Composition strategies for the creation of science-based interdisciplinary and collaborative music-theatre

Research Catalogue exposition

BLANCO ALBERT, Daniel

A thesis submitted in partial fulfilment of the requirements of Birmingham City University for the degree of Doctor of Philosophy

The Faculty of Arts, Design and Media, Birmingham City University (Royal Birmingham Conservatoire)

October 2023

Notes about the Research Catalogue exposition:

https://www.researchcatalogue.net/shared/ebf8fcbb422577cf910aea62b80ea603

- You can navigate the research project from the Cover Page. The table of contents on the right side is clickable and will direct you to every section of the thesis.
- The research project is presented as a compendium of composition strategies and techniques. Although the design of the pages and the numbering may suggest a certain order, you can navigate freely and interact with the content in any order.
- Most elements, including titles and footnotes, are clickable. Generally, clickable text will appear in a different colour than the main text.
- Shorter pieces of writing may appear in pop-up windows. In those cases, the footnotes are not clickable and are presented below the text[1].
- In some cases, mainly related to musical examples, sections of scores will appear by clicking the highlighted text that references them.
- All the videos can be enlarged by clicking "Fullscreen" in the bottom right corner of the video player.
- Many examples use binaural recordings. Please use headphones for a better experience, as they feature surround or panning effects keys to the research that would be lost on stereo speakers. Every binaural recording is labelled as such.

[1] As in this example.

Abstract and research questions

The practice-based PhD research project comprises the development and application of composition strategies and techniques generated through interdisciplinary collaboration to integrate elements and ideas from non-sonic disciplines into the musical discourse of new music-theatre works, specifically opera. I explore mechanisms of mapping and association that engage with both the specific subject matter of each piece and the creative collaborative environment in which they are created, thus generating different compositional resources that I use to inform the creative process. By using mapping techniques, I can deeply engage and communicate a subject matter on different levels in the musical composition.

The framework for this research is the intertwining of art and science on a variety of levels from a music compositional perspective. Within this framework, I explored the integration of knowledge and data from the natural and social sciences to inform the composition of four science-based music-theatre works: *In response to Naum Gabo: Linear Construction in Space No. 1* (2020), *Autohoodening: The Rise of Captain Swing* (2021), *The Flowering Desert* (2022), and *TRAPPIST-1* (2023).

With this approach, I aim to closely link these works with their particular subject matter instead of being composed based just on my personal musical taste. By consistently and cohesively applying the strategies and techniques explored in this research, the outcome is not creating music about science or music inspired by science, but, instead, music embedded with science in which the scientific data and knowledge inform the composition decisions. The subject matter is therefore intertwined within the musical discourse, its performativity and theatricality, and its relationship with the other disciplines and collaborators involved in the creation of these music-theatre works.

The research is presented as a Research Catalogue exposition.

My research questions are:

- How can interdisciplinary collaboration with science-based disciplines develop composition strategies and techniques for creating new music-theatre?

- How can you communicate a subject matter on many compositional levels in a piece of music-theatre?

To answer these questions, I present a portfolio consisting of a compilation of strategies and techniques that I developed and applied in the composition of four science-based music-theatre pieces created through interdisciplinary collaboration. Each strategy and technique is accompanied by specific examples extracted from the scores and the documentation, showing their application in context. The portfolio is divided into two sections, each focusing on one of the research questions.

For the purpose of this research, I will distinguish between strategy and technique as follows:

- **Composition Strategy** – A conceptual overarching approach that defines an artistic decision with a purpose. For example, using data from a planetary system in order to integrate the rotation of the planets into a sonic event.

- **Composition Technique** – The execution of an idea in a score[1]. For example, the transformation of data into musical parameters that can be read by the performers.

[1] Whether it is a musical score, a text score, a graphic score, a performance score, etc.

Acknowledgements

Many thanks to:

My supervisors, Prof. Aleksandar Dundjerović, Prof. Michael Wolters, and Prof. William Chaplin, for their invaluable support and guidance.

The academics and members of staff that have supported me throughout this journey: Prof. Joe Cutler, Dr Seán Clancy, Dr Carrie Churnside, Prof. Christopher Dingle, Dr Sian Vaughan, Dr Oliver Carter, Dr Sarah Cooper, Dr Selina Schmidt, Julie Timms, Mark Eastwood, and Prof. Nicola Royan.

The key collaborators that made this research project possible: Roxanne Korda, Dr Amaury Triaud, Colin Hutcheson, Post Workers Theatre (Demitrios Kargotis, Dash MacDonald, and Nicholas Mortimer), Gavin Stewart, Leon Trimble, Alexander Kaniewski, and Tadas Stalyga.

The performers that made the music included in the portfolio a reality: Hannah McDonald, Dalma Sinka, Olivia Thornber, Megan Artemova-Thomas, Edward Harrison, Teddy Woolgrove, Michael CT Lam, Aaron Kendall, Arjun Jethwa, Aidan Hammond, Dominika Blatt, William Hammond, Lucy Samuels, Edwin Podolski, Ricardo Brown, Alicja Humeniuk, Verena Koay, Oliver Farrow, Alex Collet-Sinfield, Jose Lluna, and Jennie Robson; as well as David Kirkham, Reiss Smith and Katherine Christie Evans for their technical support. Also, many thanks to Ben Jones and George', of the St Nicholas-at-Wade with Sarre Hoodeners, for their recording of the song *Poor Ole Hoss*.

All the institutions and venues that supported the research or the works included in the portfolio: Royal Birmingham Conservatoire, Midlands4Cities, Think Tank Planetarium (Birmingham), Infinite Opera, Grand Union Gallery, Vivid Projects, Digbrew Co, The Barber Institute of Fine Arts, GMB Union, Birmingham School of Art, Goldsmiths University of London, ÒBNC and the Luleåbiennalen 2022. Many thanks, especially to Midlands4Cities, the AHRC, and the UKRI, for funding this research project.

All my friends and family, and all the people that have supported me during all these years: Søren Kaae, Carles Tamarit Merino, Oliver Webb, Joan Enric Lluna, Maria José Aroca, Lise Olson, Josep Ribera Vanyó, Joe Broughton, Paloma Trigas, Andrew Toovey, Edwin Roxburgh, Gerardo Adesso, Marcin Sz, Alis Oldfield, Dietrich Grosse, Sandra Taylor, Isaac Macho, and Conchi Moyano.

And special thanks to my parents, Barbara Albert Borrás and Jose Miguel Blanco Serrano, and to my partner, Maja Pluta.

Table of contents

1 Introduction

In this introduction, I present an overview of the personal background that led me to this research project, its context, and an overview of the four pieces included in the portfolio.

1.1 Personal background

During my time collaborating as a composer of music for theatre productions at the Birmingham School of Acting (2015-2018), I started approaching the compositional process with a special interest in creating unified and cohesive scores that explored the different theatrical layers of the plays. To achieve that, and at the same time tackle the difficulties of composing long scores under the pressure of the constant theatrical changes and time limits, I started creating compositional strategies that embedded non-musical elements directly related to the play into the music. These methods proved to be effective in creating scores for the plays, engaging with different layers of meaning and connection with the original material[1].

