (striated and non-striated) rhythms, with short reprises of the soloistic moments from the opening section. The trajectory of the piece is that of building towards a sudden silence – after which the ear expects the start of something new. Hence, 'Overture'.

Written initially with West Road Concert Hall, Cambridge in mind (see Figure 2), the examination of this piece begins the exploration of the role of imagined, remembered and virtual environments in the cognitive processes of composition. The vision of imagined performers, entering the stage one by one, heavily influenced the musical material, and this provides a satisfying emphasis to the arguments made in the thesis for the role of absent performers in the compositional process. The recording of this piece was created digitally, and this part of the commentary primarily examines the insights gained from examining this process. These insights themselves have also contributed to the creation of *symmetry II*, which will be examined further on in the commentary.

Figure 1. West Road Concert Hall, Cambridge, the performance space which inspired *Emergence//Overture*.[4]

As mentioned in Chapter One, the process of creating the recordings of the portfolio pieces is as much a part of the research as the process of their composition. *Emergence//Overture* was not originally intended to be recorded using virtual instruments. As such, it has turned into a useful study into what can be learned from recording an existing score in this way. When writing for a real performer, the score is a means of communication with real people, who, through notation or text, can be instructed to perform certain actions, such as gradually moving the violin bow from the neck to the bridge, or to play with characteristics such as 'lightly', *rubato*, and so on. It is therefore only necessary to understand the limitations of performer and instrument. Additionally, real performers will add their own nuances and expression to the written part, no matter how detailed, and will bring their own ideas to the piece in rehearsal.

In making a virtual recording, however, it is necessary to mould every note to achieve the same effects. In Iannis Xenakis's thesis defense, in conversation with Messiaen, the latter discusses how important it is 'to know' and 'to love' your material.[5] In that instance, it was the mathematically generated and manipulated pitch material which was being discussed. Here though, it is the fact of having to pay attention to every level of detail to appropriately interpret the piece.

[4] Image from www.meet-cambridge.com/venue/west-road-concert-hall
[5] Iannis Xenakis and Olivier Messiaen, *Arts-Sciences, Alloys: The Thesis Defense of Iannis Xenakis Before Olivier Messiaen, Michel Ragon, Olivier Revault D'Allonnes, Michel Serres, and Bernard Teyssèdre* (Hillsdale, NY: Pendragon Press, 1985), 31.

This is especially true of dynamics and timings at the micro-level, where performers will naturally lean into a note, or add a gradual crescendo, depending on the part and context. When making a virtual recording it is necessary to do all this manually using automation – or, where this has been included in the sample, sometimes removing this manually through the same process. This can lead to a deeper relationship with the musical material in these situations where the composer is also the 'producer' of the virtual recording.[6] This is perhaps analogous to when a composer performs or conducts their own work. This is also the reason behind referring to these recordings as 'performances'[7] rather than, for example, 'digital realisations'. Were it necessary to create a new recording from scratch, so many of these micro-level decisions around dynamics, timings, and so on, would be different, even if exactly the same effects and settings were used – akin to the differences between different 'performances' of a work in the traditional sense.

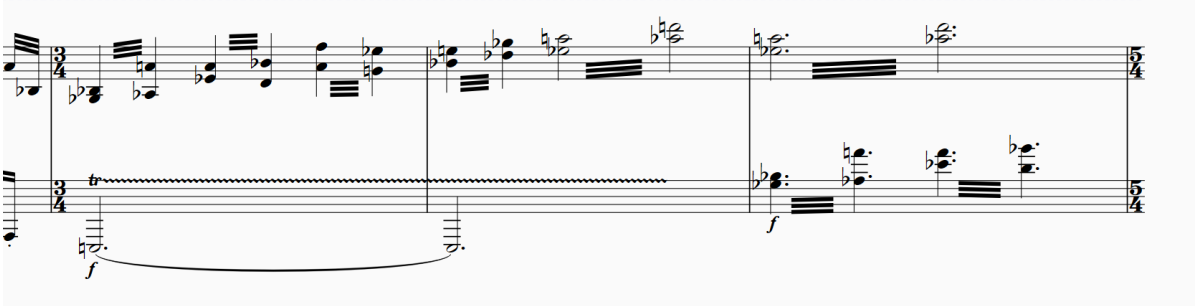
Additionally, when working with virtual performers, if the sound or technique desired is not part of the sample library, it is not available. *Emergence//Overture* was written for real instruments and performers, and it became necessary to 'fake' certain techniques, or re-write them, for the virtual recordings. Where quarter tone lip bends were written in the woodwinds, for example, the note had to be recorded twice, with the second note tuned up or down by a quarter tone artificially. An equal decrease/increase in volume was then automated from the note in standard tuning to the note which was a quarter tone flat/sharp. This crossfading between notes tricks the ear into hearing the note smoothly decreasing in pitch by a quarter tone.

Another related issue was the sostenuto (middle) pedal on the grand piano. This pedal was used in the original score to add resonances triggered by the notes played by the piano. This was not programmed into the sampled piano.[8] To achieve this effect, a second piano track was created. The harmonics triggered by the played notes, given the notes held by the sostenuto pedal, were approximated by ear, and then recorded onto this track using samples which had been made while the damper (sustain) pedal was depressed. Volume automation

[6] Writing a piece using these tools directly (as opposed to recording an already written piece) has some different impacts, discussed later in Chapter Eight.
[7] and the virtual performers, 'performers', though this is also due to their functioning as tools in ways related to both present and absent performers
[8] I do not believe that there are any sampled pianos which include true replication of the sostenuto pedal, due to the almost infinite number of combinations of depressed keys/played notes.

was then used on this track to remove the initial attack of the notes and to create a realistic balance between these sustained harmonics and the played notes. This was then mixed with just the piano, then the piano and the other solo instruments.

For one particular figure in the piano, the recording process actually revealed a considerable amount about the material and its playability. The initial figure, shown notated in Figure 1, asked the performer to arpeggiate a series of chords as fast as possible. Due to the tempo and therefore the speed of changes, and the amount the left hand was asked to do, it was clear that much of the work of realising this material was left up to the pianist.[9]



Musical Example 2. Original version of bars 111-113 of *Emergence//Overture*, using arpeggiated tremolandi (see Chapter Seven for discussion of this notation technique in a situation where its use is effective). 05:11 in the recording.

[9] This is done effectively by composers such as Brian Ferneyhough, where *attempting to play* impossible notation actually achieves the desired result, but here it did not fit with the way the rest of the piece was written.

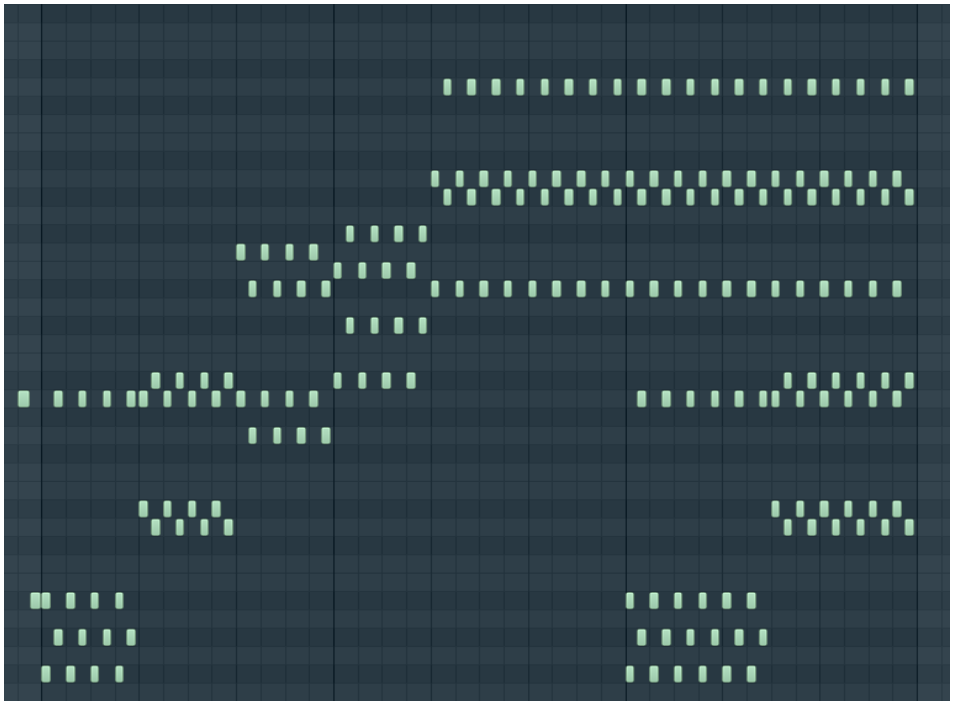


Figure 2. The MIDI data produced from the original version of the score for bars 111-113 of *Emergence//Overture*.

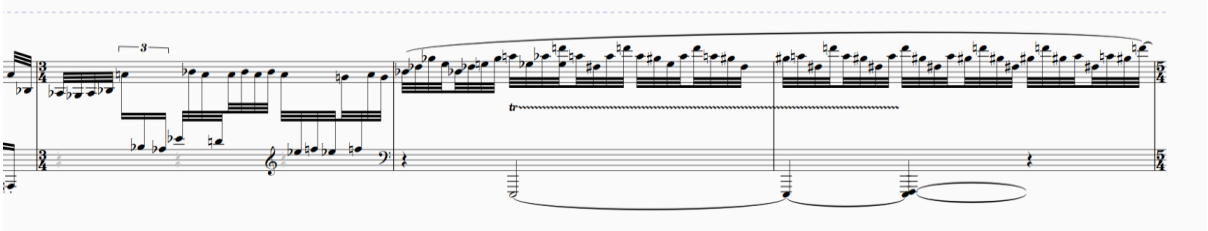
As mentioned above, when creating a recording digitally, it is necessary to mould every note. Essentially, to take on the role of conductor, recording engineer, and instrumentalist, as well as composer. In undertaking to realise this gesture on the piano, it became clear that notating the *specific* gesture, rather than just asking the performer to arpeggiate a series of very rapid chords, would achieve the desired effect in a more consistent and effective manner. The MIDI data (extracted from the original score) is shown in Figure 3. As well as showing the complexity of the part – which also detracted from the harmonic role of the gesture – it shows how a direct translation of score into notes does not look or sound anything like a real performance.

Through looking at the MIDI data, considering how a pianist would play the notated score, and listening to the results, multiple decisions were made, in addition to the decision to explicitly write out the figure. The removal of the left-hand trill allows the left hand to help the right hand with the ascending line, before jumping back down to play the trill as the right hand finishes the arpeggiated final bar. This replaces the additional arpeggios in the left hand which reduced the playability – and the trill keeps the harmonic role of the gesture clear.

Figure 3. The final MIDI data for bars 111-113 of *Emergence//Overture* after the editing process

So, in having to focus in on the details, a higher degree of empathy with the eventual performer became necessary, and resulted not just in a more successful recording, but an improved notated score. The real instrument (the piano), the imagined performer (the pianist), and the virtual performer all influenced both the composition and its recording. It is worth noting that the MIDI notes in the final version are not perfectly synchronised, yet this is not reflected in the score. This lack of synchronisation is to mimic *performance* and so does not need to be represented on the final score. This further speaks to the relationship between composer and performer. Even in detailed notation, elements of how the part will be played

are left entirely to the performer.



Musical Example 3. The final version of bars 111-113 of *Emergence//Overture* after the editing process.

The imagined performers were an integral part of the original compositional process. They existed as 'dramatic actors', walking on stage to join the lone oboe, as expert section leaders reprising their opening solo roles throughout the piece, as 'black-boxed' instrumental sections, where only the *resulting* sound was consciously thought about, and as future *collaborators* who were communicated to through both notation and written instructions. In the eventual recording, these performers were now 'virtual', which had considerable impacts for how the score was understood.

Chapter Nine of this thesis will explore in depth this role that absent performers play in the compositional process. The role of *tools* in influencing compositional creativity, however, has been made clear in this discussion of the process of recording *Emergence//Overture*. The literature in Part One implies that the cognitive role of these digital tools is a revolution of instance, not of kind. That is, compositional tools have always had a degree of influence on compositional creativity, and they have always formed part of the cognitive systems which make up the complex process of creating a musical work. Each new tool is therefore 'revolutionary' in its own right, in that it may open up different affordances (and also close off certain affordances). Nevertheless, the fact of a tool contributing to creativity is not, in itself, revolutionary.

The recording process of *Emergence//Overture* shows how the tools of composition both provide access to creative offloading, but also require a level of skill, including skill not directly related to the tool in question, to be used intuitively and transparently. Digital tools also demonstrate the importance of the relationship between composer and performer, and this will be explored further in Chapters Eight and Nine. The next chapter will develop the conceptual framework of Integrated Tool Competency to provide a means to understand how the use of tools in the past affects a composer's competencies in the present – providing a

way to understand the role of these kinds of tools in the compositional process, even in their absence.

CHAPTER SEVEN: Integrated Tool Competency

Part One of this thesis ended in exploring the role of present tools and performers in the cognitive processes of musical composition. This chapter breaks new conceptual ground, through exploring the role of *absent* tools in the relevant cognitive processes of musical composition. This is achieved through the development of the concept of 'Integrated Tool Competency', referring to competencies developed and retained, in the context of the literature discussed in the opening chapter, through the use of tools. Through case studies, examples, and thought experiments, this concept will be elaborated, and its impacts discussed.

As shown in the opening chapter, studies which focus on music and imagination, and studies which focus on music cognition in a 4E context, are largely separate. This reinforces the idea that a 4E understanding of creative cognition is only relevant when specific tools are in use. This is what leads to the objection to the vision of the compositional process discussed in the Chapter Five: As compelling as its view of composition might be, it ignores what is happening in the *absence* of some or all of these tools. It ignores what is happening in the absence of pen, paper, piano, computer and so on, when compositional work is still clearly possible.

The simple answer to this objection might be that tools *can* be integrated into the cognitive processes of composition, but that they don't *have* to be. That is, even if one were to accept the externalist view of composition *when the composer is using tools*, the traditional view of composition, as an internal process of which the score is merely a record, would be correct the rest of the time. However, it seems more consistent to take a ground-up approach to understanding internal representation, where the 'ground' is an understanding of cognition and creativity as fundamentally embodied, extended, embedded, and enacted. This chapter argues this point primarily through the claim that the cognitive use of tools not only makes possible (or easier) certain cognitive processes, but also develops our capacity to complete similar tasks in the absence of those tools. In some instances, this claim simply re-affirms and synthesises arguments cited above. However, in the more radical cases, where tools and related gestures are completely absent from the process in question, it becomes an attempt to break new conceptual ground.

Integrated Tool Competency

This chapter proposes the concept of 'Integrated Tool Competency' as a way of understanding the role of absent tools in musical composition. As a working definition, Integrated Tool Competency refers to cognitive abilities developed through the use of tools. These abilities

a) remain in the absence of those tools and

b) could not be (or have not been) achieved without those tools.

For composition, this concept extends the integration of tools into a composer's cognition beyond the moment of their use, including both unconscious competencies such as audiation and conscious actions such as imagining using a certain tool.

How might a tool become 'integrated' under this conceptual framework? We could consider five stages, often overlapping. An application of these stages to the cognitive processes of musical composition will follow in the examples below, but here they are described in their most general form.

1) Being able to make use of a tool as part of performing a cognitive task. This may even be to the point where it can be considered 'transparent' as described by Clark.[1] This stage is slightly complicated by the fact that some competencies may need to be developed and integrated in order for this tool to function as part of the cognitive apparatus, or for transparency to be achieved.[2]

2) Being able to make use of conscious, embodied referral (i.e., gestures) to a remembered tool when performing a cognitive task.

3) Being able to make use of conscious referral to a remembered tool when performing a relevant cognitive task, without an accompanying physical gesture.

[1] Clark, *Natural Born Cyborgs.*
[2] Ibid., 37. Latour, *Reassembling the Social*, 210.

Instead, the agent *imagines* using the tool and this aids in the completion of the cognitive task.

4) Being able to *unconsciously* refer to a tool used in the past, when confronting a relevant cognitive task. Interestingly, this could include unconscious bodily movement, despite being a deeper level of integration than embodied gestural reference to a past tool. In this instance, the agent is not aware that this is how they are completing the task. It is still being 'referred' to, but, in the same way that present technology can become transparent in use, the referral to the tool has become so dovetailed that it happens transparently.

5) Being able to complete a relevant cognitive task without either conscious or unconscious referral to a past tool. The cognitive function the tool serves has become so integrated into the being of the agent, has perhaps developed so much surrounding competency in brain and body, that the task is simply *done*. This seemingly internal cognitive competency has, in fact, been developed through the use of a tool, perhaps could not have been developed without the use of that tool, and has been integrated through multiple extended, embodied stages.

These final two stages of integrating a tool-related competency are hard to separate from the point of view of the agent in question. Nevertheless, they are different conceptually. They also take the greatest departure from existing literature. In fact, one could even argue that it is unnecessary to explore these final two stages. After all, the prevailing view of cognition, which externalist accounts challenge, is that concepts and capacities are held in the mind, in the brain, inside the skin. Surely here we can just look to the wealth of 'traditional' work in the philosophy of mind and related disciplines, as explanations of how these seemingly interior stages function.

However, if a fundamental aspect of cognition is that we are embodied beings situated in a cognitively useful world, it is strange to have a completely different perspective on any cognitive process which does not clearly entangle itself with 'external' things in the moment it is taking place. The Integrated Tool Competency concept is a proposal for how to start to bridge this gap, by providing a framework for exploring how the use of tools shapes the mind, even in the absence of those tools.

Integrated Tool Competency argues that the use of tools in creative pursuits, such as musical composition, engenders competencies that would not exist without the past use of these tools. The referral to an absent compositional tool acts in the same way as a referral to a present tool, in the relevant cognitive process, whether consciously or unconsciously, or the tool may be instrumental in developing a cognitive competency which requires no such reference. As such, the tools of composition can not only be considered essential as constituent parts of the cognitive processes of composition in the moment of their use, but as essential in their integration as part of the cognitive competencies of the composer.

Applications

Audiation

There is a particular compositional skill which can be productively explored through Integrated Tool Competency: audiation. Audiation is the skill of hearing accurate sounds in one's head, either from reading notation, as a creative or improvisational act, in response to imagining playing an instrument in a certain way, or a combination of the above. As explored in Chapter Three, musical imagery, or the 'inner ear', has been widely studied, and audiation could be productively considered as *directed* musical imagery. As audiation is seen as an important part of a musician's development, much has been written on the best ways to develop it.[3] Audiation is trained by exercises, by listening to music and reading scores, by learning instruments, and by interacting with the tools of composition when composing.[4] Especially when considering notation, it is a learned skill, developed through the use of tools: scores, instruments, and even the composer's own voice.

The idea that imagining or acting out the action required to produce a sound is a mechanism by which an agent can 'hear' the sound internally is explored by Godøy in his 2001 article,

[3] See Edwin E. Gordon, 'Research Studies in Audiation: I'. *Bulletin of the Council for Research in Music Education*, no. 84 (1985), 34–50; Edwin E. Gordon, 'All about Audiation and Music Aptitudes', *Music Educators Journal*, 86, no. 2 (1999), 41–44.

[4] See also Laura Bishop, Freya Bailes, and Roger T. Dean, 'Musical Expertise and the Ability to Imagine Loudness', *PLOS ONE* 8, no. 2 (27 February 2013) https://doi.org/10.1371/journal.pone.0056052, a study which found that expert musicians were more capable of imagining loudness and changes in loudness.

'Imagined Action, Excitation, and Resonance'.[5] He argues that 'the visualisation of movement as trajectories in time-space could be an integral element of imagining a sound.'[6] Reybrouck specifies ideomotor simulation,[7] as the mechanism by which this occurs. He points out that

> 'the transition from overt action (sensorimotor) to internalized (ideomotor) forms of action […] does not imply the abandoning of the sensorimotor control systems that link the sensors to the central nervous system and the effectors (the muscles). It only cuts off the actual manifestation of the output or effector side of the control system.'[8]

This implies that, along with the metaphorical/emotional gestures discussed in Chapter Four, composers may engage in gestures which directly relate to the sound production of the musical part they are writing. These may be accurate or not – and this matters more for Chapter Eight, where the relationship between composer and performer is considered – but, for Godøy and Reybrouck, they are directly tied to the imagined sound, as a means by which composers 'experience' a sound which is not there.

As a thought experiment, and an example of an application of the Integrated Tool Competency conceptual framework to a relevant compositional skill, it is interesting to therefore consider the development of the skill of audiation through the use of an already quite integrated tool – the voice. Applying the stages of developing a competency to the development of the skill of audiation through singing might look something like the following:

> 1) Vocalisation - actively singing to find or match a note or phrase, heard and/or written.[9]

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[5] Godøy, 'Imagined Action, Excitation, and Resonance'.
[6] Ibid., 241.
[7] For a musicological exploration of this relationship in both directions (motor behaviours to assist auditory imagery, auditory imagery to assist motor behaviours), see David Allen, 'Mental Representations in Clarinet Performance: Connections Between Auditory Imagery and Motor Behaviours' (PhD. dissertation, University of Sheffield, 2009).
[8] Mark Reybrouck, 'Musical Imagery between Sensory Processing and Ideomotor Simulation', *Musical Imagery*, ed. Rolf Inge Godøy and Harald Jørgensen (Amsterdam: Swets and Zeitlinger, 2001), 129-130.
[9] For further exploration of the role of instruments other than the voice in aiding musical cognition, see Mark Reybrouck, 'Music Cognition and the Bodily Approach' and see de Souza, *Instruments at Hand*.