I therefore applied a similar approach to my compositions for the company I co-founded, Infinite Opera. In the physics dissemination opera *Entanglement! An Entropic Tale* (2018), I tackled the subject matter of physics by collaborating with the physicist and librettist Roxanne Korda. In the opera trilogy *Besse* (2019), both

[1] I, for example, recorded the voices of the cast of a production of Federico García Lorca's *Blood Wedding* (1931) to create eerie vocal soundscapes that reflect the different voices of the village intertwined together, integrating in the musical discourse how people in the village know and control each other.

Roxanne Korda and I engaged with the subject matter of beer brewing by collaborating with the brewery Digbrew Co. and its founder and visual artist, Oliver Webb. These collaborations influenced the creation of the operatic works on different levels, affecting their music composition decisions, their engagement with different spaces, or their performativity. The different strategies and techniques developed through interdisciplinary collaboration showed to enrich these works, engaging deeply with their subject matters. It also opened a stream for further exploration in the fields of contemporary opera composition, interdisciplinary collaboration, or program music, as well as in the intertwining of arts and science[2].

1.2 Research Context

In the past few decades, we have seen opera engage with very diverse topics. We can find works about politics, physics, pop culture icons, entomology, fashion, video games, or beer, amongst many others[3]. The development of many different

[2] In *Entanglement! An Entropic Tale* we worked with physics concepts such as entropy or quantum entanglement. In *Besse*, we integrated the chemistry of brewing into the macrostructure of the piece.

[3] For example:

- Politics – Bushra El-Turk's *Woman at point zero* (2023), based on the homonymous novel by Nawal El Saadawi.
- Physics – Héctor Parra's *Hypermusic Prologue* (2009), created in collaboration with the theoretical physicist Lisa Randall.
- Pop culture icons – Eef van Breen's *'u'* (2010), an opera in the Klingon language of the popular TV series Star Trek.
- Entomology – Anne Guzzo's *Locust: The Opera* (2018), a work about entomology based on the book by Jeffrey A. Lockwood *Locust: The devastating rise and mysterious disappearance of the insect that shaped the American frontier* (2004).
- Fashion – Alastair White's *WEAR* (2018), "an immersive sci-fi fashion presentation at the wild, impossible edges of contemporary art music" (Tête à Tête, 2018).

disciplines in the last century has widened the possibilities for music-theatre composers: a nuclear science opera could not have been composed in the XVII century simply because that discipline of study and its knowledge were not yet developed.

The dynamic development of many disciplines and streams of thought, alongside the proliferation of small companies that defy the traditional conservatism and conventions of the genre[4], inspire new works that tackle current issues, discoveries, trends, and debates. Festivals such as Tête à Tête: The Opera Festival (London) [5], PROTOTYPE (New York), or NOA (Vilnius), and organisations such as Indie Opera Toronto, show this very well. This contrasts with the general programming of major opera houses, which still mostly rely on old repertoire[6] or on new works that respond

- Video games – Dan Viscontis' *PermaDeath* (2018), an interactive multimedia opera about the life and death of a videogame avatar.
- Beer - Infinite Opera's *Besse* (2019), an operatic trilogy about brewing created in collaboration with the brewery Digbrew Co. and its owner, the visual artist Oliver Webb.

[4] The "booming fringe", as described by Bill-Bankes Jones (2018).

[5] According to Claire Seymour (2019), "one thing about Tête à Tête productions is that they can respond to the moment", strongly tackling themes such as immigration, Brexit, or "environmental looms".

[6] A quick look at the Operabase statistics for the 2023-2024 season shows that the most performed operas are by Mozart, Bizet, Puccini, and Verdi. They are composers generally dead for more than hundred years (ninety-nine in the case of Puccini at the date of writing these words) whose works, in reality, difficultly respond to the current socio-cultural context and that are representative of a particular region of the world in a past time.

to literature or cultural products of the past[7], even if they occasionally engage with current topics in the public debate, such as ecologism[8] or immigration[9].

Many of these new works, especially those from small-scale companies such as my own, Infinite Opera[10], are created using collaborative processes, interdisciplinary practice, and the mixed media applied to the genre. This is highlighted by NOA Festival (2022) in their "About the Festival" section:

> Crossing the borders of traditional opera and searching for interdisciplinary crossings, the festival declares freedom, collective creation, openness to diverse ideas and forms of cooperation. Uninhibited by any framework and unwilling to restrict itself via topical, temporal or format references, the festival mostly presents world premieres of diverse productions[11].

In this line, the composer Jennifer Walshe proposed in 2016 the term "New Discipline" to connect compositions with "disparate interests", sharing the "concern

---

[7] For example, new takes on Shakespearean classics such as Thomas Adès' *The Tempest* (2004), or Brett Dean's *Hamlet* (2017).

[8] For example, Giovanni Battistelli's *CO2* (2015), inspired by Al Gore's *An Inconvenient Truth* (2006), premiered at La Scala (Milan); or Stuart MacRae's *Anthropocene* (2019), premiered by Scottish Opera.

[9] For example, Will Todd's *Migrations* (2022), commissioned and premiered by Welsh National Opera.

[10] I co-founded Infinite Opera in 2018 with the librettist Roxanne Korda. We have created pieces in the past such as the previously mentioned physics dissemination opera *Entanglement! An Entropic Tale* (2018) or the beer opera *Besse* (2019).

[11] NOA (2022) *About the Festival*. Available at https://noa.lt/en/about-the-festival/ [Last accesed 25 September 2023].

of being rooted in the physical, theatrical and visual, as well as musical; pieces which often invoke the extra-musical" (Walshe, 2016).

Concepts such as the "openness to diverse ideas and forms of cooperation" or the invocation of the "extra-musical", are at the core of this research, and are explored through practice. The strategies and techniques presented in the portfolio are the distillation of interdisciplinary collaborative processes with practitioners from diverse disciplines[12]. The practitioners actively contributed by bringing "disparate interests" that became subject matters for the works, but also new perspectives and possibilities of engagement and hybridisation between disciplines, which informed the compositions[13].

In opera, however, the engagement with a subject matter can easily be superficial on a music composition level[14], relying mainly on the text or the dramaturgy to embed it in the piece. Composers will mostly create the music to accompany or

[12] To inform these processes, I used as a starting point Halprin's RSVP cycles, a methodology for collaboration developed by Lawrence and Anna Halprin. RSVP stands for Resources, Score, Valuation, and Performance (Halprin, 1970). This is a methodology applied to opera productions by practitioners such as Robert Lepage (Dundjerovic, 2009). The development in cycles informed the collaborative aspects in *The Flowering Desert*, *TRAPPIST-1*, and *Autohoodening: The Rise of Captain Swing*.

[13] A thorough analysis of the collaborative process in the creation of *TRAPPIST-1*, for Kingma flautist and electronics, can be found in Gavin Stewart's doctoral thesis "The Shakuhachi retranslated: an exploration, expansion, and evaluation of new instrumental capabilities through the collaborative creation of new works for the Kingma System C flute" (2023). Similarly, a thorough analysis of the collaborative process in the creation of *The Flowering Desert* can be found in Roxanne Korda's doctoral thesis "'LIBRETTISING' SCIENCE: Using operatic narrative and performance to re-present scientific thought in an investigation of new methods towards developing contemporary opera" (2023).

[14] This is also an issue of debate in the field of art and science, as we will discuss below.

respond aesthetically to a certain narrative based on their personal musical craft and taste, not necessarily having an interest in integrating the subject matter within the composition. We can see this, for example, in Philip Glass' third physics-related opera about the eponymous astronomer, *Kepler* (2009). According to Jay M. Pasachoff and Naomi Pasachoff (2009: 724), in the opera, "Glass has resisted the temptation to assign the six anonymous soloists to each of the six planets known in Kepler's time, or to try to translate the planetary orbital periods directly into the musical notes or harmonies that they imply"[15]. They continue stressing Glass' craft rather than considering the interrelation of the music with the subject matter: "instead, swelling arpeggios in the extensive string section, together with varied use of percussion from a maraca to gongs and drums, make for a stimulating and engrossing work". This applies as well to his first physics-related opera, *Einstein on the Beach* (1975), which he regarded as a portrait opera alongside *Satyagraha* (1979) and *Akhnaten* (1983). He describes them as "musical/dramatic portraits of powerful personalities who have engaged my attention at particular times" (Glass, 2008: 723). *Einstein on the Beach* creates a compelling aesthetic with the dialogue between the music and Robert Wilson's formalist dramaturgy; however, as in *Kepler*, the music is heavily based on Glass' stylistic choices, and the interrelation of the music with the subject matter becomes secondary, operating tangentially. This formula of portrait opera would be similarly used in his *Galileo Galilei* (2002).

To explore options to engage deeply with a subject matter in music composition, my research questions focus on the integration and the communication of a subject matter on different compositional levels in a music-theatre setting, looking to

[15] I did not resist the temptation of applying similar techniques to the ones described by Jay M. Pasachoff and Naomi Pasachoff and not used by Philip Glass in *Kepler* in two of the works presented in this practice-based research project: *The Flowering Desert* and *TRAPPIST-1*. These techniques and their application in the compositions are analysed in **2.1 Integration of Data**.

intertwine the disciplines involved in the creation of the work within the composition. We can consider this as an evolution of the idea of programme music. Programme music, according to Grove Music Online, is "music of a narrative or descriptive kind; (…) often extended to all music that attempts to represent extra-musical concepts without resort to sung words" (Scruton, 2001). If we take the idea of "attempting to represent extra-musical concepts" without having to rely on a "musical narration" or "description", we can access very exciting possibilities.

For example, Michael Wolters' opera *Ava's Wedding* (2015) depicts the problems and tragedies that result from the characters' Englishness. They are "burdened by lies and misunderstandings. If they all told the truth, their problems would disappear - but of course they don't. They're English!" (Wolters and Taylor, 2015). The compositional strategy to engage with Englishness on a different level to the narrative was to compose each scene following a different musical style from renowned English composers. Therefore, each scene would be composed using the technique of pastiche in the style of composers such as Henry Purcell, Vaughan Williams, or Andrew Lloyd Webber, achieving to deliver directly within the music the concept of Englishness. This approach of linking the concept on a macrostructural level helps settling the subject matter and gives unity and cohesion to the eclecticism of the score, allowing for playfulness on other levels.

Another example would be Jennifer Walshe and Timothy Morton's opera *TIME TIME TIME* (2019), in which they engage with the subject matter of time in different ways. One of them is the use of the concept of entropy, which is related to the concept of time by the second law of thermodynamics. As entropy can be measured in a defined system, they monitor the audience with heat-sensitive cameras during the performance, varying the length of the piece "dependent on the level of entropy present in the room" (Serpentine, 2019). This compositional decision engages with

the concept of entropy not just with the music composition itself, but also with the space and the audience, being integrated on different levels of the piece.

Following the concept of entropy, I already started exploring the idea of communicating a subject matter on different compositional levels in the physics opera[16], *Entanglement! An Entropic Tale* (2018). Here, for example, the thickness of the texture depends on the position in time of the story. From the beginning to the end, the dropping number of energetic interactions in the universe[17] is depicted with a decrease in the number of pitches available to compose. This results in an entropic climactic point composed with a single pitch[18]. This strategy is also useful, especially for the physics dissemination character of the piece when, for example, depicting the quantum entanglement between two particles in a different position in space and time. In this case, the thickness of the texture determines the position of the characters in their own timelines. In this opera, the integration of the subject matter responds to a compositional process that encompasses the whole work, helping to generate, in this case, harmonic cohesion on a macrostructural level. However, by focusing the integration of subject matter only on the musical discourse, it misses on having a direct impact on other layers of the composition. This results in the opera relying heavily on the sung text to communicate the subject matter.

---

[16] Composed in collaboration with the librettist and physicist Roxanne Korda.

[17] "(…) If the universe is an isolated system, then its entropy too must increase with time. Indeed, the implication is that the universe must ultimately suffer a "heat death" as its entropy progressively increases toward a maximum value and all parts come into thermal equilibrium at a uniform temperature. After that point, no further changes involving the conversion of heat into useful work would be possible. In general, the equilibrium state for an isolated system is precisely that state of maximum entropy" (Drake, 2023).

[18] This affects to everybody but the character of Entropy, who accumulates all the pitches at the end of the piece.

As mentioned in the abstract, and building on previous work such as the aforementioned physics dissemination opera, *Entanglement! An Entropic Tale* (2018), the framework for this practice-based research is art and science.

Research in the connections between arts and science has been recently prolific. Academic discussion about influence, interdisciplinary collaboration, and aesthetics in this topic is available in several published books (Barry and Born, 2014; Ede, 2000; 2005; Kemp, 2000; Reichle, 2009; Strosberg, 2015) and articles in journals such as Nature (Eldred, 2016; Lehmann and Gaskins, 2019). Many of them provide examples of artists working in this field, critically discussing several artworks in relation to the issues that art-science presents. Furthermore, publications that document activities and projects under the art and science umbrella are available on paper (Arends and Thackara, 2003; Wilson, 2010) and digitally (e.g., NATUREVOLVE, or HOLO).

Although most of the academic discussion around art and science has been focused on the visual arts, most of its criticism can also be applied to the performing arts. Martin Kemp (2000:v) complained that "too many of the increasingly fashionable art-science initiatives seemed to be operating at a surface level, in which obvious points of contact (e.g., artists using scientific imagery) were simply narrated or in which objects from art and science were juxtaposed without really interpenetrating". On this issue, Siân Ede exposed that "while 'Sci-Art' sometimes seems to be all the rage, not all of it is interesting as art. Indeed, I do not believe that art can be directly about science" (Ede, 2005:3).

This issue can be juxtaposed to music-theatre. By looking at titles such as Philip Glass' *Galileo Galilei* (2002) and *Kepler* (2009), Constantine Koukias' *Tesla - Lighting in His Hand* (2003), John Adam's *Doctor Atomic* (2005), Jonathan Dove's *Man on the*

Moon (2006), or Elżbieta Sikora's *Madame Curie* (2011), we can see that many science-related operas are, in reality, biopics of people related to science, where the scientific element is embedded mostly through their personal lives or their ideas. Despite the artistic quality of these operas, which is not discussed here, this fact brings back the idea of the "fashionable art-science initiatives (…) operating at a surface level" (Kemp, 2000:v)[19].