2) Sub-vocalisation – 'imagining' singing to find or match a note or phrase, but still activating some of the relevant muscle groups. When one actively imagines talking, for example, the speech apparatus engages despite no noticeable movement of lips, tongue and jaw, and no sound production. In 1995, J. David Smith and colleagues explored the role of sub-vocalization in audiation,[10] and Warren Brodsky et al. demonstrated in a 2008 study that sub-vocalisation plays a part in notational audiation.[11]

3) Imagined vocalisation without sub-vocalisation – 'imagining' singing to find or match a note or phrase, without relying on activating any muscle groups. This requires a higher level of integration, as it does not rely on active embodiment in the same way as sub-vocalisation. This allows the skill of audiation to break away from various restrictions imposed by active vocalisation or by sub-vocalisation, such as only being able to sing one line at a time, being restricted in register, or requiring all the musical imagery to be real-time.

4) Unconscious imagined vocalisation – feeling as though the correct notes are simply being imagined when needed, but still being achieved through unconscious referral to vocalisation, which may even include some unnoticed activation of various relevant muscle groups. This may further allow the skill of audiation to break away from the restrictions mentioned when considering imagined vocalisation above.

5) Complete transparency – simply hearing the correct notes at will or when engaging with visual stimuli. This is the final point of integration, and different from the previous stage as there is not even any unconscious referral to the mechanisms of singing. This is interesting because of *how this state of transparency was reached*.

This application of Integrated Tool Competency shows how it might be productively applied to various complicated issues of musical competency. The sub-vocalisation stage, and the

[10] J. David Smith, Margaret Wilson, and Daniel Resiberg, 'The Role of Subvocalization in Auditory Imagery', *Neuropsychologia*, 33, no. 11 (1995), 1433-1454.
[11] Warren Brodsky, Yoav Kessler, Bat-Sheva Rubinstein, Jane Ginsborg and Avishai Henik. 'The Mental Representation of Music Notation: Notational Audiation'. *Journal of Experimental Psychology: Human Perception and Performance* 34, no. 2 (2008), 427–45.

studies evidencing it, also provide a useful bridge between the various overlapping stages, demonstrating how studying certain aspects of musical competency which are unique to music can contribute to a general understanding of creative cognition. This example also underlines the point that there are numerous studies, empirical and theoretical, which can be synthesised to explain the first stages of the development of an integrated competency, whereas the latter stages are an attempt to break new conceptual ground.

It might be argued that many composers report imagining and creating music in their heads before learning how to write scores or use other musical tools to a high level of proficiency,[12] and that this discredits the extended mind view of composition. Audiation is important as a defence against this potential objection. Given that audiation is a skill which is partly developed by listening to music, it could be argued that, through listening to music, certain sounds (and aspects and combinations of those sounds, and even initial understandings of how those sounds are produced) become integrated; and re-combining them becomes possible. So, if the skill of audiation can in part be developed simply by listening to music, this would explain composers reporting being able to imagine new music in their heads before having had formal training. However, there will be considerable differences in these initial musical images as compared to when the skill has been developed from learning an instrument, singing, using manuscript paper, or a combination of the above.

Digital Technology

Digital technology, particularly notation software, is a good place to start when considering *differences* between the competencies developed and integrated through the use of different tools. On one hand, the act of writing using notation software is less material than on paper, making conscious or unconscious referral to physical actions and their results more difficult (what muscle memory is there from inputting notes on a screen as compared to interacting directly with paper?). Similarly, the offloading of skills as complex as audiation and instrumental knowledge onto the virtual environment in such a complete way could perhaps

[12] 'I started composing in my head to relieve boredom while playing football [at school.]' Christopher Dingle and Julian Anderson, *Julian Anderson: Dialogues on Listening, Composing and Culture*, (London: Boydell Press, 2020), 276. Interestingly, Anderson goes on to discuss how difficult it was to then write down those ideas. Overcoming this tension between idea and tool is clearly important.

reduce a composer's competency in those skills in the absence of that environment.[13] The designed transparency of the software could also limit the potential competencies retained after its use, as well as any attempts to perform tasks outside its intended use. On the other hand, the audio feedback of digital software offers a direct link between the visual and the auditory, which could aid in the development of notational audiation.

A consideration of notation software is that a score is also a set of instructions for performers. While notation software will warn about notes which are outside the standard playable range of an instrument,[14] it does not factor in any other practical considerations. Of course, neither does manuscript paper. The point here is that the software plays back what is written regardless of playability, whereas with paper and pen the 'playback' will not happen if the part isn't playable (in a performance, workshop, or rehearsal) or if the composer doesn't have the level of competency (which requires some practical understanding of the instrument) to 'hear' what has been written. The importance of having an understanding of performer as well as instrument will be explored in Chapter Eight.

Required Competencies, Intent, Refreshment, Subscription

If tools can be integrated into the body schema, and these effects persist after use,[15] and the body forms part of cognition, then this already lays the groundwork for the *cognitive* use of tools being integrated. Integrated Tool Competency provides a possible explanation for how the experiences of being part of powerful cognitive networks might shape the way composers plan new pieces, in the same way that it could be argued that working closely with expert performers shapes the way composers write complex music. Different competencies may be created through the use of different tools – but different competencies may also be *required* to use certain tools. The framework helps understand which competencies are developed through working with tools. It is also worth considering how certain of these competencies

[13] See Corcoran and Spiro, 'Score-dependency' for an example of this happening to certain classical performers with regards to notation.
[14] This can itself be an issue, as many expert performers will be able to comfortably play outside this range – thus unnecessarily restricting the music if Sibelius's warnings are taken at face value.
[15] Cardinali et al., 'Tool-use Induces Morphological Updating of the Body Schema'; Willett et al., High-Performance Brain-to-Text Communication Via Handwriting'.

may need to be developed before successfully working with other tools.[16] We construct cognitive worlds, but how do we use them?[17] This provides a more sophisticated picture of the process of composition, before Chapter Eight provides another piece of the puzzle – an exploration of the role of absent performer.

Considering the powerful affordances of virtual compositional tools, composers may develop competencies which still require access to those tools. To put it another way, they may develop competencies related to knowing where in the software to turn to solve a problem, rather than integrating experiences of being part of a cognitive system and retaining those competencies in the absence of that system. Digital tools may be a kind of cognitive equipment to which one must remain 'subscribed', as described by Bruno Latour.[18] The fact that the complex layers of affordance offered by DAWs are explicitly designed to feel like an 'embodied whole'[19] may lead even experienced composers to think, 'I know I can write this piece, I just need to get to my computer.'

As mentioned in Chapter Four, 'affective framing' and intent may be an important aspect of how environments offer affordances.[20] Consider trying to take a photograph of a forest, compared to running through that same forest. When trying to take a photograph, the eyes are looking for interesting combinations of colours, or trying to find a composition that matches those photographs which one has seen in the past. As soon as the world is framed through the action of running, the rocks, roots, and mud suddenly take on a new significance. The eyes and feet of the runner now experience the world as a series of affordances for running, and the rest of the body adjusts as necessary. Given the various imaginative and practical tasks completed during a period of composition, it seems that this 'affordance switching' is crucial, whether conscious or not, to the moment-by-moment compositional process.

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[16] As Clark puts it, in discussing transparent technology and how it dovetails with the biological organism, this may require both a 'natural fit' and the 'systematic effects of training'. Clark, *Natural-Born Cyborgs*, 38.
[17] Clark, *Supersizing the Mind*, 59; Latour, *Reassembling the Social*, (Oxford: Oxford University Press, 2005), 210.
[18] Latour, *Reassembling the Social*, 210. Relatedly, see Betsy Sparrow, Jenny Liu and Daniel M. Wenger, 'Google Effects on Memory: Cognitive Consequences of Having Information at our Fingertips', *Science*, 333 (2011), 10.1126/science.1207745 for an exploration of a phenomenon regarding search engines, whereby users know they have access to information and therefore don't remember it, they just remember the steps they have to take to access it..
[19] Strachan, *Sonic Technologies*, 67-69.
[20] Maiese, *Embodiment, Emotion, and Cognition*; Witt et al., 'Tool Use Affects Perceived Distance'

Accessing those competencies, then, may require a certain 'affective framing', or a level of intention. Also, some tools may require competencies in order to use – or in order to use transparently – thus putting a limit on how competencies are developed. This implies that it is important to develop certain competencies, and therefore to know whether different tools will engender the development of different competencies. In composition this is particularly important. As has been argued here, using notation software without integrated competencies to do with audiation (and an understanding of performer and instrument) can lead to less effective use of that software.

It is argued here that an experienced composer has access (consciously or unconsciously) to experiences of various aspects of the cognitive systems involved in musical composition. These include the physical motions, the auditory feedback, the musical results, and so on. There may also be competencies which have been developed through the use of these tools to the point where not even unconscious referral is required. This allows for the completion of more complex compositional tasks *in the absence* of tools such as pencil and manuscript paper than would have been possible had they never been used. In other words, the skilled use of cognitive equipment is essential to the process of composition, and through using these tools, the composer will develop competencies which remain when those tools are absent.

This chapter has proposed a conceptual framework by which to understand the mechanisms by which tools may become integrated into a composer's cognitive competencies. Integrated Tool Competency refers to cognitive abilities developed through the use of tools. These abilities remain in the absence of those tools and could not be (or have not been) achieved without those tools. The development and application of this concept provides support for the main hypothesis, that the use of tools by composers shapes the cognitive processes of composition, even when those tools are absent. The framework can also be applied to answering the research sub-question regarding the integration of the experience of working with performers. This will be done in Chapter Nine, after the second part of the musical commentary, which focuses on the role of virtual, absent, and present performers in the composition of two pieces: *symmetry I* and *symmetry II*.

CHAPTER EIGHT: Musical Commentary, Part Two; *symmetry II, 'dare mighty things'* and *symmetry I, 'resonance'.*

This chapter will explore two pieces inspired by the work of the painter Wassily Kandinsky. Kandinsky's late works function by balancing contrasting objects. For example, an intensely coloured circle in the bottom left of a painting may be balanced by a larger, lightly shaded irregular shape in the top right. Kandinsky's *Point and Line to Plane* explores this approach to symmetry and balance in art – an approach mirrored in both pieces examined here.[21] *symmetry I, 'resonance'*, is a piece for solo piano composed in 2019, and *symmetry II, 'dare mighty things'* is a piece for 20 string players composed in 2021. As with Chapter Six, it is advised to listen to the work in question before reading the relevant section, and to have the recording to hand while reading.

These two pieces each take a slightly different approach to symmetry and a markedly different approach to their composition. In terms of chronology, these will be explored in reverse, as *symmetry II* primarily deals with concepts related to the previous chapter, and *symmetry I* primarily deals with concepts related to the next chapter. *symmetry II* was composed using the affordances offered by digital tools and virtual performers and is explored through this lens.[22] *symmetry I* was composed in a more 'traditional' way, with reference to a then future workshop with an expert pianist. This workshop fortunately took place just before lockdown restrictions were put in place, so the differences between the imagined, future pianist and working with the actual, present pianist are able to be explored. The processes of composing these two pieces provide valuable insights into the affordances offered by different compositional tools and into the role of imagined, real, and virtual performers in the compositional process.

[21] Wassily Kandinsky and Hilla Rebay, *Point and Line to Plane* (North Chelmsford, MA: Courier Corporation, 1979).

[22] The affordances offered by digital tools and virtual performers were necessary due to not having the cognitive capacities to compose in my 'normal' way due to long COVID. For the main text of these commentaries I have tried to avoid personal/emotive language and content due to the nature of this thesis as an academic document. As mentioned in the introduction, this chapter takes some work from a blog post written for the RMA which does go into more depth about the emotional and practical impacts of the illness. Here I am only discussing practical, observable effects of the technology.

symmetry II, 'dare mighty things'

This piece, for 20 string players, was composed through consciously taking advantage of the affordances offered by digital tools and virtual performers. The audio recording of the piece was therefore created as the main act of composition, with the score for certain sections being written afterwards solely for the purpose of this commentary.[23] s*ymmetry II, 'dare mighty things'* comprises 23 interwoven sections, using material derived from a single 5-note chord, with an attempt to balance the sections to achieve 'symmetry', despite their intense contrasts. The string players are treated as individuals, even when all playing together, which creates complex, dynamic textures.

The piece is used here as a case study exploring the role that virtual performers can play in the compositional process, and how this relates to imagined and remembered performers. The concept of 'offloading' is particularly useful here. The metaphor of Otto and Inga in Clarke and Chalmer's seminal paper was certainly not meant to argue that the use of external objects only counts as cognitive if it makes up for some neurological condition.[24] Consider the previous examples given, of physically moving Scrabble titles to find a word, or rotating Tetris blocks to see where they fit, rather than imagining where they would fit.[25] Or, for that matter, think of the numerous spatial metaphors in the way we write and talk about music. An extended view of musical cognition might see these as more than metaphors. The process of composing *symmetry II*, however, was perhaps more in the realm of Otto; a matter of looking for ways to 'offload' those compositional processes which required more mental focus or energy than was available.

The process of composing *symmetry II* began with the creation of 23 'combinations' of potential sounds (from the virtual performers), rhythmic density, and harmonic material.

[23] This was a decision made as my health improved and I realised that, while *symmetry II* has a lot to say in terms of the thesis, it is not at the level where I would want it performed publicly – and if a workshop was possible, it would not be necessary for a performance of the piece from start to finish to be rehearsed and performed in order for the relevant insights to be gained from that process. Unfortunately, no such workshop was possible.

[24] Clark and Chalmers, 'The Extended Mind'. While the purpose of the music and musical commentary here is to influence the thesis (rather than the thesis influencing the composition), it does seem that if I had not been studying the idea of the extended mind and creative feedback loops at the point of falling ill, I might not have stumbled upon this way of working, which makes *explicit* and *conscious* the cognitive extension and feedback which is usually *unconscious.* Just like Otto and his notebook.

[25] Kirsh, 'The Intelligent Use of Space'.

These combinations relate to the multitude of different objects in Kandinsky's work which somehow feel perfectly balanced – to the point where if you removed or changed one object, the painting would no longer 'work'.[26] When it came to the harmonic material, their purpose was to create systems which led to "rote" compositional work, like the exercises one might do as part of a composition class and which could be easily broken up into smaller tasks, rather than constant creative decision making.

All the material was generated by rotating the intervals of a 5-note chord, always starting on the same note (Figure 4). Each of the 10 resulting chords can be considered a 'cell' and also generated a 12-note row based on the order of appearance of the notes.

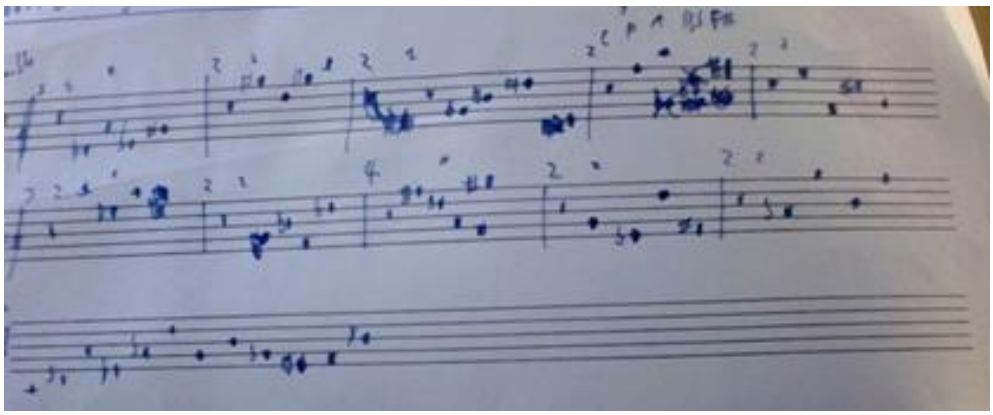


Figure 4. Harmonic material for *symmetry II*. Note the evidence of physicality and interaction with the environment even in this simple bit of work on paper.

This material was then used in 4 ways:

A) Cell harmonised by consecutive cells
B) Solo/duet/trio moving through cells sequentially.
C) Melodic development of the 12-note row; harmonised by a single cell.
D) Statement of the 12-note row in some form, with the initial note harmonised by a cell, and then using each successive note as an axis around which to invert the initial harmony.[27]

The composition process was then as follows:

[26] By dividing the piece into 23 sections, I had also begun the micromanagement and (temporal) division of labour which had allowed me to record the previous two pieces.
[27] This technique was inspired by the way that in Kandinsky's work you can see how the rotation of one object would necessitate the rotation or change of other objects in order to maintain the painting's balance.

1) Invent 23 ‘combinations’ (Figure 5).
2) Demo those combinations using software instruments, focusing on timbre.
3) Compose these demos into sections, including appropriate harmony, using the limitations and potentials of virtual performers as a compositional tool.
4) Combine these sections into a recording of the piece, including quotes from other sections.
5) Create elements of a score based on the recording.

Combination	Harmony	Timbre	Rhythm	Length (approx., in seconds)	A t c
1	A Cell 1 all the way	Noisy loud -> percussive loud	Busy pulsed – sparse unpulsed	30 or 60	
2	B Inversion	Pure quiet	Sparse pulsed	25	
3	A Cell 1 starting at 2	Percussive loud + quiet + noisy quiet	Sparse pulsed – busy unpulsed	40	
4	A Inversion as far as needed	Pure quiet + percussive quiet	Busy pulsed	25	
5	C initial row, harmonised by cell 3	Noisy quiet + pure loud	Busy unpulsed	30	

Figure 5. 'Combinations' for *symmetry II*. Some of these were edited after creating test versions with the virtual performers. As an aside, it is perhaps interesting to compare the materiality of the previous figure, where ink smudges and crossings out are visible, to the neatness – though obvious hurried-ness – of this figure.

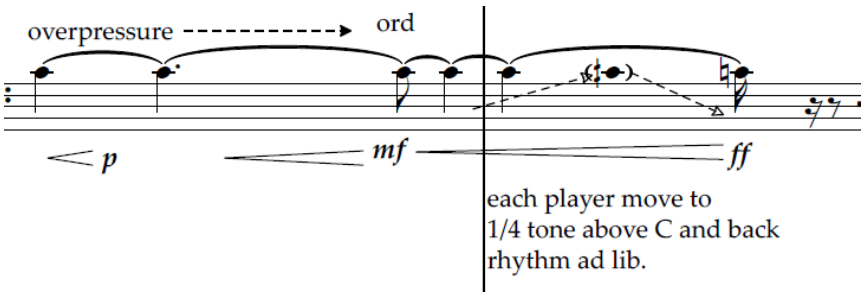
With this working process, the work of audiation, sight-reading, knowledge of instrumental techniques, orchestration, and rehearsal was offloaded onto the virtual performers. Some ideas were simpler to realise with virtual performers, and so these would easily flow into the piece. Others were harder, and then a decision had to be made whether to change those ideas or commit to expending energy including them. An amount of creativity, then, was offloaded onto the *limitations* of these particular tools of composition.

As well as often being led down the 'path of least resistance' by what was easy to quickly render using virtual performers, this creative offloading also came from the influence of the sounds of the virtual instruments on compositional decisions. A well sounding Bartók pizzicato (the sample at that note was more striking than on surrounding notes), for example, became the catalyst for the transition between two sections. Generally, when collaborating with performers, composers write, then workshop, then write – the two are temporally distinct. This specific kind of influence from virtual performers, then, only really relates to writing for real performers in the rare situations where a composer is working closely with performers during the actual process of composition, and they perhaps find an interesting multi-phonic, for example, or have a certain quality to their bowing, which then influences the composition.

Most interestingly, however, instant, malleable audio feedback dramatically eased the cognitive load of the compositional process. It was possible to run a section on a loop, editing the MIDI data and instrumental parameters until they sounded acceptable - like a potter at a wheel, shaping clay.[28] And, in broader terms, the whole process of composing the piece followed a similar process of feedback and refinement. Having a malleable image of each section embedded in the scaffolding of the work-in-progress while testing and experimenting – and seeing where the refinements lead rather than aiming towards a piece that was already to some degree fully formed – made the *experience* of composition feel like half discovery, half creation. There were no questions of 'will it work?', but rather 'is it working?'. This requires so much less effort, which in turn allows for more work to be done on limited reserves of energy and focus. Just like the potter at the wheel is both an example of extended cognition *and* a metaphor for how even less obviously physical cognition is still involved in the material, external world, the process of composing *symmetry II* is an explicit example of a feedback loop between material and composer, while also being a metaphor for the way these processes are work even when they are less obvious to composer or observer.