Music-theatre, however, is an excellent medium to explore the connections between art and science. Its non-realistic quality, based primarily on the dialogue between music and dramaturgy (through the sung voice in opera) and its relationship with other artistic disciplines, can be used to engage with abstract ideas and subject matters. It is as "realistic" to have the Wagnerian god Wotan singing while surrounding Brünnhilde with a circle of fire than to have an anthropomorphised electron (or any other scientific concept) singing on stage.

In other non-realistic performing arts disciplines, such as dance, this idea has already been explored. Ede (200:56) mentions, for example, the case of a piece by Nikky Smedley (*Talking of the Sex of Angels*, 1995), in which, at a point, the choreography follows the tracks made by a pair of positron-electron in a cloud chamber, representing the double slit experiment. Despite its representational quality, the piece presents a phenomenon difficult to communicate: the indeterminacy of quantum physics. Ede reflects that "contemporary dance was a particularly good medium for this as it represents ideas and feeling through abstract movement conveyed through the concrete limitations of the human body", and that the performance stressed on a different level the influence of the observer in quantum physics.

[19] This links with the idea of the superficial engagement with a subject matter in opera composition presented in Philip Glass' example on his opera *Kepler* (2009).

Similarly, music-theatre, through its multi-layered artistic nature, can achieve the communication of a subject matter on different levels, generating meaningful connections between different ideas. This is especially relevant when we consider the collaborative aspect. On collaboration in art and science projects, Ede stresses that "the potential for profound levels of engagement should be acknowledged" (2000:65), with the artists exploring the connections with the human perspective.

With interdisciplinary collaboration as part of the creative process, there are operatic pieces that engage deeper with a subject matter, similarly to Siân Ede's artistic idea of creating "images which suggest alternative ways of seeing [science]" (Ede, 2005:3). This is the case of Héctor Parras' *Hypermusic Prologue* (2010), which is the result of a collaboration with Harvard's theoretical physicist Lisa Randall. In the piece, according to Parra in an article about the work, the music "expresses the ideas of physics", and represents "the four basic forces of nature" (Powell, 2009). Ede's ideas can apply as well to my work *Entanglement! An Entropic Tale* (2018) and to Walshe and Morton's *TIME TIME TIME* (2019), with different integrated uses of entropy and time in the pieces (described above) and interdisciplinary collaboration at the core of their creation.

The strategies and techniques presented in the research have been developed through interdisciplinary collaboration to generate a deep engagement between the subject matter and its artistic outcome[20], looking for the "interpenetration" of the art and science objects. In section 2[21], I present and analyse in context the application of a series of these strategies and techniques used to integrate a subject

[20] In this case, each of the four music-theatre works included in the portfolio.

[21] **2 How can interdisciplinary collaboration with science-based disciplines develop composition strategies and techniques for creating new music theatre?**

matter within the musical discourse. In section 3[22], I present and analyse how different strategies and techniques can be used to communicate a subject matter on different compositional levels.

1.3 Pieces featured in the portfolio

Four works are featured in the practice-based research project portfolio. In order of composition, these are: *In response to Naum Gabo: Linear Construction in Space No. 1* (2020), *Autohoodening: The Rise of Captain Swing* (2021), *The Flowering Desert* (2022), and *TRAPPIST-1* (2023). Stylistically, compositionally, and in notation, they are very different works, as they respond to different subject matters and interdisciplinary collaborative settings. However, they share in common the application of similar strategies and techniques to integrate data and knowledge derived from research into their creation, showcasing their potential application in different creative contexts. These strategies and techniques are analysed in response to the research questions.

1.3.1 In response to Naum Gabo: Linear Construction in Space No. 1

Music-theatre piece created in response to the homonymous sculpture by the Russian constructivist artist and engineer Naum Gabo[23]. This work is the result of a

[22] **3 How can you communicate a subject matter on many compositional levels in a piece of music theatre?**

[23] Naum Gabo was a Russian-born engineer and sculptor who became, through his work and writings, one of the main exponents of constructivism. His *Linear Construction in Space No. 1* sculpture at The Barber Institute of Fine Arts was made in St. Ives in 1942/43 and is one of the many

collaboration between the company I co-direct[24], Infinite Opera, and the Barber Institute of Fine Arts as part of the University of Birmingham's 2020 Art and Science Festival. The piece engages with the philosophy behind Gabo's artistic work (which pioneers contemporary art and science practices) and with the mathematical process that informs the sculpture, making it a meta-art&science work.
The full score and the documentation of its performance at the Barber Institute of Fine Arts on the 3rd of March 2023 are available in **5.1 Appendix #1**.

1.3.2 Autohoodening: The Rise of Captain Swing

Operatic protest masquerade collaboratively created between the "design troupe" Post Workers Theatre[25] and Infinite Opera. This piece uses social science research on the working conditions at the international corporation Amazon alongside ethnographic research on the Kentish folk custom of hoodening. This tradition is set around a 19th-century ploughing team that satirises their working reality. These two elements are juxtaposed to compare the revolts in agricultural England during the industrial revolution[26] with the current situation of exploitation suffered by many workers at Amazon fulfilment centres, especially during the COVID-19 pandemic.

---

different versions of this sculpture. It is made with a rigid frame of Perspex (a plastic: polymethyl methacrylate) and a single thread of nylon, which, by its constant minimal change of disposition, creates an illusion of depth, space, and infinity. With more profound changes, especially in their structural frame, some of these sculptures would add the term "Variation" to their name, indicating "that it differs from the original version in having a stepped-back (or winged) treatment on two sides instead of having all four sides the same" (Alley, 1981).

[24] Alongside the librettist and singer Roxanne Korda.

[25] As they define themselves on their website: www.postworkerstheatre.com/about [Last accessed 29 September 2023].

[26] In these revolts, threatening letters were sent to landowners under the anonymous signature of Captain Swing.

Due to the impossibility of performing this piece live because of the different COVID-19 lockdowns, the piece eventually became a film. It premiered at Vivid Projects (Birmingham) on the 10th of December 2021.

The full score in the format of a songbook, the folk band supporting materials, and the full film with subtitles are available in **5.2 Appendix #2**.

1.3.3 *The Flowering Desert*

Opera designed to be performed at planetariums based on the recently discovered TRAPPIST-1 planetary system. It is the result of the collaboration between Infinite Opera and the astrophysicist Dr Amaury Triaud, a leading expert on the topic and a participant in the discovery of TRAPPIST-1[27]. In this work, we explored integrating the musicality of the planetary system into the musical discourse using data from sources such as the orbital rotation of the planets or the distances between the planets and the star. The idea of rotation engages with the semi-spherical architectural quality of the planetarium space. We also engaged with the process of the discovery from the scientist's point of view, stressing the impact that this discovery had on the search for life in the universe[28].

---

[27] We also collaborated with the following practitioners: Colin Hutcheson (planetarium lead), Leon Trimble and Tadas Stalyga (visuals), and Alexander Kanievski (movement and costume design), as well as with several placement students from the Birmingham School of Art.

[28] "Now we can assess the actual conditions, and explore counter-arguments that Earth-sized planets around stars such as TRAPPIST-1A might in fact be hospitable to life. (…) We are optimistic." (Triaud and Gillon, 2017).

The full score, the video documentation of a dress rehearsal at the Birmingham Think Tank Planetarium on the 18th of January 2023, and a full studio recording in binaural mode are available in **5.3 Appendix #3**.

1.3.4 TRAPPIST-1

Music-theatre work for flautist and electronics based on the discovery of the homonymous planetary system. It was co-created with the flautist and researcher Gavin Stewart, as part of his research project to build repertoire for the Kingma system C flute[29], in collaboration with Dr Amaury Triaud. In this work, the collaboration with a different practitioner fuelled the development of some unexplored strands in the composition of the other piece about the TRAPPIST-1 planetary system, *The Flowering Desert*, such as the use of microtonality in the transformations of data into pitches. We also focused on the personal experience of Amaury during the discovery, associating the flautist with the scientist and the planets with the electronics part.

The full score and a mock audio recording of the full piece are available in **5.4 Appendix #4**.

[29] A flute system designed by Eva Kingma whose "modifications make the instrument fully quartertonal throughout its range and also allow for many additional microtones, multiphonics, glissandi, and other unique timbral effects" (Kessel, 2018:1).

2 How can interdisciplinary collaboration with science-based disciplines develop composition strategies and techniques for creating new music theatre?

In this section, I present a series of key strategies and techniques derived from interdisciplinary collaboration used in the composition of the four science-based works included in the portfolio.

It is divided into two main strategic approaches: integration of data and representation of ideas.

2.1 Integration of data

A direct manner to engage with science-based disciplines is to work with data derived from research. This data, whether quantitative (expressed in numerical form) or qualitative (expressed non-numerically), can be used to inform composition decisions in dialogue with the other practices involved in the creation of a music-theatre work. By using data, we can connect a work with the reality of its subject matter and showcase, through musical or performative transformations, the relationship between its components.

2.1.1 Quantitative or numerical

The use of scientific numerical data in music composition is a practice present in much music nowadays. One example is the numerous sonification[1] projects to represent sonically black holes or gravitational waves, many of them used in the context of sci-art or science dissemination. This is possible thanks to the mathematical nature of music, which allows to transform numerical data easily into musical parameters such as frequencies or patterns of rhythm.

In the music-theatre context, we can see the use of quantitative data, for example, in Jennifer Walshe's opera *TIME TIME TIME* (2019), in which live data from the audience, measuring the entropy level in the room, informs performance decisions. Quantitative data is also used in Michael Wolters' radio opera *Kathryn und Peter durchqueren die Antarktis* (2004), which features his *Antarctica Duet* (2003), a work for two recorders informed by "a cross-section diagram of Antarctica" that follows the ice and bedrock lines "in eight tone steps" (Wolters, 2003).

In this research, I engaged with quantitative data mainly in two manners: the transformation of numerical data into musical parameters and the embodiment of data.

[1] Sonification is the representation of data with sound.

2.1.1.1 Transformation of numerical data into musical parameters

I explored this technique in the two pieces that engage with the discovery of the planetary system TRAPPIST-1: the chamber opera for planetariums, *The Flowering Desert*, and the music-theatre piece for flute and electronics, *TRAPPIST-1*.

I worked in collaboration with one of the leading experts in the topic, Dr Amaury Triaud, who described this system to me as "really musical by its physical parameters"[2]. With his guidance through the data and the process of the discovery, I developed different transformations of the most relevant data into musical parameters to generate blocks of musical material to be used in the composition of these two pieces.

2.1.1.1.1 Harmonic material

I generated harmonic material using mainly two different sets of data: the orbital period ratios and the distance of the planets to the star. A general idea from the beginning of the composition of these two pieces was to engage with the concept of "music of the spheres"[3], aiming to create a harmonic sound world unique to the TRAPPIST-1 system.

---

[2] Triaud, A. (2019) Email to Daniel Blanco, Roxanne Korda, and William Chaplin, 24th of October.

[3] The "music of the spheres" is a philosophical concept that relates the movement of the celestial bodies with music. This idea, of Pithagorean origin, was later developed by Johannes Kepler in his work *Harmonices Mundi* (1619).

2.1.1.1.1.1 Orbital period ratios

One of the most striking features of the planetary system TRAPPIST-1 is its harmonicity. The orbital periods of the seven planets are locked in a chain of resonances (Luger et al., 2017). This means that the relation between the orbits of neighbouring planets can be expressed as simple ratios. For example, while planet H rotates twice around the star, planet G rotates three times. These ratios can be expressed musically as intervals as follows:

Planets B/C	Planets C/D	Planets D/E	Planets E/F	Planets F/G	Planets G/H
8/5	5/3	3/2	3/2	4/3	3/2
Minor 6th	Major 6th	Perfect 5th	Perfect 5th	Perfect 4th	Perfect 5th

Table 1 - Orbital rotation ratios of TRAPPIST-1 and their transformation into musical intervals.

With this transformation[4], I generated two chords: one built using the series from the planet B to H, and the second from the planet H to B:

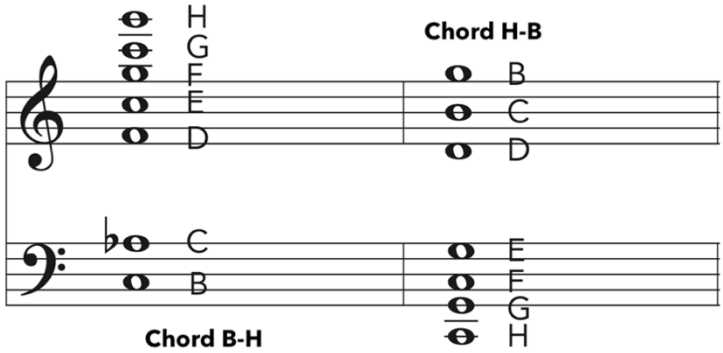

Figure 1 - Chords generated from TRAPPIST-1's orbital rotation ratios.

[4] This same transformation also appears in sci-art sonification projects such as TRAPPIST Sounds, by System Sounds. Their works are available here: www.system-sounds.com/trappist-sounds/ [Last accessed 2 October 2023].

I used this transformation as the main harmonic material to compose the *Overture* and the four *Mélodrame* sections[5] of the opera *The Flowering Desert*. These showcase the point of view of the Measurer, a character that represents a scientist witnessing the discovery of TRAPPIST-1. With this decision, I wanted to embed an important feature of the system for the scientific community (its harmonicity) into the character and the sections that represent them and the process of the discovery.

Example #1

Use of harmonic material generated with orbital period ratios (marked in blue in the score). Chord B-H (transposed):

The Flowering Desert - Mélodrame 1.
Excerpt: Bars 37-53.
Score follower video.
Binaural audio (please use headphones to experience the audio surround effect).

Example #2

Use of harmonic material generated with orbital period ratios (marked in blue in the score). Chord H-B (transposed):

The Flowering Desert - Mélodrame 4.
Excerpt: Bars 54-66.
Score follower video.
Binaural audio (please use headphones to experience the audio surround effect).

[5] In the case of the four *Mélodrame* sections, this harmonic material is used in combination with a rhythmic transformation based on the orbital rotation of the planetary system.