[28] See Malafouris, 'At the Potter's Wheel: An Argument for Material Agency', for arguments as to the significance of this.

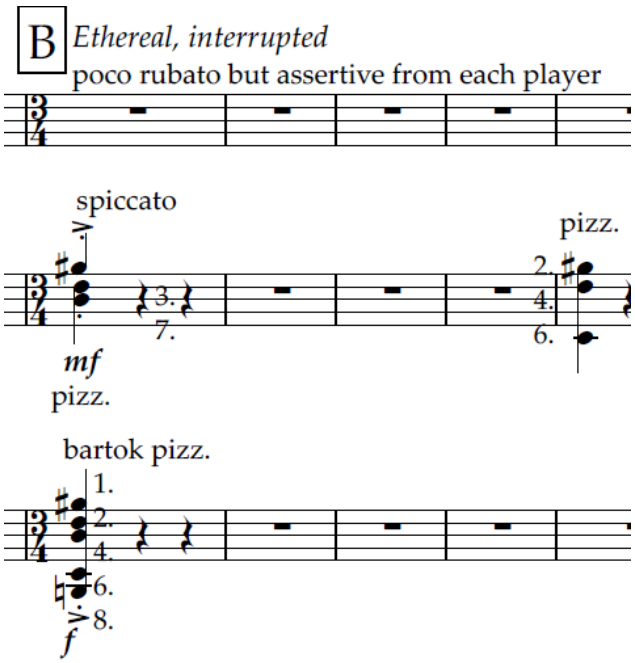
Notation



Musical Example 4. Instruction to performer 'as instrumentalist' in *symmetry II*.

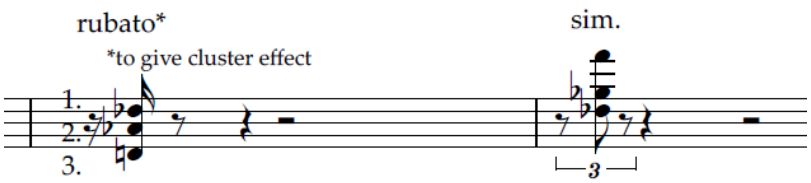
The process of writing the score after having already made the recording has illuminated many points about the compositional process. Perhaps most interesting is the fact that the results achieved with total control over the virtual performers are best realised by giving a considerable degree of freedom to the players in the final, written score. Conversely, finding ways to notate the more complex sounds played by the virtual performers became more of a transcription challenge – like the 'composition exercises' which were created as part of the original compositional process.

The opening page of the piece instructs the players to 'play each part as if it was a solo part'. This is important, as the parts are often notated together where they are playing the same note, but performers are expected to treat these notes as if they were individual lines. This is to consistently achieve the effect of a piece for '20 string players' as opposed to a piece 'for string orchestra'.



Musical Example 5. Programmatic and emotive instructions to performers in *symmetry II*.

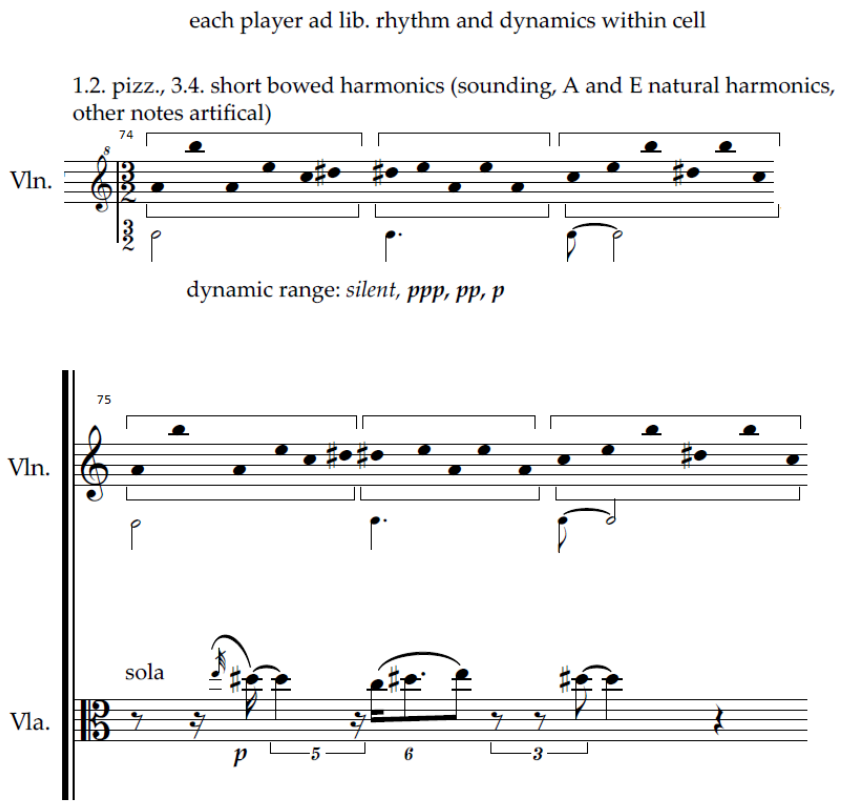
In some cases, written instructions to performers as to how to play the part were given. These instructions to performers 'as instrumentalists', instructing them with regards to their expertise on their instrument as to how to play certain parts, are important (Figure 8). See also Figure 13 (page 90). Programmatic or emotive instructions are also given, which relate to the performer more as 'creative agent with understanding of aesthetics' than a purely practical 'performer with access to a variety of auditory results from their instrument.' The lines between these kinds of instruction are blurred, but they are only separated here to make sure that both are understood. There is a difference between 'move to ¼ tone above C and back, rhythm *ad lib*' written in a part (Musical Example 4), and '*Wild*' or '*Ethereal, interrupted'* written above a section (Musical Example 5).



Musical Example 6. Description of intended effect of performance instruction in *symmetry II*.

There are also additional notes on the score, explaining the intention of a certain instruction – to ensure the intended effect is achieved (see Musical Example 6). While both types of

instruction move beyond solely using notation, the latter assumes that the performers will play in a different way to try and match the programmatic instruction in a way that, it is hoped, will match the desired musical result. Instructions like this require a degree of understanding of notation and what it does and does not convey.

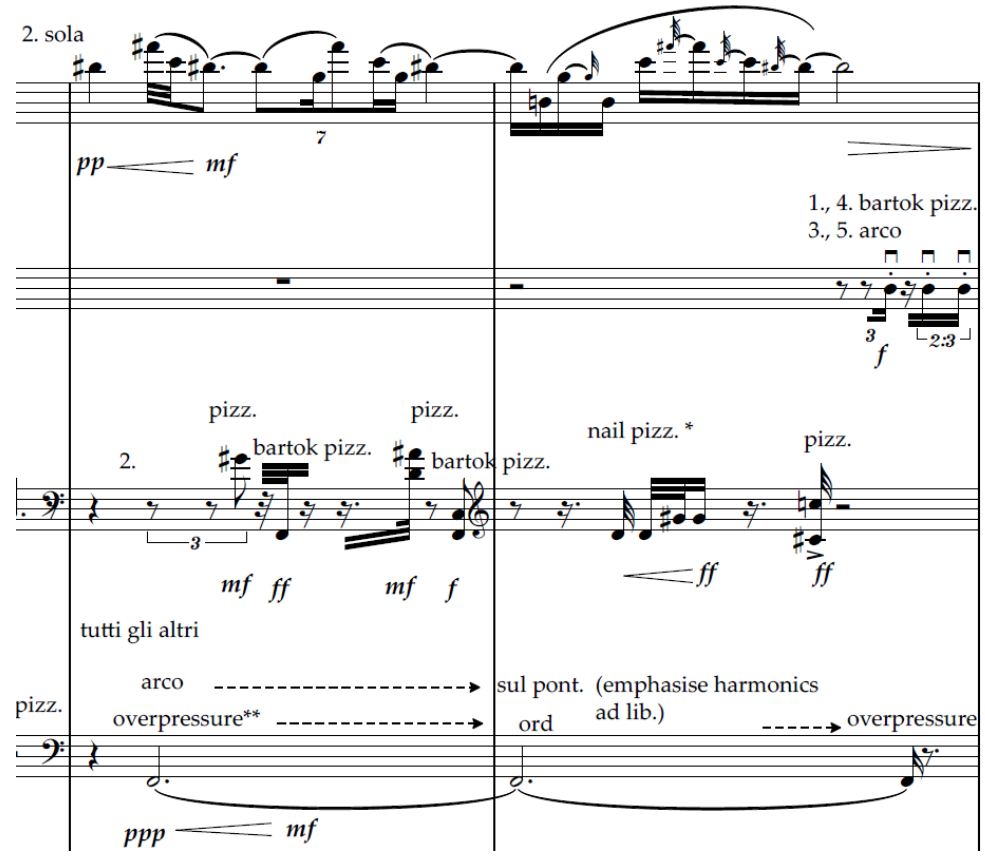


Musical Example 7.

Real performers instructed to play with freedom, for the same result as when the virtual performers were used to achieve total control. 1:37 in the recording of *symmetry II*.

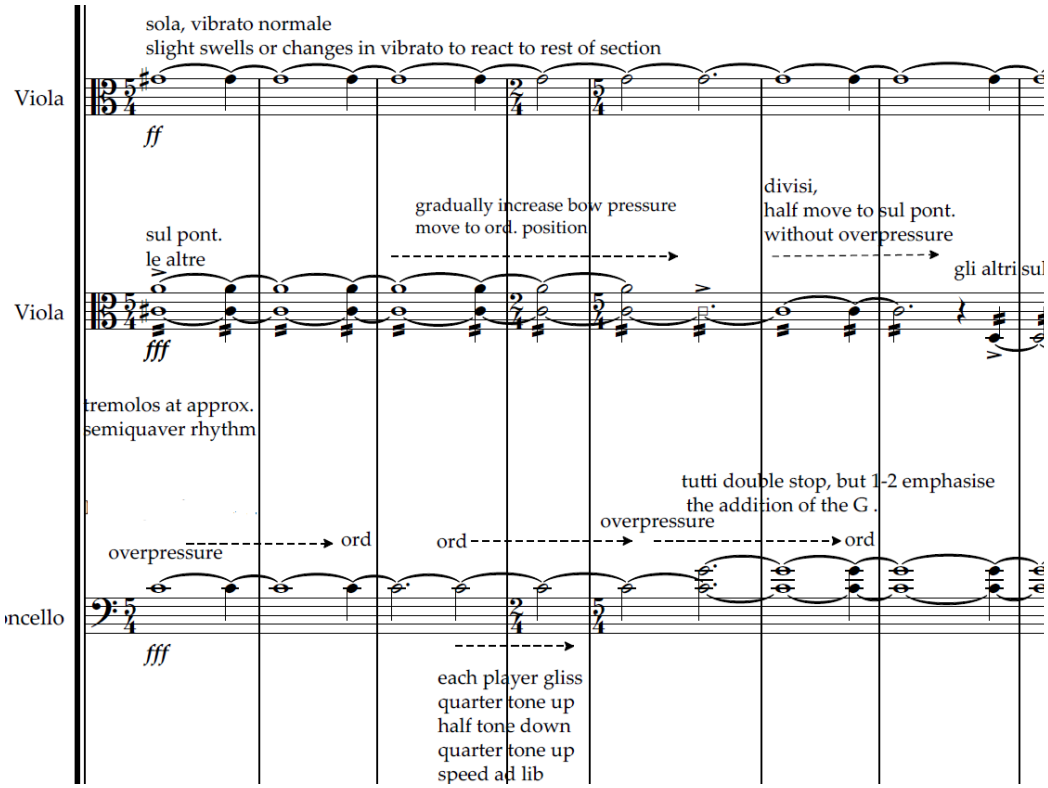
In more extreme cases, the eventual performers of the work are given considerable freedom in how to play the part, as this is the best way to achieve the musical result. This is not an aesthetic decision (such as those made by those composers working with graphic scores, improvisation, and so on), but a practical one. Where the best way to achieve the musical result is with detailed, complex notation, then that is what is used – but where the best way is in giving players material to explore *ad libitum*, then that is what is done.

Figure 11 shows how a heterophonic section in the recording was notated in the score. Note how the players are instructed as individuals, as mentioned at the beginning of the score and of this section. In the recording, each note was placed and changed with total control, to create the desired effect. In notation, this would be astronomically complex for no real benefit. Instead, the players move through the harmonic structure *ad libitum*, in a dynamic range including silence (so that not every player plays every note). Each section of the harmony lasts for a particular note value as written.



Musical Example 8 (left).

An example of when detailed, complex notation was the most effective way to achieve the desired result. 6:10 in the recording of *symmetry II*.



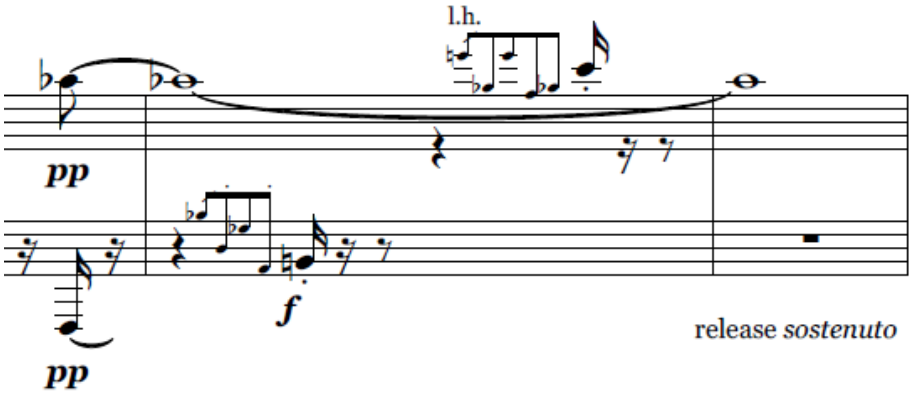
Musical Example 9 (below).

Many instructions to performers 'as instrumentalists' as to how to play the notated part. 00:00 in the recording of *symmetry II*.

While in many cases detailed notation was the best way to achieve the intended result (Musical Example 8), it is interesting that the randomness inherent in giving freedom to different players with the same material (see again Musical Example 7) was the best way to get the same result as when writing using virtual performers with total control. This has considerable implications for understanding the role of the performer and the score in the compositional process, as explored in the next chapter.

symmetry I, 'resonance'

symmetry I, 'resonance' is a piano piece composed for the 2020 BFE/RMA Research Conference Composition workshop. In the same way that Wassily Kandinsky balanced small, dense, structured shapes with larger, paler forms, the piece attempts to balance structural sections so they have equal 'weight', rather than equal lengths. It does this by balancing sections with each other in what might be considered a 'holistic manner', considering for each section whether new harmonic material is introduced, the length of the section, whether the section is striated or non-striated, the range of notes, and, of course, the dynamics. Throughout the piece, resonances from strings held with the sostenuto pedal provide a sonic backdrop to these symmetrical events, like the blank canvas. Untouched by paint, yet integral to the work.



Musical Example 10. Demonstrating the physicality of the piano. Bar 15 of *symmetry I*. 1:15 in the recording.

A specific example of a conscious form of the connection with absent performer which will be discussed in the next chapter appeared early in the process of composing *symmetry I.* In bar 15 (Musical Example 10), it was necessary to have a held note in addition to the staccato arabesques and the resonances from the sostenuto pedal. Without access to a piano, the

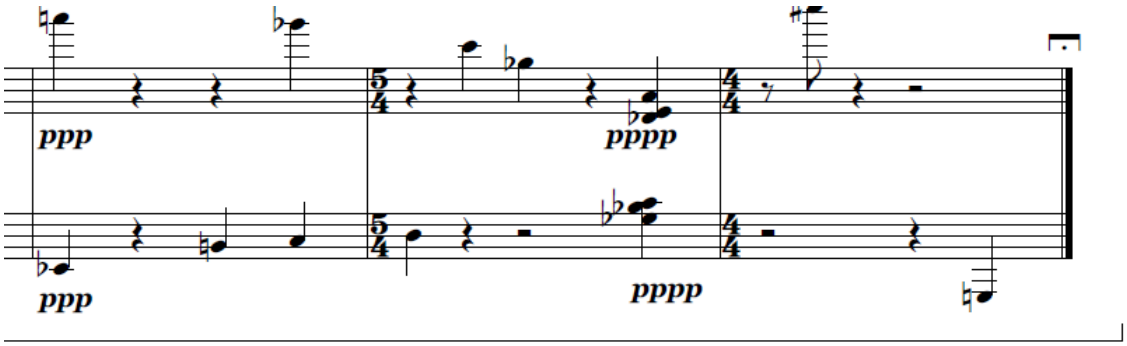
writing process became a case of judging the time to move the hand, the appropriate note to hold, and how this would affect the next part. In composition it is not just the text-produced-so-far that affects the text-yet-to-come[29] but the physical actions necessary to perform it. This is the kind of cognitive process involved in musical composition which is often taken as read; or experienced subconsciously. The important thing here is not that it happened, but that it can be observed in the context of the surrounding chapters of this thesis.

Sometimes performance norms and notation are not enough to communicate an appropriate effect. An example in *Symmetry I* is the notation 'arpeggiated tremolando'. This effect has a clear intended result. After countless attempts at notating it in various ways, for this piece it was decided to simply explain it to the performer 'as person', rather than as instrumentalist:

> The notation 'arpeggiated tremolando' means to play a tremolando but, where there are more than 2 notes, to *separate* them and play as fast as possible in any order (this gives the same effect as a 2 note tremolando, whereas a rapid oscillation between 2 dyads or a single note and a dyad is its own effect).

This makes two points clear. Firstly, notation and performance norms are an essential piece of cultural apparatus:[30] imagine if composers had to explain every aspect of performance in such detail. Secondly, by understanding a score or instrumental part as a communication with, as well as a set of instructions for, a performer, the work is realised more accurately and more easily. This is something which is or should be taught to composers, but there are also relevant insights to be drawn in terms of this study. While the concept of empathetic embodiment focuses on a bodily empathy, the core of which is the 'acting out' of parts, it also implies a deeper empathy, an intellectual connection, with an imagined or future performer.

[29] See Van Hulle, *Modern Manuscripts*, 132.
[30] See Malafouris, *How Things Shape the Mind*; Latour, *Re-assembling the Social*; Clark, *Natural-Born Cyborgs;* Tomasello, *The Cultural Origins of Human Cognition* and many more of the references about external cultural symbols and the ratcheting effect.



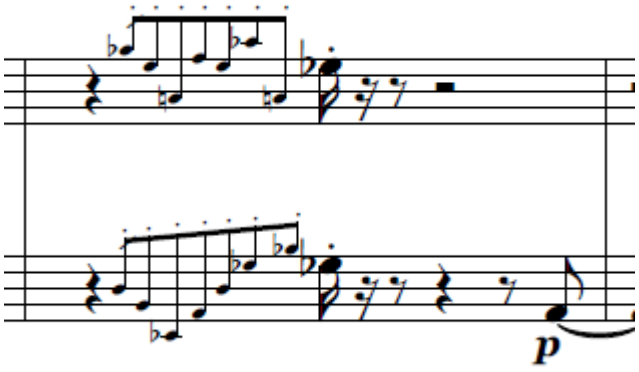
Musical Example 11. The final three bars of *symmetry I*. 3:40 in the recording. Note that the pedal line hanging over the double bar line is purposeful.

The most difficult part of *symmetry I*, according to the pianist, was the *pppp* chord in the penultimate bar (Musical Example 11) – a very simple compositional decision (a gradual decrease in dynamic towards the end of the piece) posing a challenge to the player and the instrument. The fact that this compositional decision did not fully take into account the eventual performer and the limitations of the instrument - but that it was immediately apparent in the workshop - demonstrates the split between writing for a future or imagined performer and working closely with one. This is a particularly striking example because the material is conceptually so simple compared to other more complex parts of the piece which proceeded without difficulty.

This case study demonstrates that working closely with a performer can serve a variety of cognitive purposes:

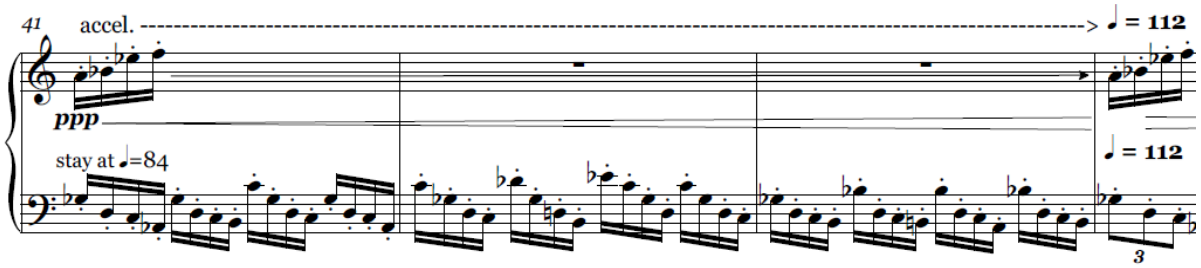
> Firstly, it allows the composer to offload certain cognitive processes, such as knowledge of instrumental capabilities or the ‘acting out’ of gestures, to the performer.
>
> Secondly, performers reveal potentialities of the instrument or their capabilities which the composer would not otherwise have access to.
>
> Thirdly, performers may make suggestions which may influence the creation of the work, thus becoming part of the extended cognitive network responsible for the work coming-into-being.