2.1.1.1.1.2 Distance from the planets to the star

This transformation showcases the system more directly than with the orbital period ratios, as the distance between planets can be easily associated with the distance between pitches (rather than with a concept such as the harmonic relation between orbits). I took the distance in km from each planet to the star[6] and used these numbers as frequencies, adapting them to the human audible register, resulting in the following pitches[7]:

Planet B	Planet C	Planet D	Planet E	Planet F	Planet G	Planet H
$1{,}72037 \times 10^{11}$ km	$2{,}35766 \times 10^{11}$ km	$3{,}31957 \times 10^{11}$ km	$4{,}36227 \times 10^{11}$ km	$5{,}73857 \times 10^{11}$ km	$6{,}98622 \times 10^{11}$ km	$9{,}23018 \times 10^{11}$ km
172,037 Hz	235,766 Hz	331,957 Hz	436,227 Hz	573,857 Hz	698,622 Hz	923,018 Hz
F3 -26 cents	Bb3 +20 cents	E4 +12 cents	A4 -15 cents	D5 -40 cents	F5 +0 cents	Bb5 -17 cents

Table 2 - Conversion of distances from the TRAPPIST-1 planets to their star into pitches.

[6] As the planetary orbits are elliptical, the distance of each planet to the star is not constant during each rotation. To unify the choice of distances in km for this transformation, I took the distance at the semi-major axis in each planet's orbit (the longest radius of the ellipse).

[7] Calculated using A=440 as a pitch reference. The result is approximated to cents (a division representing 1/100 of a semitone) in natural numbers. For example, on Planet G, 698,622 Hz results in F5 +0,41 cents, which is a level of precision unachievable by human performers.

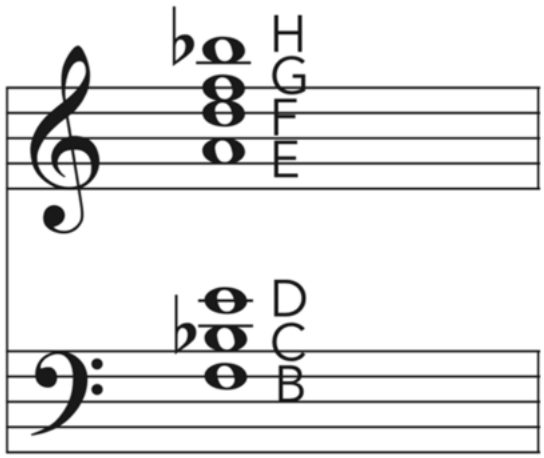

Figure 2 - Chord generated with the distances from the planets of the TRAPPIST-1 system to their star.

In *TRAPPIST-1* (for flautist and electronics), this transformation becomes the main harmonic material for the electronics part (representing the planetary system), exploring its microtonality and how the different pitches (each representing a planet of the system) interact between them (**Example #3**).

In *The Flowering Desert*, this transformation is used as the harmonic material for the moments that focus on the Mother Star. This character (sung by a chorus) represents the Star as the entity governing the planetary system. In this case, I adjusted the pitches to their nearest semitone to facilitate its performance[8] (**Example #4**).

[8] All the harmonic transformations in *The Flowering Desert* are approximated to semitones. From the beginning of its composition, I decided this piece would not explore microtonality for practical reasons. The piece uses a relatively large force for a chamber opera (8 instrumentalists and 6 singers), including in its instrumentation the vibraphone and the piano, which cannot easily play microtonally. This opera is also designed to be performed in planetariums, which added an extra difficulty to the performers and the singers, especially in a COVID-19 context with limited rehearsal possibilities. In contraposition, I decided to explore the microtonal potential of these harmonic transformations in the piece *TRAPPIST-1*, written for a Kingma system flute (designed to play microtonal music) and electronics (in which a specific microtonal pitch can be programmed easily).

With the distance between planets as a data source, we can also generate a 7-note musical scale (one note per planet) if we encapsulate the planetary system into an octave. Several transformations are possible, depending on the parameters you decide to play with. For example, a TRAPPIST-1 science dissemination article from the Spitzer Space Telescope assigns one note to each planet using a diatonic scale[9]. For both *The Flowering Desert* and *TRAPPIST-1*, I used the star as the first note of a chromatic scale (C) and planet H as the last note (B for an ascending scale, or C# for a descending scale). Within that frame, I calculated the other notes, which correspond approximately to the distance between planets.

In the case of The Flowering Desert, I approximated the result to the nearest semitone, creating the following scale and its inversion:

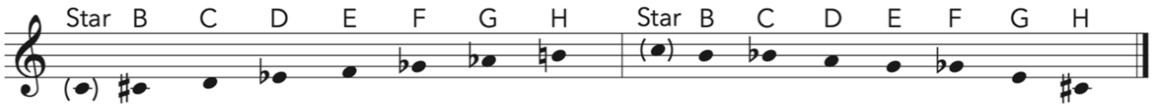

Figure 3 - Music scale and its inversion generated with the distances from the planets of the TRAPPIST-1 system to its star. Approximated to semitones.

In *TRAPPIST-1*, due to its focus on microtonality, I approximated the results of the same transformation to cents:

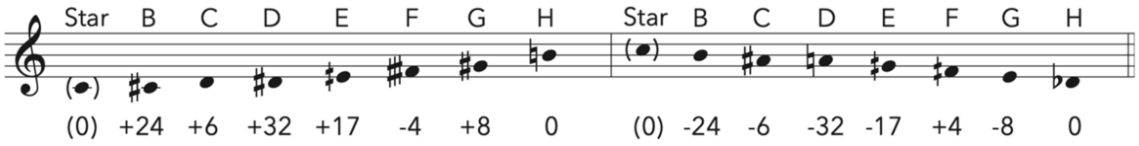

Figure 4 - Music scale and its inversion generated with the distances from the planets of the TRAPPIST-1 system to its star. Approximated to cents.

[9] Payle, T. (2017) *Making music from exoplanets*. Available at: https://www.spitzer.caltech.edu/blog/making-music-from-exoplanets [Last accessed 2 October 2023].

In both works, the resultant scales and chords are not necessarily fixed[10] and can be transposed using any other pitch as the fundamental note. For example, in *TRAPPIST-1*, I transposed the scales presented in Figure 4 to have D+32 cents[11] as the note representing the star (**Example #5**). This transposition is used by the flautist during the piece to represent the scientist in relation to the planetary system (discussed further in **3.1.1.2 *TRAPPIST-1***). In *The Flowering Desert*, the harmonic material based on orbital ratios (Figure 1) appears transposed in different moments to structure the *Mélodrame* sections (Figure 6)[12].

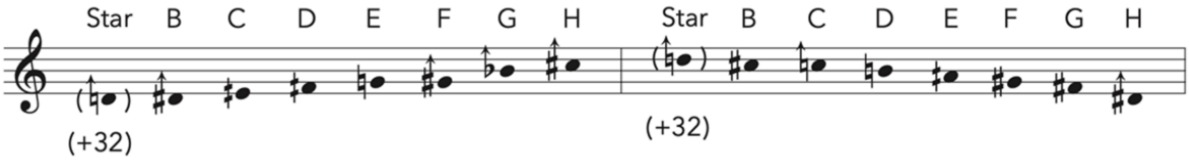

Figure 5 - Music scale and its inversion transposed using D+32 cents as the first note of the scale. To facilitate the performance in the piece, these scales are presented in a simpler microtonal notation.