When writing for an imagined or future performer, the composer must, through training and empathetic intuition, understand the physical gestures necessary to perform a part and the ways in which the performer will interpret the part and any written instructions. These understandings will influence the creation of the work, as the embodied, extended cognitive processes of composition interact with the embodied process of future performance. Understanding what an expert pianist is capable of therefore provided creative impetus at the macro and micro level in the composition process of *symmetry I.*



Musical Example 12. Arabesques at bar 10 of *symmetry I*. 0:51 in the recording.

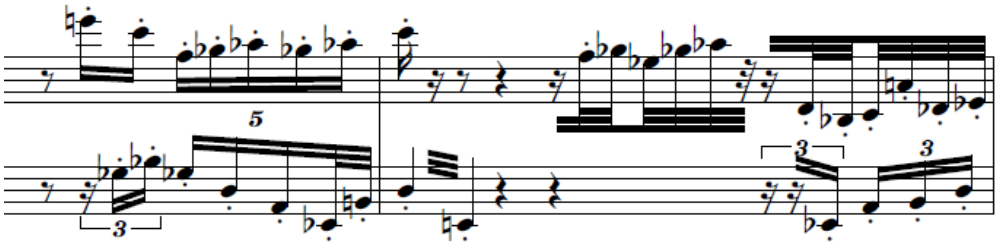
As can be seen in the arabesques in the opening (Musical Example 12), the different tempi in bars 41-43 (Musical Example 13), and the interweaving parts in bar 50 (Musical Example 14, overleaf), the imagined, expert performer had a considerable degree of influence on the compositional process, by making such writing possible. The role of the 'imagined expert pianist' in the creation of this piece, and the updating of both the piece and the image of the performer in light of the real rehearsal and performance, very much relate to the following and final chapter of this thesis, which explores the role of the absent performer in the cognitive processes of musical composition.



Musical Example 13. Tempo changes at bar 41 of *symmetry I*. 2:58 in the recording.

This chapter has analysed the process of composing *symmetry I* and *symmetry II*, revealing multiple useful insights. s*ymmetry II* showed how the recording process of

Emergence//Overture influenced the creation of new work. They have both shown how intertextuality can extend outside the field of art in which an agent is working. Most importantly, however, the analysis of the process of composing these pieces demonstrates the essential role that performers – virtual, present, and absent – play in the compositional process. This leads to the next chapter of this thesis, which attempts to understand the role of absent performers in the cognitive processes of composition through an application of the Integrated Tool Competency framework developed in the previous chapter and theories of empathy and social cognition explored in Part One.



Musical Example 14. Complex interweaving parts in bars 50-51 of *symmetry I*. 3:26 in the recording.

CHAPTER NINE: The Role of the Absent Performer

As argued above, the musical score is not just a tool for allowing performers to perform the work. It is an essential part of the cognitive processes of musical composition. However, the fact that an *aspect* of that score is that it is a tool for allowing performers to perform the work is actually very important. The ways composers might act out (consciously or unconsciously) the physical gestures of performance have been discussed above, but these also extend to a level of empathy with those who will make those same gestures in the actual performance of the work.[1] The composer's knowledge of how a performer will understand the score, especially the physical gestures they will need to make in order to produce the desired sound, are a crucial part of the process of writing that score. Exploring this, in the context of the Integrated Tool Competency framework developed in Chapter Seven, goes some way towards developing an understanding of how the relationship between performer and absent composer, as described by Le Guin,[2] might work in reverse. This chapter argues that this relationship is *itself* an essential part of the cognitive processes of musical composition. It does this firstly through an examination of the performer as implicit in compositional practice, secondly through an examination of the performer as embodied by the composer, and finally through an examination of the integration of the experiences of working with performers, in reference to Chapter Seven.

The Implicit Performer

The first important thing about the fact that the score is a set of physical instructions for performers is that this is *implicit in the process of writing of the part.* An aspect of how composers are taught to write an instrumental part, for example, is putting appropriate string markings, pedal indications, fingerings and so on, especially where these are different than expected. In this case the performer might still be seen more as a repository of auditory possibilities than a collaborator to be communicated with. Nevertheless, the performer's physicality is integrated into the compositional process in the way that composition is taught.

[1] See Boyle, 'Empathetic Embodiment in the Compositional Process' for an initial approach to this idea, one which might be better re-articulated in light of work done and cited in this thesis.
[2] Le Guin, *Boccherini's Body*.

Given a certain shared set of competencies and performance norms, then, the score acts as a series of instructions (nearly always allowing for a degree of interpretation) to performers, which will result in a performance of the work.[3] This fact has a huge influence on composition and is perhaps one of the largest factors which differentiates composition from other creative acts which have been studied through a 4E lens. While many manipulations of material may not be done with a conscious interaction of the embodied and physical process of performance, the eventual performer is always a necessary concern. A series of notes on a stave meant for, say, a violin, is not just a bunch of dots and lines: they imply a set of physical actions and interactions with the instrument which will produce the required sounds. Even in reading a score for the first time without playing, there may well be a sub-physical, ideomotor simulation response as if actually playing through the part.

Someone with musical ideas, but no training, will not be able to empathize with or act out the processes of playing an instrument to a high level to the same degree as an experienced composer. Despite this, it is impossible to disconnect a sound from its source (though acousmatic music has attempted this to varying degrees of success).[4] A less experienced composer might well consciously or subconsciously imagine a violin and violinist while writing a violin line even if the part is impossible and the motions they are imagining are not the way a violin is played.[5] These may in fact relate more closely to the 'metaphorical gestures' described in Chapter Five than the empathetic gestures which will be described here.

Much of the pedagogical literature on composition uses 'performer' and 'instrument' interchangeably. The integration of a performer and their instrument is a fascinating example of transparent technology;[6] and points to a limitation in the *accuracy* of any empathetic embodiment taking place between a composer and a performer whose instrument the

[3] For the kind of notated music being discussed here, 'performance of the work' seems the correct nomenclature. In different musical traditions or situations, it may be more productive and accurate to consider the performance (or perhaps recording) being produced as 'the work'.
[4] See, for example, Frank J. Malina, Pierre Schaeffer, and Joyce Mandelbrojt. 'A Conversation on Concrete Music and Kinetic Art', *Leonardo*, 5, no. 3 (1972), 255-260.
[5] Technological mediation of the compositional process (production of sound by score editing software, for example) complicates this idea somewhat. It might be that, when working digitally without experience of working with real performers, composers are writing parts which sound acceptable played back on the software, with no regard for the physicality of performance. See the discussion in Chapters Four and Six.
[6] E.g., Clark, *Natural-Born Cyborgs.*

composer does not have the level of competency to ‘see through’. Regardless, when a composer is writing for a performer or instrument (or performer-instrument assemblage, if you like), the score acts as a physical instruction, and as such, as part of the process of creating the score, the composer engages with the physical gestures required to realize what is written. When composing, then, the composer is constantly engaging with the physicality of performance.

Embodying the Performer

The sensori-/ideomotor simulation phenomena have been discussed throughout this thesis. When a composer is acting out the actions of playing an instrument, especially one which they themselves do not play, this can be understood not just as a creative act, but as an act which links the composer to the performer. That composers act out the physical gestures of performance when composing is crucial to understanding the compositional process.

This ‘acting out’ of physical gestures is not just a case of practicality. It can also be considered as part of the creative force brought to bear on the creation of the work. That is, the acting out of a gesture which results (or is believed to result) in a certain sound, is part of the cognitive system which results in the creation of a part. The act of physically or sub-physically acting out a motion with auditory results is a part of the embodied process of composition; but is also inextricably linked with the imagined performer and their physical potentialities in integration with their instrument.

Where this point differs from a more general understanding of embodiment in composition is that it suggests that an understanding of the physicality of performance, and of the physical gestures and interactions with instruments that make up the act of performance, is an essential part of the cognitive processes of composition. Furthermore, this understanding manifests itself physically, or at the very least in imagined physicality, as the composer acts out the physical gestures of performance in the act of composition.

As has been explored through the musical commentary, virtual performers blur the lines between present and absent performers. There is an element of disembodiment, yet this could be mediated by the ideas discussed above, about the sensori-/ideomotor phenomena, and

relating sound to imagined gesture and vice versa. This would be more true the more experience the composer has working with *real* performers. Both practically and theoretically speaking, then, integrating these experiences and related competencies is therefore essential to working effectively with virtual performers and avoiding potential pitfalls – from unreadiness-to-hand at the moment of use, or for the real performer at the moment of performance.

Integration and Empathy

As discussed in Chapter Four, working with a present performer provides numerous affordances for the cognitive processes of composition. Physical gestures and their results can be instantly accessed and reacted to by the composer; cognitive load is distributed through the scores, instrumental parts, instruments, and performers in the workshop or rehearsal space; additionally, performers will contribute their own ideas and interpretations, perhaps even in a *collaborative* manner that brings them into the creative process. When writing for an imagined or future performer, these forms of empathy and offloading can by definition not take place, or at the very least must be mediated through integration of the experience of working with performers.

When working with present performers in a workshop, rehearsal, or collaborative context, the composer has access to mental states and feedback instantaneously, in a feedback loop more complex than when working only with other tools. This means that when working closely with a performer, when trying out material and making suggestions, the composer has instant access to an empathetic understanding with the performer. It may also be that when working closely with a performer, unknown techniques, sounds or ways of realising material may come to light. Similarly, while a performer could potentially play a certain realisation of musical material or a certain musical gesture, they might suggest another, perhaps easier, way of doing a similar thing. Working with a present performer, then, provides numerous affordances for the cognitive processes of composition.

This ‘creative offloading’ is a potent form of cognitive offloading which crosses the boundaries into collaboration and shared creativity. When writing for an imagined or future performer, these forms of empathy and offloading as discussed in Part One seem not to take

place. Through the Integrated Tool Competency conceptual framework developed in Chapter Seven, however, it can be argued that being part of cognitive systems involving performers develops competencies which would not exist without having been part of those systems. While the composer might well have a 'Theory Theory' top-down idea of 'the performer', and the implicit performer may also be present, the integration of the experiences of working with performers allows the affordances they offered to be accessed – consciously or unconsciously – to solve a similar problem. These integrated competencies also increase the accuracy of the *conscious* empathy with performer, be that acting out the physicality of performing a part, as in the above section, or figuring out how to write instructions on the score to ensure the goal of the piece is realised in performance. Virtual performers further complicate this issue, by providing some of the affordances previously only offered by workshop and rehearsal environments, even when the composer is not in that environment. This allows composers to bypass some of the competencies which would be required without the use of virtual performers – but this may have adverse effects when it comes to writing parts which can be interpreted as the composer hopes.

This points to empathy as a core aspect of an extended view of compositional cognition, whether as an attempt to understand the function of the mind, as a practical or pedagogical approach, or both. This is empathy of the 'Theory Theory' kind but with integrated experiences of empathy which fit under the Interaction Theory and Direct Perception concepts. These different theories appear to be mediated by ideas within Simulation Theory. This empathy is also an aspect which is trained as a composer develops. Experienced composers will have worked with many performers; therefore, their cognitive processes can make use of varied integrated experiences and competencies; imagined and remembered feedbacks; imagined and remembered sounds and their means of production.

When writing for or working with an ensemble the cognitive load is magnified, as the composer places themselves in an environment with multiple performers, multiple physicalities and ways of producing sound, and so on. In a situation where the composer is working with multiple performers, Interaction Theory, which argues that emotions are accessible in the environment in the form of facial expressions or gestures, would imply that they have pre-conscious access to the emotions of the ensemble as a whole. This might ease the greater cognitive load caused by considering each performer separately. When writing for an imagined future *ensemble*, then, the cognitive load might be greater, depending on the

level of integrated competency, and require a degree of 'black-boxing'[7] of individual, imagined, performers. The conductor of an ensemble is a performer themselves, and one can imagine composers placing themselves into the role of eventual conductor so as to better understand the ensemble as a whole. Essentially, composers must make use of internal representations of performers and instruments to take advantage of any of the 'offloading' which is so easily accessible in a rehearsal or workshop space.

As argued in Chapter Seven, a view of *internality* as built from a base of *externality* (rather than the other way round, or seeing the two as separate), is an important concept for this thesis. In terms of theories of empathy, as discussed in this section, this becomes a case of seeing these different theories of empathy as connected and feeding into one other. In this case, this is used to build an understanding of the connection between composer and absent performer. The entwined processes of creating the musical work and communicating it to performers make use of a constant interaction with the embodied process of performance, and this is a crucial part of the extended cognitive process of composition.

This connection between composer and absent performer, whether that be future, remembered, or entirely imagined, also provides an angle for understanding other agents who may have been integrated in a similarly way, such as teachers, collaborators, audiences, and so on. Similarly, it could be valuable for understanding the role of extra-compositional experiences in developing compositional competencies.

The Relationship between Composer and Absent Performer

The virtual performers of the digital age may be at the composer's fingertips, 'extending the orchestra of the mind' as transparent technology – yet does that limit the paths a composer's creative imagination might take? It has been argued in this chapter that the cognitive role of absent performers is based on integration of past experiences of working with co-present performers. Absent performers are therefore not only repositories of auditory outputs,

[7] Understanding an object or system in the world purely with regard to what it 'outputs' from whatever 'input' it receives, without consideration of the processes by which this happens. The degree to which external scaffolding assists this particular cognitive function is heavily implied by work on symbolic and material culture. See, for example, Malafouris, *The Cognitive Life of Things.*

mediated by simulated physicality. They are also integrated collaborators and interpreters, embodied by the composer in the act of writing a part. In these guises they offer affordances for compositional action. Consider again the relationship between performer and absent composer described by Elizabeth Le Guin.[8] When explored in reverse, through the concepts developed in this thesis, this relationship reveals fundamental things about musical composition itself.

[8] Le Guin, *Boccherini's Body*.

CHAPTER TEN: Conclusion

In response to a central research question:

> **What is the role of absent compositional tools in the cognitive processes of musical composition?**

this thesis has developed and tested two hypotheses:

> **The use of tools by composers shapes the cognitive processes of composition, even when those tools are absent. This is due to the integration of the experience of using those tools.**
>
> **The experience of working with performers shapes the cognitive processes of composition, even when those performers are absent. This has a substantial impact on how the relationship between composer and performer should be considered.**

To examine how well the central research question has been answered, it is necessary to first focus on the sub-questions.

Research Questions

1) What is the role of *present* compositional tools in the cognitive processes of musical composition?

Chapter Two outlined the post-Cartesian theories which provide the best route towards understanding the role of present compositional tools. Chapter Three showed that there has been some work specifically about the role of technology in thought, and also explored theories of empathy which can be brought to bear when it comes to understanding the role of present performers. Chapter Four demonstrated that while there have been musicological applications of these ideas, they often focus on performance, collaboration, and embodiment. Chapter Six examined the process of composing *des colombes et des crocodiles* as a demonstration of how musical material in the composer's environment might influence the

compositional process. Chapter Eight explored, through analysing the process of composing *symmetry II*, how the affordances offered by digital tools can influence the compositional process. Chapter Five built upon these ideas, to present a view of composition as an embodied process which is connected to the environment – social and material – of the composer. The answers provided to the above research sub-question are useful in themselves, but primarily function to provide a foundation for answering the next question.

2) How might the use of tools in the past be integrated into the competencies of a composer?

Chapter Seven developed the 'Integrated Tool Competency' conceptual framework to answer this question. The sensorimotor system, the body schema, and the extended cognitive processes of composition interact with real and imagined tools and are shaped and re-shaped by these experiences. These tools therefore develop competencies in the composer, becoming gradually more 'transparent' through continued use. They aid relevant cognitive processes, not as 'representations' in the traditional sense, but as a series of increasingly integrated competencies. Empirical studies were also used to evidence these arguments, but further empirical studies, especially specifically musical ones, would strengthen the concept and the answers it provides.

a) How might the experiences of working with performers be similarly integrated?

Through the Integrated Tool Competency conceptual framework, Chapter Nine argued that the experiences of working with performers engender competencies in composers which would not otherwise exist. These competencies allow for more effective composition in the absence of performers, and for more effective use of certain tools. These integrations (and where they might have been lacking) are demonstrated in Chapters Six and Eight through the analysis of recording *Emergence//Overture* and of composing *symmetry I* and *symmetry II*.

i) What does this mean for the relationship between composer and performer?

By extending the Integrated Tool Competency concept it becomes possible to develop an understanding of how composers and performers relate across

time. This required further engagement with research into sensorimotor and ideomotor phenomena and the existing work on empathy and social cognition explored in Chapter Three. An exploration of the recording process of *Emergence//Overture* in Chapter Six, and of the composition process of *symmetry II* which it influenced, demonstrated how the relationship between composer and performer is complicated by digital tools. Digital tools require an integrated understanding of performers, gained through a composer's career, but can also alter or enhance this understanding. In the case of *Emergence//Overture*, a passage for piano was improved by recording it using virtual instruments, which necessitated a more accurate understanding of how the part would be played. Chapter Nine concluded that the entwined processes of creating the musical work and communicating it to performers make use of a constant interaction with the embodied process of performance, both integrated and simulated, and that this is a crucial part of the extended cognitive process of composition.

What is the role of absent compositional tools in the cognitive processes of musical composition?

If a fundamental aspect of cognition is that we are embodied beings situated in a cognitively useful world, it is strange to have a completely different perspective on any cognitive process which does not clearly entangle itself with 'external' things in the moment it is taking place. Chapter Seven, building upon the ideas explored in Part One, and influenced by the insights gained from the composition portfolio and its analysis in Chapters Six and Eight, demonstrated how to start to bridge this gap, by providing a framework for exploring how the use of tools shapes the mind, even in the absence of those tools.

This thesis has argued that the use of tools in creative pursuits, such as musical composition, engenders competencies that would not exist without the past use of these tools. The referral to an absent compositional tool acts in the same way as a referral to a present tool, in the relevant cognitive process, whether consciously or unconsciously, or the tool may be instrumental in developing a cognitive competency which requires no such reference. Different competencies may be created through the use of different tools – but different

competencies may also be *required* to use certain tools. When considering performers as part of these cognitive systems, a deeper understanding of the relationship between composer and performer is reached.

An experienced composer therefore has access (consciously or unconsciously) to experiences of various aspects of the cognitive systems involved in musical composition. These include the physical motions, the auditory feedback, the musical results, and so on. There may also be competencies which have been developed through the use of these tools to the point where not even unconscious referral is required. This allows for the completion of more complex compositional tasks *in the absence* of tools than would have been possible had they never been used. As such, the tools of composition can not only be considered essential as constituent parts of the cognitive processes of composition in the moment of their use, but as essential in their integration as part of the cognitive competencies of the composer, retaining a role in the compositional process even *in absentia*.

Discussion and Future Directions

While the Integrated Tool Competency concept was developed while trying to understand the cognitive processes of musical composition, the concept is by no means restricted to composition and could be applied to understanding the cognitive processes of other creative acts. Some of these, often used as examples in work on 4E cognition, are much more *obviously* physical, iterative, and created through use of tools (for example painting, sculpture, or pottery), but this very fact could lead to the ignoring of the role of imagination and integrated competencies in the processes of these arts, making the ideas developed in this thesis a potential contribution to their study.

The additional complexities introduced to the post-Cartesian landscape by the second half of this thesis could be looked at further, in isolation or in the study of other elements of music or the other arts. The idea of the internal mind being built from the ground-up from the experience of being embedded in the external has the potential for real impact on how multiple aspects of cognition are considered. Similarly, the importance of intent and ‘affordance switching’ has been explored in the existing literature, and touched upon in this thesis, but could be a crucial element to explore further.

Future musical study could include an in-depth examination of specific tools, particularly in non-notated or differently notated musical cultures, and an exploration of how the development of musical tools throughout history has reshaped musical cognition. This latter exploration could aid in the creation and design of new compositional tools, including those in pedagogical settings. While this thesis has only touched on explicitly pedagogical concerns, the ideas discussed in this thesis could have a substantial impact on compositional pedagogy through understanding how existing tools might develop and require different cognitive competencies, and through demonstrating the relationship between composer and performer.

Understanding the impact of *specific* tools through this lens could then be important when considering digital tools for the notation and production of music. Similarly, expanding upon some of the ideas touched upon in this thesis would be valuable. For example, are the experiences and processes of composers with expert experience as performers or conductors different than composers who focused on composition exclusively earlier on in their careers?

Questions regarding epistemic credit and agency with regard to the *ease of use* of digital tools would also be worth answering. Compositional tools are now on offer that include entire performances which unfurl as the 'composer' holds down one note on the keyboard, or which suggest which chord should follow to complete the current harmonic sequence. If interaction with tools is how composers develop, what is the impact of tools which do half the work?

It is therefore important, as musical tools fade in and out of use, to understand the competencies which are not being developed, and any new competencies which are. Digital technology, for example, often provides audio feedback on ongoing work in a very direct way. Does this help or hinder the development of the skill of audiation? Similarly, digital tools are often designed to be intuitive, making them more easily 'transparent', but can by their nature be restrictive, if a composer attempts to do something which the software has not been programmed to achieve.

Empirical studies within these contexts would also be worth exploring. These could include asking composers to complete compositional tasks with varying available tools, or perception tests to do with matching sounds to physical actions. Additionally, interviews with composers about their experiences of the changing (or not) role of technology in composition and the

influence of those tools on their work. This would have interesting results with regards to notation and notation software in particular, as there has been such a change in the past few decades as to the ubiquity of this software in pedagogical and professional settings.

Throughout this thesis, the composition portfolio, and analysis thereof, provided essential insights towards answering the research questions. Future compositional work could also progress the ideas developed here. The use of sonic visualisation software, to both aid in the orchestral transcription and to compare the transcription with the recording, points to the further role digital technology can play in cross-disciplinary influence. There is also scope for the composition of a new piece, recorded virtually to sound convincingly 'real' but which is actually impossible to play. For the piece to sound real, the integration of, and empathy with, the embodied nature of performance would need to be at a very high level. If the piece simply ignored the possibilities of real instruments, it would not sound real. If it stuck too closely to what is possible, it would not be impossible. This would therefore offer numerous insights into the relationship between composer and performer, and its importance in the compositional process.

A final point about future compositional work is as follows: as argued in this thesis, the tools of composition are an essential part of the compositional process, whether present or not. This means that even work which has no explicit connection to the ideas presented here can still be analysed to better understand the extended musical mind. However, perhaps the main impact of this project on the day-to-day work of composing music (at least for the author) will be an acute awareness of the role of tools and performers in making musical composition possible.

Contribution

Through developing the conceptual framework of 'Integrated Tool Competency', this thesis has demonstrated a way to fully understand compositional creativity through primarily '4E' understandings of cognition. Through a study of the tools of composition, it contributes to both an understanding of the creative processes of composition, and to externalist accounts of cognition more generally. The tools of composition are no longer seen as 'merely expedients

to transplant musical experiences […] to the musical listener',[1] but as essential parts of the creative process of musical composition, even in their absence.

Musical creativity does not just take place in a cognitively useful environment, but changes and develops that environment so that it is a better place in which to create music. The hypothesis developed in this thesis is that this re-configures the competencies of composers. Specifically, that this embeddedness has impact through time, and not just through the continued existence of re-configured environments. The most important contribution of the Integrated Tool Competency conceptual framework towards a general understanding of cognition, then, is in the way it explores the integration of aspects of the external world into the mind beyond the moment of their use. *Instrumenta in absentia*, instrumental even in their absence.

Essentially, this thesis has attempted to provide a conception of the internal in cognitive processes which is built from an understanding of the role of the *external* in cognitive processes as the default, rather than seeing internality as the standard model. Tools re-shape the cognitive competencies of the thinker and remain an essential part of cognition even in their absence. This makes 4E answers to the question of the role of technology in thought equally applicable to clearly material cognition, such as Malafouris' potter at the wheel, an improviser with her instrument and co-present colleagues, or Clark and Chalmer's Otto with his notebook; and seemingly 'immaterial' cognition, such as a musician imagining new music in the absence of instrument, computer, or score.

[1] Riemann, 'Lehre von den Ton Vorstellungen', 82.

Glossary

transparency: the idea that a technology can become so integrated into the relevant cognitive process that it becomes invisible-in-use. Also referred to as *Readiness-to-hand*, smooth-coping. See page 39.

audiation: skilled musical imagery. Also referred to as 'the mind's ear'. See page 54.

affordance: the potential for action offered by an environment – in 4E literature often explicitly *cognitive* potentials. See page 20.

parity principle: central to the extended mind thesis, the parity principle argues that when an external object functions in the same way as a process inside the head, it should be considered equally cognitive. See page 23.

co-present: present in the same place and at the same time. Usually used to refer to multiple agents interacting in a situation of social cognition.

offloading: the idea that certain cognitive processes can be 'offloaded' onto external objects in the environment is central to 4E theories of cognition. See page 60.

sensorimotor system: systems of bodily engagement with the world

ideomotor system: internalised versions of sensorimotor systems.

embodied cognition: the idea that the body is essential to cognitive processes. See page 15.

embedded cognition: the idea that cognition can be embedded in the environment. See page 19.

enacted cognition: the idea that agents 'think through doing'. See page 22.

extended cognition: the idea that the mind extends beyond the brain and body, and that tools used in cognitive processes can in some cases be considered *part of* those cognitive processes. See page 23.

distributed cognition: a more radical version of embedded cognition where cognitive processes are seen to be distributed across the environment. See page 28.

Material Engagement Theory: An anthropological perspective which emphasises the way that artefacts shape (and are shaped by) culture and thought. See page 30.

Actor Network Theory: Actor Network Theory sees actors as being best understood as a locus in a network, and that it is those networks which affect the world. See page 48.

body schema: The perception (conscious and unconscious) an agent has of their body, which impacts how they interact with the world.

intercorporeality: A term from Maurice Merleau-Ponty (*intercorporéité*) which refers to the embodied interaction between self and other as key to understanding how we understand others.

Simulation Theory: Encompasses theories of empathy which see simulation of action as key to empathy. See page 33.

Direct Perception Theory: Encompasses theories of empathy which see mental states of others as being available immediately in the environment. See page 34.

Interaction Theory: Encompasses theories which see interaction with mental states available immediately in the environment as key to understanding others. See page 33.

Theory Theory: Encompasses theories which consider a top-down understanding of what it means to 'be' another person as necessary for empathy. See page 34.

intertextuality: A conceptual framework which focuses on how texts interact with each other and how they change through time.

Complete Bibliography

Abraham, Anna, *The Cambridge Handbook of the Imagination* (Cambridge, UK: Cambridge University Press, 2020).

Adolphe, Bruce, *The Mind's Ear: Exercises for Improving the Musical Imagination for Performers, Composers, and Listeners* (Oxford: Oxford University Press, 2013).

Aizawa, Ken, 'Clark on Language, Cognition, and Extended Cognition', *Andy Clark and His Critics*, ed. Matteo Colombo, Elizabeth Irvine, & Mog Stapleton (Oxford: Oxford University Press, 2019), 32-43.

Anderson, Julian and Christopher Dingle, *Julian Anderson: Dialogues on Listening, Composing and Culture*, (Suffolk, UK: Boydell & Brewer, 2020).

Anderson, John R., *How Can the Human Mind Occur in the Physical Universal?* (Oxford: Oxford University Press, 2007).

Anderson, Michael L., 'Embodied Cognition: A Field Guide', *Artificial Intelligence*, 149, no. 1 (2003), 91–130.

Aston, Alexander, 'Metaplasticity and the Boundaries of Social Cognition: Exploring Scalar Transformations in Social Interaction and Intersubjectivity', *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 65–89. https://doi.org/10.1007/s11097-018-9601-z

Atkinson, Dwight, 'Extended, Embodied Cognition and Second Language Acquisition', *Applied Linguistics*, 31, no. 5 (2010), 599–622. https://doi.org/10.1093/applin/amq009

Babbitt, Milton, 'The Composer as Specialist', *The Collected Essays of Milton Babbitt*, ed. Stephen Peles (Princeton, NJ: Princeton University Press, 1958).

Babich, Babette, 'Adorno's Radio Phenomenology: Technical Reproduction, Physiognomy and Music,' *Philosophy & Social Criticism*, 40, no. 10 (2014), 957–996. https://doi.org/10.1177/0191453714548503

Bailes, Freya, 'Musical Imagery and the Temporality of Consciousness', *Music and Consciousness 2: Worlds, Practices, Modalities*, ed. Ruth Herbert, David Clarke, Eric Clarke

(Oxford: Oxford University Press, 2019), 271–285. https://doi.org/10.1093/oso/9780198804352.003.0016

Bailes, Freya and Laura Bishop, 'Musical Imagery in the Creative Process', *The Act of Musical Composition,* ed. Dave Collins (London, UK: Routledge, 2012).

Barrett, Margaret S., *Collaborative Creative Thought and Practice in Music*, (London, UK: Routledge, 2016.

Batstone, Philip, 'Musical Analysis as Phenomenology', *Perspectives of New Music*, 7, no. 2 (1969), 94–110. https://doi.org/10.2307/832296

Beck, Birgit and Michael Kühler, *Technology, Anthropology, and Dimensions of Responsibility* (Stuttgart, DL: J.B. Metzler, 2020).

Beloborodova, Olga and Pim Verhulst, 'Broadcasting the Mind: Extended Cognition in Beckett's Radio Plays', *Beckett and Modernism,* ed. Olga Beloborodova, Dirk van Hulle, and Pim Verhulst (London, UK: Springer, 2018), 239–257.

Bird, Jon, Simon Holland, Paul Marshall, Yvonne Rogers, and Andy Clark, 'Feel the Force: Using Tactile Technologies to Investigate the Extended Mind', *DAP 08*, (2008), 1-4.

Berti, Anna and Francesca Frassinetti, 'When Far Becomes Near: Remapping of Space by Tool Use, *Journal of Cognitive Neuroscience,* 12, no. 3 (2000), 415–420.

Bishop, Laura, Freya Bailes, and Roger T. Dean, 'Musical Expertise and the Ability to Imagine Loudness', *PLOS ONE* 8, no. 2, e56052 (2013). https://doi.org/10.1371/journal.pone.0056052

Boden, Margaret A., *Mind as Machine: A History of Cognitive Science* (Gloucester, UK: Clarendon Press, 2008).

Boenn, Georg, 'The Importance of Husserl's Phenomenology of Internal Time-Consciousness for Music Analysis and Composition', conference paper presented at the *International Computer Music Conference, ICMC* (2008).

Borgo, David, ‘Strange Loops of Attention, Awareness, Action, and Affect in Musical Improvisation’, *Music and Consciousness 2: Worlds, Practices, Modalities*, ed. Ruth Herbert, David Clarke and Eric Clarke (Oxford: Oxford University Press, 2019).

Born, Georgina and Andrew Barry, ‘Music, Mediation Theories and Actor-Network Theory’, *Contemporary Music Review*, 37, nos. 5-6 (2018), 443–487. https://doi.org/10.1080/07494467.2018.1578107

Boulez, Pierre, *Penser la Musique Aujourd’hui*. (Paris: Gonthier, 1963).

Boyle, Michael, ‘Empathetic Embodiment in the Compositional Process: A 4E Perspective on the Relationship between Composer and Performer’, *Journal of Interdisciplinary Music Studies,* 10 (2020), 59-72. https://doi.org/10.25364/24.10:2020.1.4

Brattico, Elvira and Mari Tervaniemi, ‘Musical Creativity and the Human Brain’, *Musical Creativity: Multidisciplinary Research in Theory and Practice,* eds. Irène Deliège and Geraint A. Wiggins (Hove, UK: Psychology Press, 2006), 290-321.

Brodsky, Warren, Yoav Kessler, Bat-Sheva Rubinstein, Jane Ginsborg and Avishai Henik. ‘The Mental Representation of Music Notation: Notational Audiation’. *Journal of Experimental Psychology: Human Perception and Performance* 34, no. 2 (2008), 427–45. https://doi.org/10.1037/0096-1523.34.2.427

Bunch, James, *A Polyphony of the Mind: Intertextuality in the Music of Salvatore Sciarrino* (PhD. dissertation, University of Illinois, 2016).

Cardinali, Lucilla, Francesca Frassinetti, Claudio Brozzoli, Christian Urquizar, Alice C Roy, and Alessandro Famè, ‘Tool-use Induces Morphological Updating of the Body Schema’, *Current Biology*, 19, no. 12 (2009).

Cardinali, Lucilla, Claudio Brozzoli, Christian Urquizar, Alice Roy, and Alessandro Famè, ‘When Action is Not Enough: Tool-use Reveals Tactile-Dependent Access to Body Schema’, *Neuropsychologia,* 49 (2011), 3750-3757.

Coplan, Amy and Peter Goldie, *Empathy: Philosophical and Psychological Perspectives* (Oxford: Oxford University Press, 2011).

Carter, Adam and Orestis Palermos, ‘Is Having Your Computer Compromised a Personal Assault? The Ethics of Extended Cognition’, *Journal of the American Philosophical Association*, 2, no. 4 (2016), 542–560. https://doi.org/10.1017/apa.2016.28

Cash, Mason, ‘Extended Cognition, Personal Responsibility, and Relational Autonomy. *Phenomenology and the Cognitive Sciences*, 9, no. 4 (2010), 645–671. https://doi.org/10.1007/s11097-010-9177-8

Cassou-Noguès, Pierre, ‘The Social Impact and the Intrusive Dimension of Enhancement’, *Phenomenology and the Cognitive Sciences*, 16, no. 1 (2017), 75–89. https://doi.org/10.1007/s11097-016-9480-0

Chalmers, David, ‘Extended Cognition and Extended Consciousness’, *Andy Clark and His Critics*, ed. Matteo Colombo, Elizabeth Irvine, & Mog Stapleton (Oxford: Oxford University Press, 2019), 9-20.

Chappell, Kerry, Lindsay Hetherington, Hermione Ruck Keene, Heather Wren, Angelos Alexopoulos, Oded Ben-Horin, Kim Nikolopoulos, Janne Robberstad, Sofoklis Sotiriou, and Bogner Franz, ‘Dialogue and Materiality/Embodiment in Science|arts Creative Pedagogy: Their Role and Manifestation’, *Thinking Skills and Creativity*, 31 (2019), 296-322. https://doi.org/10.1016/j.tsc.2018.12.008

Chatterjee, Margaret, ‘Towards a Phenomenology of Time-Consciousness in Music’, *Diogenes*, 19, no. 74 (1971), 49–56. https://doi.org/10.1177/039219217101907404

Chemero, Anthony P., *Radical Embodied Cognitive Science* (Cambridge, MA: MIT Press, 2011).

Christensen, Justin, ‘Improvisation: An Ideal Display of Embodied Imagination’, *The Oxford Handbook of Sound and Imagination, vol. 2*, ed. Mark Grimshaw-Aagaard, Mads Walther-Hansen and Martin Knakkergaard (Oxford: Oxford University Press, 2019), 15-36.

Cimini, Amy Marie, ‘Music Theory, Feminism, the Body: Mediation’s Plural Work’, *Contemporary Music Review*, 37, nos. 5–6 (2018), 666–683. https://doi.org/10.1080/07494467.2018.1577642

Clark, Andy, *Being There: Putting Brain, Body, and World Together Again*, (Cambridge, MA: MIT Press, 1998).

Clark, Andy, *Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence* (Oxford: Oxford University Press, 2004).

Clark, Andy, 'Curing Cognitive Hiccups: A Defense of The Extended Mind', *The Journal of Philosophy*, 104 (2007), 163–192. https://doi.org/10.2307/20620012

Clark, Andy, 'Pressing the Flesh: A Tension in the Study of the Embodied, Embedded Mind?' *Philosophy and Phenomenological Research*, 76, no. 1 (2008a), 37–59. https://doi.org/10.1111/j.1933-1592.2007.00114.x

Clark, Andy, 'The Frozen Cyborg: A Reply to Selinger and Engström', *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008b), 343–346. https://doi.org/10.1007/s11097-008-9105-3

Clark, Andy, *Supersizing the Mind: Embodiment, Action, and Cognitive Extension* (Oxford: Oxford University Press), 2008c).

Clark, Andy, 'Memento's Revenge: The Extended Mind, Extended', *The Extended Mind,* ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 43-66.

Clark, Andy, 'Finding the Mind', *Philosophical Studies*, 152, no. 3 (2011), 447–461. https://doi.org/10.1007/s11098-010-9598-9

Clark, Andy and David Chalmers, 'The Extended Mind', *Analysis*, 58, no. 1 (1998), 7–19.

Clarke, David, 'Music, Phenomenology, Time Consciousness: Meditations after Husserl', *Music and Consciousness: Philosophical, Psychological, and Cultural Perspectives*, ed. Eric Clarke (Oxford: Oxford University Press, 2011), 1-28.

Clarke, David and Eric Clarke, *Music and Consciousness: Philosophical, Psychological, and Cultural Perspectives* (Oxford: Oxford University Press, 2011).

Clarke, Eric and Mark Doffman, *Distributed Creativity: Collaboration and Improvisation in Contemporary Music* (Oxford: Oxford University Press, 2017).

Cook, Nicholas, *Music, Imagination, and Culture* (Oxford: Oxford University Press, 1990).

Cook, Nicholas, *Beyond the Score: Music as Performance*. (Oxford: Oxford University Press, 2013).

Cook, Nicholas, *Music as Creative Practice*. (Oxford: Oxford University Press, 2018).

Coplan, Amy, 'Understanding Empathy: Its Features and Effects', *Empathy: Philosophical and Psychological Perspectives*, eds. Amy Coplan and Peter Goldie (Oxford: Oxford University Press, 2011), 2–18. https://doi.org/10.1093/acprof:oso/9780199539956.003.0002

Copland, Aaron, *Music and Imagination*, (Cambridge, MA: Harvard University Press, 1980).

Covington, Kate, 'The Mind's Ear: I Hear Music and No One Is Performing', *College Music Symposium*, 45 (2005), 25–41.

Craenan, Paul, *Composing under the Skin: The Music-making Body at the Composer's Desk*, (Leuven: Leuven University Press, 2014).

Croft, John, 'The Spectral Legacy', *Journal of the Royal Musical Association*, 135, no. 1 (2010), 191–197. https://doi.org/10.1080/02690401003620730

Cross, Ian, Felicity Laurence, and Tal-Chen Rabinowitch, 'Empathy and Creativity in Group Musical Practices: Towards a Concept of Empathic Creativity', *The Oxford Handbook of Music Education, Volume 2*, eds. Gary E. McPherson, and Graham F. Welch (Oxford: Oxford University Press, 2012).

Csikszentmihalyi, Mihaly, *Flow and the Foundations of Positive Psychology: The Collected Works of Mihaly Csikszentmihalyi*. (Amsterdam, NL: Springer Netherlands, 2014).

Csordas, Thomas J., 'Intersubjectivity and Intercorporeality', *Subjectivity*, 22, no. 1 (2008), 110–121. https://doi.org/10.1057/sub.2008.5

Cuffari, Elena, 'Gestural Sense-making: Hand Gestures as Intersubjective Linguistic Enactments', *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 599–622. https://doi.org/10.1007/s11097-011-9244-9

Cuffari, Elena, 'Yanna B. Popova, Stories, Meaning, and Experience: Narrativity and Enaction', *Phenomenology and the Cognitive Sciences*, 16, no. 1 (2017), 181–185. https://doi.org/10.1007/s11097-016-9462-2

Cusick, Suzanne G., 'Feminist Theory, Music Theory, and the Mind/Body Problem', *Perspectives of New Music*, 32, no. 1 (1994), 8–27. https://doi.org/10.2307/833149

Day, Matthew, 'Religion, Off-Line Cognition and the Extended Mind', *Journal of Cognition and Culture*, 4, no. 1 (2004), 101–121. https://doi.org/10.1163/156853704323074778

de Bruin, Leon C. and Lena Kästner, 'Dynamic Embodied Cognition', *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 541–563. https://doi.org/10.1007/s11097-011-9223-1

Dehaene, Stanislas, *The Number Sense: How the Mind Creates Mathematics, Revised and Updated Edition* (Oxford: Oxford University Press, 2011).

Deliège, Irène and Geraint A. Wiggins, *Musical Creativity: Multidisciplinary Research in Theory and Practice* (Hove, UK: Psychology Press, 2006).

Dietrich, Eric, 'Some Strangeness in the Proportion, or How to Stop Worrying and Learn to Love the Mechanistic Forces of Darkness', *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008), 349–352. https://doi.org/10.1007/s11097-008-9102-6

Dillon, Stephen C., and Andrew R. Brown, 'Access to Meaningful Relationships Through Virtual Instruments and Ensembles', *Proceedings of the ISME Commission for Community Music Activity: CMA XII Harmonizing the Diversity that is Community Musical Activity* (2010), 33-36.

Dobrian, Christopher, 'Aesthetic Considerations in the Use of "Virtual" Music Instruments', *Proceedings of the Workshop on Current Research Directions in Computer Music* (2001).

Donin, Nicolas and Jacques Theureau, 'Theoretical and Methodological Issues Related to Long Term Creative Cognition: The Case of Musical Composition, *Cognition, Technology & Work*, 9, no. 4 (2007), 233–251. https://doi.org/10.1007/s10111-007-0082-z

Dotov, Dobromir G., Lin Nie, and Anthony Chemero, 'A Demonstration of the Transition from Ready-to-Hand to Unready-to-Hand', *PLOS ONE*, 5, no. 3 (2010), e9433. https://doi.org/10.1371/journal.pone.0009433

Dreyfus, Herbert L., *What Computers Still Can't Do: A Critique of Artificial Reason* (Cambridge, MA: MIT Press, 1992).