[10] Only the chord generated by transforming distances into frequencies (Figure 2) is fixed. If this chord was transposed, the frequencies of the new notes would not correspond to the distances anymore. In the case of the music scales, as they are encapsulated into an octave, it does not matter if the fundamental note of the scale is different, as the distance between semitones remains constant. In the case of the chords generated by orbital ratios, the data informs how the chord is built with specific intervals, but not its fundamental note.

[11] In the piece *TRAPPIST-1,* this pitch represents the star, as it is the result of transforming the distance from the TRAPPIST-1 planetary system to Earth into a frequency.

[12] Discussed in **2.1.1.1.4.1 Tonal centres**.

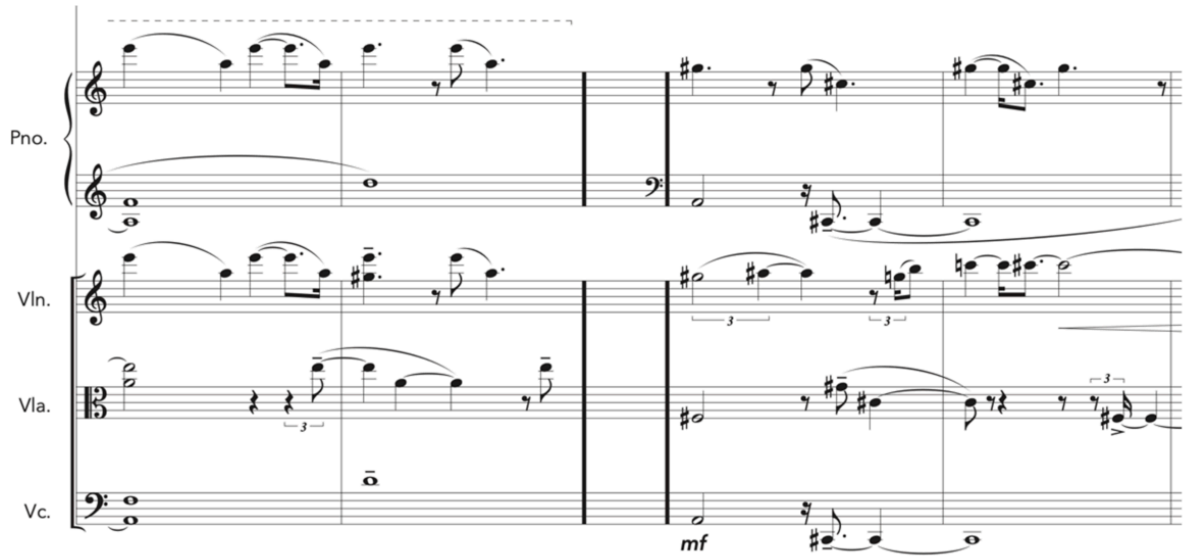

Figure 6 - The Flowering Desert, Mélodrame 4, Bars 31-32 and 38-39. Piano and strings. Example of transpositions of harmonic material generated with the orbital ratios of TRAPPIST-1 (Figure 1). The harmony in the first fragment is transposed to the tonal centre of Planet D and its fundamental note is A. In the second fragment, the same harmonic material is transposed to the tonal centre of Planet H, whose fundamental note is C#. These transpositions are informed by the descending scale presented in Figure 3.

Example #3

Use of the harmonic material generated with the distance from the planets to the star (Table 2) in the electronics part of *TRAPPIST-1*.

TRAPPIST-1 – Scene 1, "Exoplanet hunter".

Excerpt: [00:00:00] to [00:01:00].

Score follower video.

Binaural audio (please use headphones to experience the audio surround effect).

Example #4

Use of the harmonic material generated with the distance from the planets to the star (Figure 2) in *The Flowering Desert* (marked in blue in the score).

The Flowering Desert - Scene 3.

Excerpt: Bars 156-175.

Score follower video.

Binaural audio (please use headphones to experience the audio surround effect).

Example #5

Melodic use of the musical scale generated with distances (Figure 5) in *TRAPPIST-1*.

TRAPPIST-1 – Scene 4, "Announcement".

Excerpt [00:06:53] to [00:08:04].

Score follower video.

Binaural audio (please use headphones to experience the audio surround effect).

2.1.1.1.2 Rhythmic material

I generated rhythmic material using the data from the orbital rotation period of the planets[13] and from the distance between each planet and the star[14]. With these transformations, I was interested in creating rhythmic units that could be used

[13] This is different from the orbital period ratios seen in **2.1.1.1.1.1 Orbital period ratios**. The orbital period of the planets used for the rhythmic transformations is expressed in Earth days. The orbital period ratios used before are mathematical relations: they are the result of dividing the orbital periods of neighbouring planets. For example, the orbital rotation of planet E lasts for approximately 6 days, and the orbital rotation of Planet D lasts approximately 4 days. The orbital rotation ratio for planets E and D is 3/2, as seen in Table 1.

[14] In this case, rather than to generate frequencies, to generate distances between notes.

independently (e.g., as an ostinato representing a planet as in Figure 7) or in combination, generating rhythmic patterns or *taleae*[15] (e.g., a rhythmic pattern result of a combination of the planetary system as in Figure 8). I use the term "rhythmic unit" to describe the cycle between two attacks, counted in beats.

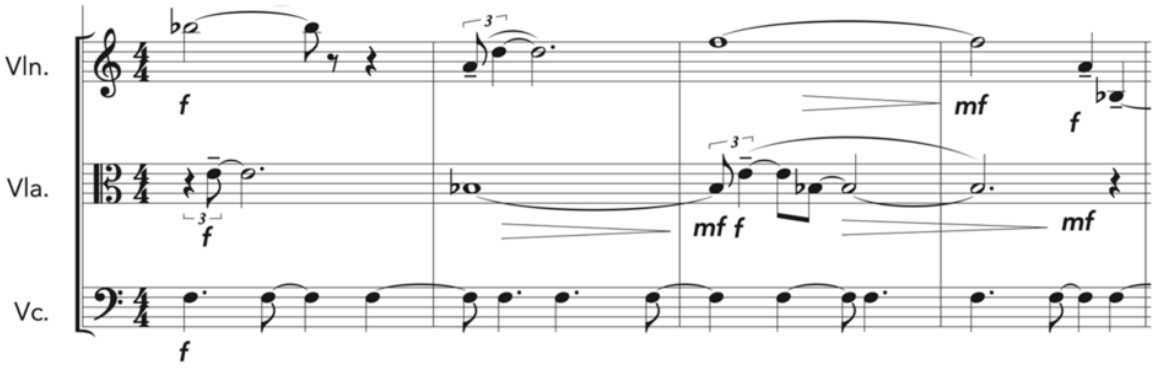

Figure 7 - The Flowering Desert, Scene 3, Bars 156-159. The cello part repeats a dotter-crotchet figure, a rhythmic unit characteristic of Planet B. In this case, the note is held for the duration of the whole rhythmic unit.