Duby, Marc, 'Playing the Inner Ear', *The Oxford Handbook of Sound and Imagination, vol. 2*, ed. Mark Grimshaw-Aagaard, Mads Walther-Hansen and Martin Knakkergaard (Oxford: Oxford University Press, 2019), 97-116.

Durt, Christopher, Thomas Fuchs, and Christian Tewes, *Embodiment, Enaction, and Culture: Investigating the Constitution of the Shared World* (Cambridge, MA: MIT Press, 2017).

van der Schyff, Dylan, Andrea Schiavio, Ashley Walton, Valerio Velardo, and Anthony Chemero, 'Musical Creativity and the Embodied Mind', *Music & Science*, 1 (2018). http://doi.org/10.1177/2059204318792319

Emmerson, Simon, 'Playing the Inner Ear: Performing the Imagination', *The Oxford Handbook of Sound and Imagination, vol. 2*, ed. Mark Grimshaw-Aagaard, Mads Walther-Hansen and Martin Knakkergaard (Oxford: Oxford University Press, 2019), 259-278.

Farnè, Alessandro, Atsushi Iriki, and Elisabetta Làdavas, 'Shaping Multisensory Action–Space With Tools: Evidence From Patients With Cross-Modal Extinction', *Neuropsychologia,* 43 (2005). 238–248.

Fenwick, Tara and Richard Edwards, *Actor-Network Theory in Education* (London, UK: Routledge, 2010).

Flower, Linda and John Richard Hayes, 'A Cognitive Process Theory of Writing', *College Composition and Communication*, 32, no. 4 (1981), 365–387. https://doi.org/10.2307/356600

Francesconi, Denis and Massimiliano Tarozzi, 'Embodied Education: A Convergence of Phenomenological Pedagogy and Embodiment', *Studia Phaenomenologica,* 12 (2012), 263–288.

Freedberg, David and Vittorio Gallese, 'Motion, Emotion and Empathy in Esthetic Experience', *Trends in Cognitive Sciences,* 11, no. 5 (2007), 197-203.

Freiman, Marcelle, 'The Art of Drafting and Revision: Extended Mind in Creative Writing', *New Writing*, 12, no. 1 (2015), 48–66. https://doi.org/10.1080/14790726.2014.977797

Froese, Tom, 'Making Sense of the Chronology of Paleolithic Cave Painting from the Perspective of Material Engagement Theory, *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 91–112. https://doi.org/10.1007/s11097-017-9537-8

Froese, Tom and Ezequiel A. Di Paolo, 'Sociality and the Life-Mind Continuity Thesis', *Phenomenology and the Cognitive Sciences*, 8, no. 4 (2009), 439-463. https://doi.org/10.1007/s11097-009-9140-8

Froese, Tom and Thomas Fuchs, ‘The Extended Body: A Case Study in the Neurophenomenology of Social Interaction, *Phenomenology and the Cognitive Sciences*, 11, no. 2 (2012), 205–235. https://doi.org/10.1007/s11097-012-9254-2

Froese, Tom and Shaun Gallagher. "Getting Interaction Theory (IT) Together: Integrating Developmental, Phenomenological, Enactive, and Dynamical Approaches to Social Interaction." *Interaction Studies* 13, no. 3 (2012): 436-468.

Fuchs, Thomas and Hanne De Jaegher ‘Enactive Intersubjectivity: Participatory Sense-Making and Mutual Incorporation’, *Phenomenology and the Cognitive Sciences*, 8, no. 4 (2009), 465–486. https://doi.org/10.1007/s11097-009-9136-4

Galetzka, Cedric, ‘The Story So Far: How Embodied Cognition Advances Our Understanding of Meaning-Making’, *Frontiers in Psychology*, 8, 1315 (2017). https://doi.org/10.3389/fpsyg.2017.01315

Gallagher, Shaun, *How the Body Shapes the Mind*. (Gloucester, UK: Clarendon Press, 2006).

Gallagher, Shaun, ‘Understanding Others: Embodied Social Cognition’, *Handbook of Cognitive Science*, ed. Paco. Calvo & Antoni Gomila (London, UK: Elsevier, 2008), 437-452. https://doi.org/10.1016/B978-0-08-046616-3.00022-0

Gallese, Vittorio, ‘The Roots of Empathy: The Shared Manifold Hypothesis and the Neural Basis of Intersubjectivity’, *Psychopathology*, 36, no. 4 (2003), 171–180. https://doi.org/10.1159/000072786

Gallese, Vittorio and Alvin Goldman, ‘Mirror Neurons and the Simulation Theory of Mind-Reading, *Trends in Cognitive Sciences*, 2, no. 12 (1998), 493–501. https://doi.org/10.1016/S1364-6613(98)01262-5

Gallese, Vittorio, Juhani Pallasmaa, Harry Mallgrave, and Sarah Robinson, *Architecture and Empathy* (Tapio Wirkkala-Rut Bryk Foundation, 2015).

Gangopadhyay, Nivedita, ‘Introduction: Embodiment and Empathy, Current Debates in Social Cognition’ *Topoi*, 33, no. 1 (2014), 117–127. https://doi.org/10.1007/s11245-013-9199-2

Garratt, Peter, *The Cognitive Humanities: Embodied Mind in Literature and Culture*, (London, UK: Springer, 2016).

Gentilucci, Maurizio, Alice Roy, and Silvia Stefanini, 'Grasping an Object Naturally or With a Tool: Are These Tasks Guided by a Common Motor Representation?', *Experimental Brain Research,* 157, no. 4 (2004), 496-506.

Gieser, Thorsten, 'Embodiment, Emotion and Empathy: A Phenomenological Approach to Apprenticeship Learning,' *Anthropological Theory,* 8, no. 3 (2008), 299–318. https://doi.org/10.1177/1463499608093816

Gilbert, Anthony, 'Musical Space: A Composer's View', *Critical Inquiry,* 7, no. 3 (1981), 605–611. https://doi.org/10.1086/448117

Godøy, Rolf Inge, 'Imagined Action, Excitation, and Resonance', *Musical Imagery,* ed. Rolf Inge Godøy and Harald Jørgensen (Amsterdam: Swets and Zeitlinger, 2001), 237-250.

Godøy, Rolf Inge and Harald Jørgensen, *Musical Imagery* (London, UK: Routledge, 2012).

Goehr, Lydia, *The Imaginary Museum of Musical Works: An Essay in the Philosophy of Music: An Essay in the Philosophy of Music* (Gloucester, UK: Clarendon Press, 1992).

Goldsworthy, Chris, 'The Effect of Dynamic Social Material Conditions on Cognition in the Biomedical Research Laboratory, *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 241–257. https://doi.org/10.1007/s11097-018-9600-0

Gomila, Antoni and Paco Calvo, 'Directions for an Embodied Cognitive Science: Toward an Integrated Approach', *Handbook of Cognitive Science,* ed. Paco Calvo & Antoni Gomila (London, UK: Elsevier, 2008), 1-25. https://doi.org/10.1016/B978-0-08-046616-3.00001-3

Gordon, Edwin E., 'Research Studies in Audiation: I', *Bulletin of the Council for Research in Music Education, 84* (1985), 34–50.

Gordon, Edwin E., 'All about Audiation and Music Aptitudes', *Music Educators Journal*, 86, no. 2 (1999), 41–44. https://doi.org/10.2307/3399589

Grimshaw-Aagaard, Mark, Mads Walther-Hansen, and Martin Knakkergaard, *The Oxford Handbook of Sound and Imagination, vol. 1* (Oxford: Oxford University Press, 2019a).

Grimshaw-Aagaard, Mark, Mads Walther-Hansen, and Martin Knakkergaard, *The Oxford Handbook of Sound and Imagination, vol. 2* (Oxford: Oxford University Press, 2019b).

Le Guin, Elizabeth, *Boccherini's Body: An Essay in Carnal Musicology* (Berkeley, CA: University of California Press, 2006).

Hanslick, Eduard, *Vom Musikalisch-Schönen,* trans. Lee Rothfarb and Christoph Landerer as 'Eduard Hanslick's On the Musically Beautiful: A New Translation' (Oxford: Oxford University Press, 1854/2018).

Hanson, F. Allan, 'The Anachronism of Moral Individualism and the Responsibility of Extended Agency', *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008), 415–424. https://doi.org/10.1007/s11097-008-9098-y

Hargreaves, David, Jonathan James Hargreaves, and Adrian C. North, 'Imagination and Creativity in Musical Listening', *Musical Imaginations: Multidisciplinary Perspectives on Creativity, Performance and Perception*, eds. David Hargreaves, Dorothy Miell, and Raymond MacDonald (Oxford: Oxford University Press, 2011), 156-172.

Hargreaves, David, Dorothy Miell, and Raymond MacDonald, *Musical Imaginations: Multidisciplinary Perspectives on Creativity, Performance and Perception* (Oxford: Oxford University Press, 2011).

Harman, Graham, *Prince of Networks: Bruno Latour and Metaphysics* (re.press, 2009).

Harman, Graham, 'Technology, Objects and Things in Heidegger', *Cambridge Journal of Economics*, 34, no. 1 (2010), 17–25.

Harman, Graham, *Tool-Being: Heidegger and the Metaphysics of Objects* (Chicago, IL: Open Court, 2011).

Haselager, Pim, Jelle van Dijk, Iris van Rooij, 'A Lazy Brain? Embodied Embedded Cognition and Cognitive Neuroscienc', *Handbook of Cognitive Science*, ed. Paco. Calvo & Antoni Gomila (London, UK: Elsevier, 2008), 273-290. https://doi.org/10.1016/B978-0-08-046616-3.00014-1

Hatten, Robert S., 'The Place of Intertextuality in Music Studies', *The American Journal of Semiotics*, 3, no. 4 (2008), 69–82. https://doi.org/10.5840/ajs1985345

Haugeland, John, ‘Mind Embodied and Embedded’, *Mind and Cognition: 1993 International Symposium*, eds.Yu-Houng H. Houng and J. Ho (Nanking, Academica Sinica, 1993), 233-267.

Haworth, Christopher, ‘Protentions and Retentions of Xenakis and Cage: Nonhuman Actors, Genre and Time in Microsound’, *Contemporary Music Review*, 37, nos. 5-6 (2018), 606–625. https://doi.org/10.1080/07494467.2018.1577639

Hays, Kathryn, Cris Kubli, and Roger Malina, ‘Creativity and Cognition in Extreme Environments: The Space Arts as a Case Study’, *Frontiers in Psychology*, 11 (2020). https://doi.org/10.3389/fpsyg.2020.575291

Heersmink, Richard, ‘Embodied Tools, Cognitive Tools and Brain-Computer Interfaces’, *Neuroethics*, 6, no. 1 (2013), 207–219. https://doi.org/10.1007/s12152-011-9136-2

Heersmink, Richard, ‘Distributed Selves: Personal Identity and Extended Memory Systems’, *Synthese*, 194, no. 8 (2-017a), 3135–3151.

Heersmink, Richard, ‘Extended Mind and Cognitive Enhancement: Moral Aspects of Cognitive Artifacts’, *Phenomenology and the Cognitive Sciences*, 16, no. 1 (2017b), 17–32. https://doi.org/10.1007/s11097-015-9448-5

Heidegger, Martin, *Basic Writings*, ed. David Farrell Krell (London, UK: Routledge).

Heinrichs, Jan-Hendrik, ‘Artificial Intelligence in Extended Minds: Intrapersonal Diffusion of Responsibility and Legal Multiple Personality’, *Technology, Anthropology, and Dimensions of Responsibility*, ed. Birgit Beck and Michael Kühler (Stuttgart, DL: J.B. Metzler, 2020), 159-176. https://doi.org/10.1007/978-3-476-04896-7_12

Henare, Amiria, Martin Holbraad, and Sari Wastell, *Thinking Through Things: Theorising Artefacts Ethnographically* (London, UK: Routledge, 2007)

Hodder, Ian, ‘The Entanglements of Humans and Things: A Long-Term View’, *New Literary History*. 45, no. 1 (2014), 19-36. https://doi.org/10.1353/nlh.2014.0005

Hoffman, Adria R., and Bruce A. Carter, ‘A Virtual Composer in Every Classroom’, *Music Educators Journal*, 99, no. 3 (2013), 59–62.

Høffding, Simon, *A Phenomenology of Musical Absorption* (London, UK: Springer, 2018).

Høffding, Simon, 'Performative Passivity: Lessons on Phenomenology and the Extended Musical Mind with the Danish String Quartet', *Music and Consciousness 2: Worlds, Practices, Modalities*, ed. Ruth Herbert, David Clarke and Eric Clarke (Oxford: Oxford University Press, 2019), 127-42.

Høffding, Simon, and Torben Snekkestad, 'Inner and Outer Ears: Enacting Agential Systems in Music Improvisation', *Philosophy of Improvisation: Interdisciplinary Perspectives on Theory and Practice,* eds. Susanne Ravn, Simon Høffding, James McGuirk (London, UK: Routledge, 2021).

Hollan, James, Edwin Hutchins, David Kirsh, 'Distributed Cognition: Toward a New Foundation for Human-Computer Interaction Research', *ACM Transactions on Computer-Human Interaction*, 7, no. 2 (2000), 174–196. https://doi.org/10.1145/353485.353487

Holland, Simon, Katie Wilkie, Paul Mulholland, and Allan Seago, *Music and Human-Computer Interaction* (London, UK: Springer, 2013).

Horgan, Terry and Uriah Kriegel, 'Phenomenal Intentionality Meets the Extended Mind', *The Monist*, *91*, no. 2 (2008), 347–373. https://doi.org/10.5840/monist20089128

Hughes, Ed, Alice Eldridge, and Chris Kiefer, 'Syncphonia: Understanding the Value of Participatory Design in Developing Music Technology to Support Musical Ensembles That Use Notation', *Journal of Music Technology & Education*, 13, no. 1 (2020), 57–77. https://doi.org/10.1386/jmte_00016_1

Hurley, Susan, 'The Varieties of Externalism', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 101-153.

Hutchins, Edwin, *Cognition in the Wild* (Cambridge, MA: MIT Press, 1995).

Hutchins, Edwin, 'The Distributed Cognition Perspective on Human Interaction', *Roots of Human Sociality*, eds. Stephen C. Levinson and Nicholas J. Enfield (London, UK: Routledge, 2006), 375-398. https://doi.org/10.4324/9781003135517-19

Hutchins, Edwin, 'Imagining the Cognitive Life of Things', *The Cognitive Life of Things: Recasting the Boundaries of the Mind,* eds. Lambros Malafouris and Colin Renfrew (Cambridge, UK: McDonald Institute for Archaeological Research, 2010).

Ihde, Don, *Technology and the Lifeworld: From Garden to Earth* (Champaign and Urbana, IN: University of Illinois Press, 1990).

Ihde, Don, *Bodies in Technology* (Minneapolis, MN: University of Minnesota Press, 2002).

Ihde, Don, *Listening and Voice: Phenomenologies of Sound, 2nd edition* (Albany, NY: State University of New York Press, 1976/2007).

Ihde, Don, 'Aging: I don't want to be a cyborg!', *Phenomenology and the Cognitive Sciences,* 7, no. 3 (2008), 397–404. https://doi.org/10.1007/s11097-008-9096-0

Ingold, Tim, *The Perception of the Environment: Essays on Livelihood, Dwelling and Skill* (London, UK: Routledge, 2000).

Eli, Renee, 'Intercorporeality: An Invitation to Being in the Human-Body-Nature Relationship', *Journal of Conscious Evolution,* 9 (2018). https://digitalcommons.ciis.edu/cejournal/vol9/iss9/1

Irwin, Brian A., 'An Enactivist Account of Abstract Words: Lessons From Merleau-Ponty. *Phenomenology and the Cognitive Sciences,* 16, no. 1 (2017), 133–153. https://doi.org/10.1007/s11097-015-9434-y

Jansen, Julia, 'Imagination beyond the Western Mind', *Imagination: Cross-Cultural Philosophical Analyses,* eds. Hans-Georg Moeller and Andrew K. Whitehead, (London, UK: Bloomsbury Publishing, 2018), 129–140.

Japyassú, Hilton F., and Kevin N Laland, 'Extended Spider Cognition', *Animal Cognition,* 20, no. 3 (2017), 375–395. https://doi.org/10.1007/s10071-017-1069-7

Jeannerod, Marc, *The Cognitive Neuroscience of Action,* (London, UK: John Wiley & Sons, 1997)

Jeffares, Ben, 'The Co-Evolution of Tools and Minds: Cognition and Material Culture in the Hominin Lineage', *Phenomenology and the Cognitive Sciences,* 9, no. 4 (2010), 503–520. https://doi.org/10.1007/s11097-010-9176-9

Jensen, Casper Bruun, ‘Developing/Development Cyborgs’, *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008), 375–385. https://doi.org/10.1007/s11097-008-9101-7

Jensen, Rasmus Thybo and Dermot Moran, ‘Introduction: Intersubjectivity and Empathy’, *Phenomenology and the Cognitive Sciences*, 11, no. 2 (2012), 125–133. https://doi.org/10.1007/s11097-012-9258-y

Johannsen, Niels Nørkjær, ‘Technological Conceptualization: Cognition on the Shoulders of History’, *The Cognitive Life of Things: Recasting the Boundaries of the Mind*, eds. Lambros Malafouris and Colin Renfrew (Cambridge, UK: McDonald Institute for Archaeological Research, 2010), 59-69.

Johnson, Mark, *The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason* (Chicago, IL: University of Chicago Press, 1990).

Johnston, Andrew, Linda Candy, Ernest Edmonds, ‘Designing and Evaluating Virtual Musical Instruments: Facilitating Conversational User Interaction’, *Design Studies*, 29, no. 6 (2008), 556–571. https://doi.org/10.1016/j.destud.2008.07.005

Jones, Peter, Ayan Ghosh, Jacques Penders, and Heath Reed, ‘Towards Human Technology Symbiosis in the Haptic Mode’, conference paper presented at *International Conference on Communication, Media, Technology and Design* (2013).

Jospe, Karine, Agnes Flöel, and Michal Lavidor, ‘The Interaction Between Embodiment and Empathy in Facial Expression Recognition’, *Social Cognitive and Affective Neuroscience*, 13, no. 2 (2018), 203–215. https://doi.org/10.1093/scan/nsy005

Kandinsky, Wassily and Hilla Rebay, *Point and Line to Plane* (North Chelmsford, MA: Courier Corporation, 1979).

Kaspar, Kai, Sabine König, Jessika Schwandt, and Peter König, ‘The Experience of New Sensorimotor Contingencies by Sensory Augmentation’, *Consciousness and Cognition*, 28 (2014), 47–63. https://doi.org/10.1016/j.concog.2014.06.006

Kirchhoff, Michael David, ‘Extended Cognition and Fixed Properties: Steps to a Third-Wave Version of Extended Cognition’, *Phenomenology and the Cognitive Sciences*, 11, no. 2 (2011), 287–308. https://doi.org/10.1007/s11097-011-9237-8

Kirsh, David, ‘The Intelligent Use of Space’, *Artificial Intelligence*, 73, no. 1 (1995), 31–68. https://doi.org/10.1016/0004-3702(94)00017-U

Kiverstein, Julian and Andy Clark, ‘Introduction: Mind Embodied, Embedded, Enacted: One Church or Many?’ *Topoi*, 28 (2009), 1–7. https://doi.org/10.1007/s11245-008-9041-4

Kiverstein, Julian and Mark Miller, ‘The Embodied Brain: Towards a Radical Embodied Cognitive Neuroscience’, *Frontiers in Human Neuroscience*, 9 (2015). https://doi.org/10.3389/fnhum.2015.00237

Klein, Eve, ‘Feigning Humanity: Virtual Instruments, Simulation and Performativity’, *IASPM Journal*, 6, no. 2 (2016), 22–48.

Klein, Michael Leslie, *Intertextuality in Western Art Music* (Bloomington, IN: Indiana University Press, 2005).

Knappett, Carl, and Lambros Malafouris, *Material Agency: Towards a Non-Anthropocentric Approach*, (London, UK: Springer, 2008).

Knuuttila, Tarja, ‘Imagination Extended and Embedded: Artifactual Versus Fictional Accounts of Models’, *Synthese*, 198 (2017), 5077-97. https://doi.org/10.1007/s11229-017-1545-2

Konečni, Vladimiri, ‘Composers’ Creative Process: The Role of Life-Events, Emotion and Reason’, *Musical Imaginations: Multidisciplinary Perspectives on Creativity, Performance and Perception*, eds. David Hargreaves, Dorothy Miell, and Raymond MacDonald (Oxford: Oxford University Press, 2011), 141-155. https://doi.org/10.1093/acprof:oso/9780199568086.003.0009

König, Sabine U., Frank Schumann, Johannes Keyser, Caspar Goeke, Carina Krause, Susan Wache, Aleksey Lytochkin, Manuel Ebert, Vincent Brunsch, Basil Wahn, Kai Kaspar, Saskia K. Nagel, Tobias Meilinger, Heinrich Bülthoff, Thomas Wolbers, Christian Büchel, and Peter König, ‘Learning New Sensorimotor Contingencies: Effects of Long-Term Use of Sensory Augmentation on the Brain and Conscious Perception’ *PLOS ONE*, 11, no. 12, e0166647 (2016). https://doi.org/10.1371/journal.pone.0166647

Kostka, Violetta, Paulo F. de Castro, and William A. Everett, *Intertextuality in Music: Dialogic Composition*. (London, UK: Routledge, 2021).

Koukouti, Maria, and Lambros Malafouris, ‘Material Imagination: An Anthropological Perspective’, *The Cambridge Handbook of the Imagination*, ed. Anna Abraham (Cambridge: Cambridge University Press, 2020), 30–46.

Krueger, Joel, ‘Music as Affective Scaffolding’, *Music and Consciousness 2: Worlds, Practices, Modalities*, ed. Ruth Herbert, David Clarke and Eric Clarke (Oxford, Oxford University Press, 2019c), 55-70.

Krueger, Joel, ‘Extended Cognition and the Space of Social Interaction. *Consciousness and Cognition*, 20, no. 3 (2011), 643–657. https://doi.org/10.1016/j.concog.2010.09.022

Krueger, Joel, ‘Seeing Mind in Action’, *Phenomenology and the Cognitive Sciences*, 11, no. 2 (2012), 149–173. https://doi.org/10.1007/s11097-011-9226-y

Krueger, Joel, ‘Affordances and the Musically Extended Mind’, *Frontiers in Psychology*, 4 (2014). https://doi.org/10.3389/fpsyg.2013.01003

Lakoff, George and Mark Johnson, *Philosophy in The Flesh: The Embodied Mind and its Challenge to Western Thought* (New York, NY: Basic Books, 1999).

Lakoff, George and Rafael E. Núñez. *Where Mathematics Come From: How the Embodied Mind Brings Mathematics into Being* (New York, NY: Basic Books, 2000).

Laner, Iris, ‘Reflective Interventions: Enactivism and Phenomenology on Ways of Bringing the Body into Intellectual Engagement’, *Phenomenology and the Cognitive Sciences*, 20, no. 3 (2021), 443–461. https://doi.org/10.1007/s11097-020-09673-3

Latour, Bruno, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005).

Leman, Marc, *Music, Gestalt, and Computing: Studies in Cognitive and Systematic Musicology* (London, UK: Springer Science & Business Media, 1997).

Leman, Marc, *Embodied Music Cognition and Mediation Technology*. (Cambridge, MA: MIT Press, 2007).

Leman, Marc, *Music and Schema Theory: Cognitive Foundations of Systematic Musicology*. Springer Science & Business Media, 2012).

Linson, Adam and Eric Clarke, 'Distributed Cognition, Ecological Theory and Group Improvisation', *Distributed Creativity: Collaboration and Improvisation in Contemporary Music*, eds. Eric Clarke and Mark Doffman (Oxford: Oxford University Press, 2017), 52-69.

Love, Karlin and Margaret S. Barrett. 'Learning to Collaborate in Code: Negotiating the Score in a Symphony Orchestra Composers' School'. *Collaborative Creative Thought and Practice in Music*, ed. Margaret S. Barrett (London: Ashgate Publishing, 2016), 49–64.

Lyre, Holger, 'Socially Extended Cognition and Shared Intentionality', *Frontiers in Psychology*, 9 (2018). https://doi.org/10.3389/fpsyg.2018.00831

Macchiusi, Ian, *'Knowing is Seeing': The Digital Audio Workstation and the Visualisation of Sound* (PhD thesis, York University (Toronto), 2017).

MacDonald, Raymond, Charles Byrne, and Lana Carlton, 'Creativity and Flow in Musical Composition: An Empirical Investigation', *Psychology of Music*, 34, no. 3 (2006), 292–306. https://doi.org/10.1177/0305735606064838

Maes, Pieter-Jan, Marc Leman, Caroline Palmer, and Marcelo M. Wanderley, (2014). Action-Based Effects on Music Perception. *Frontiers in Psychology*, 4 (2014). https://www.frontiersin.org/article/10.3389/fpsyg.2013.01008

Magnusson, Thor, *Epistemic Tools: The Phenomenology of Digital Musical Instruments* (PhD thesis, University of Sussex, 2009a). http://sro.sussex.ac.uk/id/eprint/83540/

Magnusson, Thor, 'Of Epistemic Tools: Musical Instruments as cognitive extensions. *Organised Sound*, 14, no. 2 (2009b), 168–176. https://doi.org/10.1017/S1355771809000272

Maiese, Michelle, *Embodiment, Emotion, and Cognition* (London, UK: Springer, 2010).

Mailman, Joshua Banks, 'Cybernetic Phenomenology of Music, Embodied Speculative Realism, and Aesthetics-Driven Techné for Spontaneous Audio-Visual Expression', *Perspectives of New Music*, 54, no. 1 (2016), 5–95. https://doi.org/10.1353/pnm.2016.0008

Malafouris, Lambros, 'At the Potter's Wheel: An Argument for Material Agency', *Material Agency: Towards a Non-Anthropocentric Approach*, eds. Carl Knappett and Lambros Malafouris, (London, UK: Springer, 2008), 19-36. https://doi.org/10.1007/978-0-387-74711-8_2

Malafouris, Lambros, *How Things Shape the Mind* (Cambridge, MA: MIT Press, 2013).

Malafouris, Lambros, 'Mind and Material Engagement', *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 1–17. https://doi.org/10.1007/s11097-018-9606-7

Malafouris, Lambros and Colin Renfrew, *The Cognitive Life of Things: Recasting the Boundaries of the Mind* (Cambridge, UK: McDonald Institute for Archaeological Research, 2010).

Mallgrave, Harry, 'Enculturation, Sociality, and the Built Environment', *Architecture and Empathy*, eds. Vittorio Gallese, Juhani Pallasmaa, Harry Mallgrave, and Sarah Robinson (Tapio Wirkkala-Rut Bryk Foundation, 2015), 20-41.

Malina, Frank J., Pierre Schaeffer, and Joyce Mandelbrojt. 'A Conversation on Concrete Music and Kinetic Art', *Leonardo*, 5, no. 3 (1972), 255-260.

Malinin, Laura H., 'Creative Practices Embodied, Embedded, and Enacted in Architectural Settings: Toward an Ecological Model of Creativity', *Frontiers in Psychology*, 6 (2016). https://doi.org/10.3389/fpsyg.2015.01978

Malinin, Laura H., 'How Radical Is Embodied Creativity? Implications of 4E Approaches for Creativity Research and Teaching', *Frontiers in Psychology*, 10 (2019). https://doi.org/10.3389/fpsyg.2019.02372

Maravita, Angelo and Atsushi Iriki, 'Tools for the Body (Schema)', *Trends in Cognitive Sciences*, 8, no. 2 (2004), 79–86. https://doi.org/10.1016/j.tics.2003.12.008

March, Paul Louis, 'Playing with Clay and the Uncertainty of Agency: A Material Engagement Theory Perspective', *Phenomenology and the Cognitive Sciences*, 18 (no. 1 (2019), 133–151. https://doi.org/10.1007/s11097-017-9552-9

Marrington, Mark, 'Experiencing Musical Composition in the DAW: The Software Interface as Mediator of the Musical Ideal', *Proceedings of the 6th Art of Record Production Conference* (2010), 1-8.

Martel, Marie, Lucilla Cardinalli, Giorga Bertonati, Christophe Jouffrais, Livio Finos, Alessandro Famè, and Alice C Roy, 'Somatosensory-guided Tool Use Modifies Arm Representation for Action', Scientific Reports, 9.

Martel, Marie, Lucilla Cardinalli, Alessandro Famè, and Alice C Roy, 'Tool-use: An Open Window into Body Representation and its Plasticity', Cognitive Neuropsychology, 33, no. 1-2 (2016), 81-101.

McCaleb, J. Murphy, *Embodied Knowledge in Ensemble Performance* (London, UK: Routledge, 2017).

McDermott, James, Toby Gifford, Anders Bouwer, and Mark Wagy 'Should Music Interaction Be Easy?', *Music and Human-Computer Interaction,* eds. Simon Holland, Katie Wilkie, Paul Mulholland, and Allan Seago (London, UK: Springer, 2013), 29-47. https://doi.org/10.1007/978-1-4471-2990-5_2

Meacham, Darian, 'Introduction: Critiquing Technologies of the Mind: Enhancement, Alteration, and Anthropotechnology', *Phenomenology and the Cognitive Sciences*, 16, no. 1 (2017), 1–16. https://doi.org/10.1007/s11097-017-9505-3

Menary, Richard, 'Writing as Thinking', *Language Sciences*, 29, no. 5 (2007), 621–632. https://doi.org/10.1016/j.langsci.2007.01.005

Menary, Richard, 'Cognitive Integration and the Extended Mind', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010b), 226-243. https://doi.org/10.7551/mitpress/9780262014038.003.0010

Menary, Richard, 'Dimensions of Mind', *Phenomenology and the Cognitive Sciences*, 9, no. 4 (2010c), 561–578. https://doi.org/10.1007/s11097-010-9186-7

Menary, Richard, 'Introduction to the Special Issue on 4E Cognition', *Phenomenology and the Cognitive Sciences*, 9, no. 4 (2010d), 459–463. https://doi.org/10.1007/s11097-010-9187-6

Merleau-Ponty, Maurice, *Phénoménologie de la Perception* (Paris, FR: Éditions Gallimard, 1945).

Meyer, Christian, Jürgen Streeck, J. Scott Jordan, *Intercorporeality: Emerging Socialities in Interaction* (Oxford: Oxford University Press, 2017).

Meyer, Christian and Ulrich van Wedelstaedt, *Moving Bodies in Interaction – Interacting Bodies in Motion: Intercorporeality, Interkinesthesia, and Enaction in Sports*. (Amsterdam, NL: John Benjamins Publishing Company, 2017).

Miani, Alessandro, ‘A Language-Based Approach to Music and Intertextuality’, *From Modernism to Postmodernism: Between Universal and Local*, eds. Gregor Pompe, Katarina Bogunović Hočevar, and Nejc Sukljan (2016), 267–277.

Michael, John, ‘Mirror Systems and Simulation: A Neo-Empiricist Interpretation’, *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 565–582. https://doi.org/10.1007/s11097-012-9253-3

Michaelian, Kourken and John Sutton, ‘Distributed Cognition and Memory Research: History and Current Directions’, *Review of Philosophy and Psychology*, 4, no. 1 (2013), 1–24. https://doi.org/10.1007/s13164-013-0131-x

Moeller, Hans-Georg and Andrew K. Whitehead, *Imagination: Cross-Cultural Philosophical Analyses* (London, UK: Bloomsbury Publishing, 2018).

Monk, Dennis C., ‘The Mind’s Ear’, *Design for Arts in Education*, 90, no. 6 (1989), 17–29. https://doi.org/10.1080/07320973.1989.9938162

Moore, Margaret Elizabeth, *Imagination and the Mind’s Ear* (PhD thesis, Temple University, 2010) https://scholarshare.temple.edu/handle/20.500.12613/1951

Morgan, Craig Ashley, *The Use of Virtual Instruments by Australian Screen Composers* (PhD thesis, University of Sydney, 2016). https://ses.library.usyd.edu.au/handle/2123/14884

Moscovich, Viviana, ‘French Spectral Music: An Introduction’, *TEMPO*, 200 (1997), 21–28. https://doi.org/10.1017/S0040298200048403

Nagy, Zvonimir, *Embodiment of Musical Creativity: The Cognitive and Performative Causality of Musical Composition* (London, UK: Routledge, 2016).

Nagy, Zvonimir, ‘Music and Embodied Creative Space’, *Journal of Genius and Eminence*, 4 (2020), 64–74. https://doi.org/10.18536/jge.2020.01.06

Newen, Albert, Leon De Bruin, and Shaun Gallagher, *The Oxford Handbook of 4E Cognition* (Oxford: Oxford University Press, 2018).

Nguyen, David J. and Jay B. Larson, 'Don't Forget About the Body: Exploring the Curricular Possibilities of Embodied Pedagogy', *Innovative Higher Education*, 40, no. 4 (2015), 331–344.

Noë, Alva, *Action in Perception* (Cambridge, MA: MIT Press, 2004).

Noë, Alva, *Out of Our Heads: Why You Are Not Your Brain, and Other Lessons From the Biology of Consciousness* (New York, NY: Hill & Wang, 2009).

Noë, Alva, *Strange tools: Art and Human Nature* (New York, NY: Hill and Wang, 2015).

Noland, Carrie, *Agency and Embodiment: Performing Gestures/Producing Culture* (Cambridge, MA: Harvard University Press, 2010).

Norman, Donald A., 'Cognition in the Head and in the World: An Introduction to the Special Issue on Situated Action', *Cognitive Science*, 17, no. 1 (1993), 1–6. https://doi.org/10.1207/s15516709cog1701_1

Northoff, Georg, 'Is Appraisal 'Embodied' and 'Embedded'? A Neurophilosophical Investigation of Emotions', *Journal of Consciousness Studies*, 15, no. 5 (2008), 68–99.

Núñez, Rafael, 'Mathematical Idea Analysis: What Embodied Cognitive Science Can Say about the Human Nature of Mathematics', *Proceedings of the Conference of the International Group for the Psychology of Mathematics Education* (2000). https://eric.ed.gov/?id=ED466734

Núñez, Rafael, 'Do Real Numbers Really Move? Language, Thought, and Gesture: The Embodied Cognitive Foundations of Mathematics', *18 Unconventional Essays on the Nature of Mathematics*, ed. Reuben Hersh (London, UK: Springer, 2006), 160-181.

Núñez, Rafael, R. E., Edwards, L. D., & Filipe Matos, J. (1999). Embodied cognition as grounding for situatedness and context in mathematics education. *Educational Studies in Mathematics*, *39*(1), 45–65. https://doi.org/10.1023/A:1003759711966

O'Callaghan, James, 'Spectral Music and the Appeal to Nature', *Twentieth-Century Music*, 15, no. 1 (2018), 57–73. https://doi.org/10.1017/S1478572218000063

Odendahl, Johannes, ‘Embodied Cognition, Affects and Language Comprehension’, *Phenomenology and the Cognitive Sciences*, 20, no. 3 (2021), 483–499. https://doi.org/10.1007/s11097-020-09684-0

O’Regan, J. Kevin, ‘Solving the ‘Real’ Mysteries of Visual Perception: The World as an Outside Memory’, *Canadian Journal of Psychology/Revue Canadienne de Psychologie*, 46, no. 3 (1992), 461–488. https://doi.org/10.1037/h0084327

O’Regan, J. Kevin, and Alva Noë, ‘A Sensorimotor Account of Vision and Visual Consciousness’, *Behavioral and Brain Sciences,* 24, no. 5 (2001), 939-1031.

O’Regan, J. Kevin, and Alva Noë, ‘What is it Like to See: A Sensorimotor Theory of Perceptual Experience’, *Synthese*, 129, no. 1 (2002), 79-103.

O’Shea, James R., ‘The ‘Theory Theory’ of Mind and the Aims of Sellars’ Original Myth of Jones’, *Phenomenology and the Cognitive Sciences*, 11, no. 2 (2012), 175–204. https://doi.org/10.1007/s11097-011-9250-y

Overmann, Karenleigh A., ‘Thinking Materially: Cognition as Extended and Enacted’, *Journal of Cognition and Culture*, 17, nos. 3-4 (2017), 354–373. https://doi.org/10.1163/15685373-12340012

Pallasmaa, Juhani, *The Thinking Hand: Existential and Embodied Wisdom in Architecture* (Oxford: John Wiley & Sons, 2009).

Pallasmaa, Juhani, ‘Empathic and Embodied Imagination: Intuiting Experience and Life in Architecture’, *Architecture and Empathy*, eds. Vittorio Gallese, Juhani Pallasmaa, Harry Mallgrave, and Sarah Robinson (Tapio Wirkkala-Rut Bryk Foundation, 2015), 4-19.

Pande, Prajakt, ‘Learning and Expertise with Scientific External Representations: An Embodied and Extended Cognition Model’, *Phenomenology and the Cognitive Sciences*, 20 (2020), 463-482. https://doi.org/10.1007/s11097-020-09686-y

Di Paolo, Ezequiel, ‘Editorial: The Social and Enactive Mind’, *Phenomenology and the Cognitive Sciences*, 8, no. 4, 409–415. https://doi.org/10.1007/s11097-009-9143-5

Parisi, Francesco, ‘Temporality and Metaplasticity: Facing Extension and Incorporation Through Material Engagement Theory. *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 205–221. https://doi.org/10.1007/s11097-018-9599-2

Parkinson, Adam, ‘Embodied Listening, Affordances and Performing with Computers’, *Proceedings of ICMC ’13* (2013), 162-168.

Paul, Annie Murphy, *The Extended Mind: The Power of Thinking Outside the Brain* (London, UK: Eamon Dolan Books, 2021).

Perry, Mia, and Carmen Medina, ‘Embodiment and Performance in Pedagogy Research: Investigating the Possibility of the Body in Curriculum Experience’, *Journal of Curriculum Theorizing*, 27, no. 3 (2011), 3. https://journal.jctonline.org/index.php/jct/article/view/100

Piekut, Benjamin, ‘Actor-Networks in Music History: Clarifications and Critiques’, *Twentieth-Century Music*, 11 (2014), 191–215. https://doi.org/10.1017/S147857221400005X

Pohjannoro, Ulla, ‘Embodiment in Composition: 4E Theoretical Considerations and Empirical Evidence from a Case Study’, *Musicae Scientiae*, (2020). https://doi.org/10.1177/1029864920961447

Pohjannoro, Ulla, ‘Mind the Body: Materiality and Physicality in a Composer’s Thinking Process’, *Psychology of Music*, 50, no. 4 (2022), 1169-83.

Pressing, Jeff, ‘Some Perspectives on Performed Sound and Music in Virtual Environments’, *Presence: Teleoperators and Virtual Environments*, 6, no. 4 (1997), 482–503. https://doi.org/10.1162/pres.1997.6.4.482

Preston, John, ‘The Extended Mind, the Concept of Belief, and Epistemic Credit’, *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010a), 355-369.

Prinz, Wolfgang, ‘An Ideomotor Approach to Imitation’, *Perspectives on Imitation: From Neuroscience to Social Science. Vol 1: Mechanisms of Imitation and Imitation in Animals*, ed. Susan Hurley and Nick Chater (Cambridge, MA: MIT Press, 2005), 141-156.

Massen, Cristina and Wolfgang Prinz, ‘Movements, Actions, and Tool-use Actions: An Ideomotor Approach to Imitation’, *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 364, no. 1528, (2009), 2349–2358.

Protevi, John, ‘Affect, Agency and Responsibility: The Act of Killing in the Age of Cyborgs,’ *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008), 405–413. https://doi.org/10.1007/s11097-008-9097-z

Qaurooni Daniel, and Hamid Ekbia, ‘The “Enhanced” Warrior: Drone Warfare and the Problematics of Separation. *Phenomenology and the Cognitive Sciences*, 16, no. 1 (2017), 53–73. https://doi.org/10.1007/s11097-016-9481-z

Ramshaw, Paul, ‘Is Music Production now a Composition Process?’ Paper presented at the *First Annual Conference on the Art of Record Production* (2006).

Ratcliffe, Matthew, ‘The Feeling of Being’, *Journal of Consciousness Studies*, 12, nos. 8–9 (2005), 43–60.

Ratcliffe, Matthew, ‘Empathy Without Simulation’, *Imagination and Social Perspectives: Approaches from Phenomenology and Psychopathology*, eds. Michela Summa, Thomas Fuchs, and Luca Vanzago (London, UK: Routledge, 2018), 199-220.

Reichling, Mary J., ‘Music, Imagination, and Play’, *Journal of Aesthetic Education*, 31, no. 1 (1997), 41–55. https://doi.org/10.2307/3333470

Reybrouck, Mark, ‘Music Cognition and the Bodily Approach: Musical Instruments as Tools for Musical Semantics’, *Contemporary Music Review* 25, no. 1–2 (2006), 59–68.

Reybrouck, Mark, ‘Experience as Cognition: Musical Sense-Making and the ‘In-Time/ Outside-of-Time’ Dichotomy, *Interdisciplinary Studies in Musicology*, 19 (2019), 53–80. https://doi.org/10.14746/ism.2019.19.4

Reybrouck, Mark, ‘Music Listening as Adaptive Behaviour: Enaction meets Neuroscience. *Journal of Interdisciplinary Music Studies* 10 (2021a), 34–58. https://doi.org/10.25364/24.10:2020.1.3

Reybrouck, Mark, *Musical Sense-Making. Enaction, Experience, and Computation* (New York: Routledge, 2021b).

Riede, Felix, Niels N. Johannsen, Anders Högberg, April Nowell, and Marlize Lombard, ‘The Role of Play Objects and Object Play in Human Cognitive Evolution and Innovation. *Evolutionary Anthropology: Issues, News, and Reviews*, 27, no. 1 (2018), 46-59.

Rietveld, Erik, Ronald Rietveld, and Janno Martens, 'Trusted Strangers: Social Affordances for Social Cohesion', *Phenomenology and the Cognitive Sciences*, 18, no. 1 (2019), 299–316. https://doi.org/10.1007/s11097-017-9554-7

Robinson, Douglas, *Feeling Extended: Sociality as Extended Body-Becoming-Mind* (Cambridge, MA: MIT Press, 2013).

Robinson Sarah, and Juhani Pallasmaa, *Mind in Architecture: Neuroscience, Embodiment, and the Future of Design*. (Cambridge, MA: MIT Press, 2015).

Roe, Paul, *A Phenomenology of Collaboration in Contemporary Composition and Performance* (PhD thesis, Technology University Dublin, 2007). https://doi.org/10.21427/etkc-4g13

Rowlands, Mark, 'Extended Cognition and the Mark of the Cognitive', *Philosophical Psychology*, 22, no. 1 (2009), 1–19. https://doi.org/10.1080/09515080802703620

Rowlands, Mark, *The Nature of Consciousness*. (Cambridge, UK: Cambridge University Press, 2001).

Rowlands, Mark, 'Externalism: Putting Mind and World Back Together Again', *Philosophy and Phenomenological Research*, 72, no. 2 (2006), 487–490.

Rowlands, Mark, 'Enactivism and the Extended Mind', *Topoi*, 28, no. 1 (2009), 53–62. https://doi.org/10.1007/s11245-008-9046-z

Rowlands, Mark, *The New Science of the Mind: From Extended Mind to Embodied Phenomenology*, (Cambridge, MA: MIT Press, 2010).

Rupert, Robert D., *Cognitive Systems and the Extended Mind* (Oxford: Oxford University Press, 2009).

Ryan, Kevin and Andrea Schiavio, 'Extended Musicking, Extended Mind, Extended Agency: Notes on the Third Wave, *New Ideas in Psychology*, 55 (2019), 8–17. https://doi.org/10.1016/j.newideapsych.2019.03.001

Saariaho, Kaija, 'Timbre and Harmony: Interpolations of Timbral Structures', *Contemporary Music Review*, 2, no. 1 (1987), 93–133. https://doi.org/10.1080/07494468708567055

Sandler, Sergeiy, ‘Reenactment: An Embodied Cognition Approach to Meaning and Linguistic Content’, *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 583–598. https://doi.org/10.1007/s11097-011-9229-8

Santibáñez, Cristián, ‘Arguing with Images as Extended Cognition’, *Informal Logic*, 38, no. 4 (2018), 531–549. https://doi.org/10.22329/il.v38i4.5052

Schiavio, Andrea, and Damiano Menin, ‘Embodied Music Cognition and Mediation Technology: A Critical Review’, *Psychology of Music*, 41, no. 6 (2013), 804–814. https://doi.org/10.1177/0305735613497169

Schiavio, Andrea, Damiano Menin, and Jakub Ryszard Matyja, ‘Music in the Flesh: Embodied Simulation in Musical Understanding’, *Psychomusicology: Music, Mind and Brain*, 24 (2015), 340-343.

Schiavio, Andrea, and Dylan van der Schyff, ‘4E Music Pedagogy and the Principles of Self-Organization’, *Behavioral Science* 8, no. 8 (2018), 72.

Schiavio, Andrea, Dylan van der Schyff, Julian Cespedes-Guevara, and Mark Reybrouck, ‘Enacting Musical Emotions. Sense-Making, Dynamic Systems, and the Embodied Mind’. *Phenomenology and the Cognitive Sciences*, 16, no. 5 (2017), 785–809.

Schiavio, Andrea, Dylan van der Schyff, Silke Kruse-Weber, and Renee Timmers, ‘When the Sound Becomes the Goal: 4E Cognition and Teleomusicality in Early Infancy’, *Frontiers in Psychology*, 8 (2017), 10.3389/fpsyg.2017.01585.

Schilbach, Leonhard, ‘On the Relationship of Online and Offline Social Cognition’, *Frontiers in Human Neuroscience*, 8 (2014). https://doi.org/10.3389/fnhum.2014.00278

Schürmann, Martin, Tommi Raij, Nobuya Fujiki, and Riitta Hari, ‘Mind’s Ear in a Musician: Where and When in the Brain’, *NeuroImage*, 16, no. 2 (2002), 434–440. https://doi.org/10.1006/nimg.2002.1098

Selinger, Evan, ‘Introduction: Cyborg Embodiment: Affect, Agency, Intentionality, and Responsibility’, *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008), 317–325. https://doi.org/10.1007/s11097-008-9094-2

Selinger, Evan, and Timothy Engström, ‘A Moratorium on Cyborgs: Computation, Cognition, and Commerce’, *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008a), 327-341. https://doi.org/10.1007/s11097-008-9104-4

Selinger, Evan, and Timothy Engström, ‘Interactive Computation Is Interaction With What?: A Reply to Clark’, *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008b), 347–348. https://doi.org/10.1007/s11097-008-9103-5

Serafin, Stefania, Cumhur Erkut, Juraj Kojs, Niels C. Nilsson, and Rolf Nordahl, ‘Virtual Reality Musical Instruments: State of the Art, Design Principles, and Future Directions’, *Computer Music Journal*, 40, no. 3 (2016), 22–40. https://doi.org/10.1162/COMJ_a_00372

Shapiro, Lawrence, *The Routledge Handbook of Embodied Cognition*. (London, UK: Routledge, 2014).

Shapiro, Lawrence, *Embodied Cognition* (London, UK: Routledge, 2019).

Shapiro, Lawrence, ‘Embodied Cognition: Lessons from Linguistic Determinism’, *Philosophical Topics*, 39, no. 1 (2011), 121–140. https://doi.org/10.5840/philtopics201139117

Shapiro, Lawrence, ‘Flesh Matters: The Body in Cognition’, *Mind & Language*, 34, no. 1 (2019), 3–20. https://doi.org/10.1111/mila.12203

Shaw, Jennifer. ‘Arnold Schoenberg and the Intertextuality of Composing and Performance’, *Context: Journal of Music Research*, 31 (2006), 109-121.

Shepherd, Joshua, ‘Action, Mindreading and Embodied Social Cognition’, *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 507–518. https://doi.org/10.1007/s11097-011-9241-z

Simons, Peter M., ‘Computer Composition and Works of Music: Variation on A Theme of Ingarden’, *Journal of the British Society for Phenomenology*, 19, no. 2 (1988), 141–154. https://doi.org/10.1080/00071773.1988.11007856

Simpson, David, ‘Language and Know-How’, *Phenomenology and the Cognitive Sciences*, 9, no. 4 (2010), 629–643. https://doi.org/10.1007/s11097-010-9183-x

Sloboda, John A., Susan A. O'Neill, and Antonia Ivaldi, ‘Functions of Music in Everyday Life: An Exploratory Study Using the Experience Sampling Method’, *Musicae Scientiae,* 5, no. 1 (2001). https://doi.org/10.1177/102986490100500102

Slors, Marc, ‘Symbiotic Cognition as an Alternative for Socially Extended Cognition’, *Philosophical Psychology*, 32, no. 8 (2019), 1179–1203. https://doi.org/10.1080/09515089.2019.1679591

Solomon, Maynard, *Late Beethoven: Music, Thought, Imagination* (Berkeley, CA: University of California Press, 2003).

de Souza, Jonathan *Music at Hand: Instruments, Bodies, and Cognition,* (Oxford: Oxford University Press, 2017).

Sparrow, Betsy, Jenny Liu, and Daniel M. Wegner, ‘Google Effects on Memory: Cognitive Consequences of Having Information at Our Fingertips’, *Science*, 333, no. 6043 (2011), 776–778. https://doi.org/10.1126/science.1207745

Spaulding, Shannon, ‘Introduction to Debates on Embodied Social Cognition’, *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 431–448. https://doi.org/10.1007/s11097-012-9275-x

Spurrett, David, and Stephen Cowley, ‘The Extended Infant: Utterance-Activity and Distributed Cognition’, *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 295–323.https://doi.org/10.7551/mitpress/9780262014038.003.0013

Sterelny, Kim, ‘Thought in a Hostile World: The Evolution of Human Cognition’, *Philosophy and Phenomenological Research*, 74, no. 2 (2007), 476–497.

Sterelny, Kim, ‘Minds: Extended or Scaffolded?’, *Phenomenology and the Cognitive Sciences,* 9, no. 4 (2010), 465–481. https://doi.org/10.1007/s11097-010-9174-y

Stotz, Karola, ‘Human Nature and Cognitive-Developmental Niche Construction’, *Phenomenology and the Cognitive Sciences*, 9, no. 4 (2010), 483–501. https://doi.org/10.1007/s11097-010-9178-7

Strachan, Robert, *Sonic Technologies: Popular Music, Digital Culture and the Creative Process* (London, UK: Bloomsbury, 2017).

Summa, Michela, Thomas Fuchs, and Luca Vanzago, *Imagination and Social Perspectives: Approaches from Phenomenology and Psychopathology,* eds. (London, UK: Routledge, 2018).

Sutton, John, 'Material Agency, Skills and History: Distributed Cognition and the Archaeology of Memory', *Material Agency: Towards a Non-Anthropocentric Approach,* eds. Carl Knappett and Lambros Malafouris, (London, UK: Springer, 2008), 37-55. https://doi.org/10.1007/978-0-387-74711-8_3

Sutton, John, 'Exograms and Interdisciplinarity: History, the Extended Mind, and the Civilizing Process', *The Extended Mind*, ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 189-225. https://doi.org/10.7551/mitpress/9780262014038.003.0009

Sutton, John, Celia B. Harris, Paul G. Keil, and Amanda J. Barnier, 'The Psychology of Memory, Extended Cognition, and Socially Distributed Remembering', *Phenomenology and the Cognitive Sciences*, 9 (2010), 521–560. https://doi.org/10.1007/s11097-010-9182-y

Pedersen, Morden Axel, 'Talismans of Thought: Shamanist Ontologies and Extended Cognition in Northern Mongolia', *Thinking Through Things: Theorising Artefacts Ethnographically*, ed. Amiria Henare, Martin Holbraad, and Sari Wastell (London, UK: Routledge, 2007), 151-176. https://doi.org/10.4324/9780203088791-12

Tanaka, Shogo, 'Intercorporeality as a Theory of Social Cognition, *Theory & Psychology*, 25, no. 4 (2015), 455–472. https://doi.org/10.1177/0959354315583035

Taylor, Alan, *The Imagination of Experiences: Musical Invention, Collaboration, and the Making of Meanings* (London, UK: Routledge, 2021).

Thompson, Evan, and Mog Stapleton, 'Making Sense of Sense-Making: Reflections on Enactive and Extended Mind Theories', *Topoi*, 28, no. 1 (2009), 23–30. https://doi.org/10.1007/s11245-008-9043-2

Thompson, J. Robert, 'Implicit Mindreading and Embodied Cognition', *Phenomenology and the Cognitive Sciences*, 11, no. 4 (2012), 449–466. https://doi.org/10.1007/s11097-011-9213-3

Thompson, Roger K. R., David L. Oden and Sarah T. Boysen, 'Language-Naïve Chimpanzees (Pan troglodytes) Judge Relations Between Relations in a Conceptual Matching-to-Sample

Task', *Journal of Experimental Psychology: Animal Behaviour Processes,* 23, no. 1 (1997), 31-51.

Tomasello, Michael, *The Cultural Origins of Human Cognition* (Cambridge, MA: Harvard University Press, 2001).

Tribble, Evelyn, 'Distributing Cognition in the Globe' *Shakespeare Quarterly,* 56, no. 2 (2005), 135–155.

Tribble, Evelyn, *Cognition in the Globe: Attention and Memory in Shakespeare's Theatre* (London, UK: Palgrave Macmillan, 2011).

Tribble, Evelyn, and Nicholas Keene, *Cognitive Ecologies and the History of Remembering* (London, UK: Palgrave Macmillan, 2011).

Tribble, Evelyn, and John Sutton, 'Cognitive Ecology as a Framework for Shakespeare Studies', *Shakespeare Studies,* 39 (2011), 94-103.

Tribble, Evelyn, and John Sutton, 'Minds In and Out of Time: Memory, Embodied Skill, Anachronism, and Performance, *Textual Practice,* 26, no. 4 (2012), 587-607. 10.1080/0950236X.2012.696485

van Dijk, Ludger, and Erik Rietveld, 'Situated Imagination', *Phenomenology and the Cognitive Sciences* (2020). https://doi.org/10.1007/s11097-020-09701-2

van der Schyff, Dylan, 'Emotion, Embodied Mind and the Therapeutic Aspects of Musical Experience in Everyday Life', *Approaches: Music Therapy & Special Music Education*, 5 (2013), 50–58.

van der Schyff, Dylan, Andrea Schiavio, Ashley Walton, Valerio Velardo, and Anthony Chemero, 'Musical Creativity and the Embodied Mind: Exploring the Possibilities of 4E Cognition and Dynamical Systems Theory', *Music & Science,* 1 (2018). https://doi.org/10.1177/2059204318792319

van der Schyff, Dylan, and Andrea Schiavio, 'Evolutionary Musicology Meets Embodied Cognition: Biocultural Coevolution and the Enactive Origins of Human Musicality', *Frontiers in Neuroscience*, 11 (2017). https://doi.org/10.3389/fnins.2017.00519

Van Hulle, Dirk, ‘The Extended Mind and Multiple Drafts: Beckett’s Models of the Mind and the Postcognitivist Paradigm’, *Samuel Beckett Today / Aujourd’hui*, 24, no. 1 (2012), 277–290. https://doi.org/10.1163/18757405-024001019

Van Hulle, Dirk, ‘The Stuff of Fiction: Digital Editing, Multiple Drafts and the Extended Mind’, *Textual Cultures*, 8, no. 1 (2013), 23–37. https://doi.org/10.2979/textcult.8.1.23

Van Hulle, Dirk, *James Joyce’s ‘Work in Progress’: Pre-Book Publications of Finnegans Wake Fragments*. (London, UK: Routledge, 2016).

Van Hulle, Dirk, *Modern Manuscripts: The Extended Mind and Creative Undoing from Darwin to Beckett and Beyond* (London, UK: Bloomsbury, 2020).

Van Hulle, Dirk, and Mark Nixon, *Samuel Beckett’s Library*. (Cambridge, UK: Cambridge University Press, 2013).

Francisco J. Varela, Evan Thompson, and Eleanor Rosch, *The Embodied Mind, revised edition: Cognitive Science and Human Experience* (Cambridge, MA: MIT Press, 2017).

Varga, Somogy, and Detlef H. Heck, ‘Rhythms of the Body, Rhythms of the Brain: Respiration, Neural Oscillations, and Embodied Cognition’, *Consciousness and Cognition*, 56 (2017), 77-90.

Verbeek, Peter-Paul, ‘Cyborg Intentionality: Rethinking the Phenomenology of Human-Technology Relations’, *Phenomenology and the Cognitive Sciences*, 7, no. 3 (2008), 387–395. https://doi.org/10.1007/s11097-008-9099-x

Vygotsky, Lev, *Thought and Language* (Cambridge, MA: MIT Press, 1962).

Walsh, Philip J., ‘Cognitive Extension, Enhancement, and the Phenomenology of Thinking’, *Phenomenology and the Cognitive Sciences*, 16, no. 1 (2017), 33–51. https://doi.org/10.1007/s11097-016-9461-3

Walton, Ashley E., Michael J. Richardson, Peter Langland-Hassan, and Anthony Chemero, ‘Improvisation and the Self-Organization of Multiple Musical Bodies’, *Frontiers in Psychology*, 6 2015, 6 (2015), 313. https://doi.org/10.3389/fpsyg.2015.00313

Walzer, Daniel, ‘Software-Based Scoring and Sound Design: An Introductory Guide for Music Technology Instruction’, *Music Educators Journal*, 103, no. 1 (2016), 19–26. https://doi.org/10.1177/0027432116653449

Walzer, Daniel, ‘Technology-Mediated Musical Accompaniment: A Post-Production Analysis of Timbral Change with Virtual Instruments and Attentive Mixing’, *College Music Symposium*, 57 (2017).

Walzer, Daniel, ‘Blurred Lines: Practical and Theoretical Implications of a DAW-based Pedagogy’, *Journal of Music, Technology & Education,* 13, no. 1 (2020), 79-94. https://doi.org/10.1386/jmte_00017_1

Riemann, Hugo, ‘Ideen zu einer 'Lehre von den Ton Vorstellungen', *Jahrbuch der Musikbibliothek Peters* 21/22 (1914/15), 1-26. Translated by Robert Wason and Elizabeth Marvin as ‘Ideas for a Study 'On the Imagination of Tone', *Journal of Music Theory* 36, no. 1 (1992), 81-117

Weiss, Gail, *Body Images: Embodiment as Intercorporeality* (London, UK: Routledge, 2013).

Wheeler, Michael, *Reconstructing the Cognitive World: The Next Step* (Cambridge, MA: MIT Press, 2005).

Wheeler, Michael, and Andy Clark, ‘Culture, Embodiment and Genes: Unravelling the Triple Helix’, *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363, no. 1509 (2008), 3563–3575. https://doi.org/10.1098/rstb.2008.0135

Willett, Francis R., Donald T. Avansino, Leigh R. Hochberg, Jaimie M. Henderson, and Krishna V. Shenoy, ‘High-Performance Brain-to-Text Communication Via Handwriting’, *Nature*, 593, no. 7858 (2021), 249–254. https://doi.org/10.1038/s41586-021-03506-2

Wilson, Geoffrey, *An Autoethnography on Film Composition Practice: Integrating Virtual Instruments and the Live Performance Realisation within the DAW* (MA thesis, Masters, University of Huddersfield, 2018).

Wilson, Robert A., *Boundaries of the Mind: The Individual in the Fragile Sciences – Cognition* (Cambridge, UK: Cambridge University Press, 2004).

Wilson, Robert A., ‘Meaning Making and the Mind of the Externalist’, *The Extended Mind,* ed. Richard Menary (Cambridge, MA: MIT Press, 2010), 167-188.

Witt, Jessica K., Dennis R. Proffitt, and William Epstein, 'Tool Use Affects Perceived Distance, But Only When You Intend to Use It', *Journal of Experimental Psychology Human Perception & Performance,* 31, no. 5 (2005), 880–888.

Wood, Rachel, and Susan A. J. Stuart, 'Aplasic Phantoms and the Mirror Neuron System: An Enactive, Developmental Perspective', *Phenomenology and the Cognitive Sciences*, 8, no. 4 (2009), 487–504.

Woodward, Martyn, 'Metaplasticity Rendered Visible in Paint: How Matter 'Matters' in the Lifeworld of Human Action', *Phenomenology and the Cognitive Sciences,* 18, no. 1 (2019), 113–132. https://doi.org/10.1007/s11097-017-9553-8

Xenakis, Iannis, *Arts-Sciences, Alloys: The Thesis Defense of Iannis Xenakis Before Olivier Messiaen, Michel Ragon, Olivier Revault D'Allonnes, Michel Serres, and Bernard Teyssèdre* (Hillsdale, NY: Pendragon Press, 1985).

Zahavi, Dan, 'Empathy, Embodiment and Interpersonal Understanding: From Lipps to Schutz', *Inquiry,* 53, no. 3 (2010), 285–306. https://doi.org/10.1080/00201741003784663

Zahavi, Dan, and John Michael, 'Beyond Mirroring: 4E Perspectives on Empathy', *The Oxford Handbook of 4E Cognition*, eds. Albert Newen, Leon De Bruin, and Shaun Gallagher (Oxford: Oxford University Press, 2018), 589–606.

Zatorre, Robert J., Andrea R. Halpern, David W. Perry, Ernst Meyer, and Alan C. Evans, 'Hearing in the Mind's Ear: A PET Investigation of Musical Imagery and Perception', *Journal of Cognitive Neuroscience,* 8, no. 1 (1996), 29–46. https://doi.org/10.1162/jocn.1996.8.1.29

Zawidzki, Tadeusz Wieslaw, 'Unlikely Allies: Embodied Social Cognition and the Intentional Stance', *Phenomenology and the Cognitive Sciences,* 11, no. 4 (2012), 487–506. https://doi.org/10.1007/s11097-011-9218-y

Zawidzki, Tadeusz Wieslaw, *Mindshaping: A New Framework for Understanding Human Social Cognition*. (Cambridge, MA: MIT Press, 2013).

Zatorre, Robert J., Andrea R. Halpern, David W. Perry, Ernst Meyer, and Alan C. Evans, 'Mental Concerts: Musical Imagery and Auditory Cortex', *Neuron,* 47 (2005), 9-12.

Zhu, Lin, ‘An Embodied Cognition Perspective on Translation Education: Philosophy and Pedagogy’, *Perspectives*, 26, no. 1 (2018), 135–151. https://doi.org/10.1080/0907676X.2017.1328449