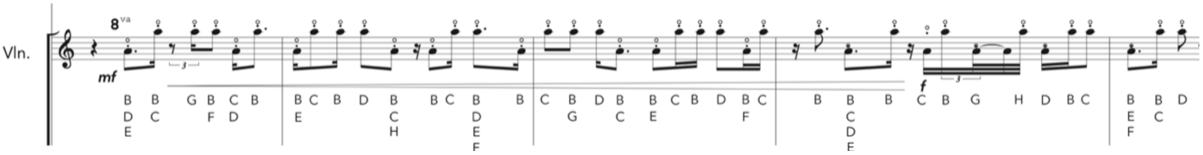

Figure 8 - The Flowering Desert, Scene 2, Bars 148-152. The violin plays a rhythmic pattern generated by combining the rhythmic units of the seven planets of the system. We can imagine it as if every time a planet completes a cycle, there is an attack. The different durations of the cycles of each planet in combination create a more complex rhythmic pattern. In this figure, each capital letter shows the "attack" of each planet. For example, Planet B "attacks" every dotted quaver, whereas Planet D, "attacks" every four quavers.

2.1.1.1.2.1 Orbital rotations

I transformed orbital rotation data into rhythmic units by converting the number of Earth days each planet takes to rotate around the star into beats. In *The Flowering*

[15] A *talea* (*taleae* in plural) is a repeated rhythmic pattern used in combination with melodic patterns in the composition technique of isorhythm, typical of 13th and 14th century polyphony.

Desert, this rhythmic material appears throughout the whole piece (Figures 7 and 8), mainly approximated to their closest quaver or semiquaver as follows:

Planet B	Planet C	Planet D	Planet E	Planet F	Planet G	Planet H
1.51 days	2.42 days	4.04 days	6.09 days	9.20 days	12.35 days	18.77 days
1.5 beats	2.5 beats	4 beats	6 beats	9 beats	12.33 beats	18.75 beats

Table 3 - Transformation of orbital rotation periods into rhythmic material for The Flowering Desert.

A more faithful transformation is used in Scene 2, however. This scene features the Mother Star as an endless process of nuclear fusion of hydrogen into helium[16]. As this process is what ultimately holds together the planetary system, the combined rotation of all the planets in the system is used to define musically the star. The character of the Mother Star is, in consequence, depicted as a musical process (that could also be endless)[17]. By using a more precise transformation, I embrace rhythmic figures such as quintuplets, which, in a long musical process, create different rhythmic combinations, differentiating the Mother Star from the other rhythmical transformations and thus defining the character[18].

---

[16] Part of the chorus' lyrics for Scene 2 stress the nuclear reaction that happens in stars. For instance, "Hydrogen 1 meets Hydrogen 1" or "Helium 3 can't meet Helium 3".

[17] See **Example #9** in **2.1.1.2.2 *The Flowering Desert***.

[18] This data transformation also appears in the middle section of Scene 1, Pantele's "Aria for the two halves of the self" (*The Flowering Desert,* Scene 1, Pages 21-27). This section presents Pantele in the context of its planetary system and foreshadows the material for Scene 2. Following this "coming of age" story, this transformation, connected specifically to the character of the Mother Star, gradually disappears throughout the piece. In fact, the Mother Star's intervention in Scene 3 does not feature quintuplets (*The Flowering Desert*, Scene 3, Pages 69-78), and the intervention in Scene 4 is merely a decreasing series of chords (*The Flowering Desert*, Scene 4, Pages 89-92).

Planet B	Planet C	Planet D	Planet E	Planet F	Planet G	Planet H
1.51 days	2.42 days	4.04 days	6.09 days	9.20 days	12.35 days	18.77 days
1.5 beats	2.4 beats	4 beats	6 beats	9.2 beats	12.33 beats	18.8 beats

Table 4 - A more precise transformation of orbital rotation periods into rhythmic material for Scene 2 in The Flowering Desert. Planets C, F and H now generate crotchet quintuplets.

Similarly, I also transformed the star's own rotation (3.295 days) into a rhythmic unit (3.33 beats), a gesture that appears predominantly in *The Flowering Desert* in Scenes 1, 2[19] and 3, and that is also connected to the character of the Mother Star (Figure 9).

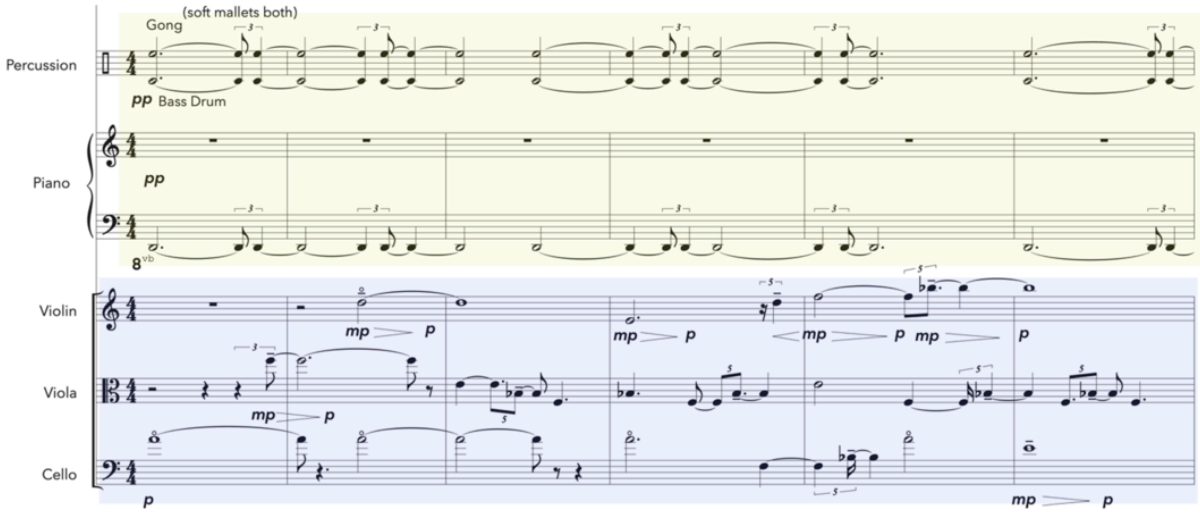

Figure 9 - The Flowering Desert, Scene 2, Bar 1. The strings section play musical material generated rhythmically from orbital rotation data (marked in blue in the score). The piano and percussion play material generated rhythmically from the star's own rotation (marked in yellow in the score).

[19] In Scene 2, the piano and percussion start playing a 3'33 beats ostinato at tempo ♩ = 60 (3'33 seconds per note). From rehearsal mark 1, with the tempo change, they now play a minim ostinato. The minim in the new tempo, ♩ = 72 lasts 3'33 seconds, keeping the same duration with a different figuration. *The Flowering Desert*, Scene 2, Pages 40 and 41.

2.1.1.1.2.2 Distances

I also explored expressing the distances between planets rhythmically. For that, I used as a basis Planet B (the first of the system), converting its distance to the star into a full 4/4 bar, and generating the other rhythmic units in relation to it. This transformation is mainly used to create rhythmic patterns for melodic generation.

Planet B	Planet C	Planet D	Planet E	Planet F	Planet G	Planet H
$1{,}72037 \times 10^{11}$ km	$2{,}35766 \times 10^{11}$ km	$3{,}31957 \times 10^{11}$ km	$4{,}36227 \times 10^{11}$ km	$5{,}73857 \times 10^{11}$ km	$6{,}98622 \times 10^{11}$ km	$9{,}23018 \times 10^{11}$ km
4 beats	App. 5.5 beats	App. 7.66 beats	App. 10 beats	App. 13.33 beats	App. 16 beats	App. 21 beats

Table 5 - Transformation of distances into rhythmic material in The Flowering Desert.

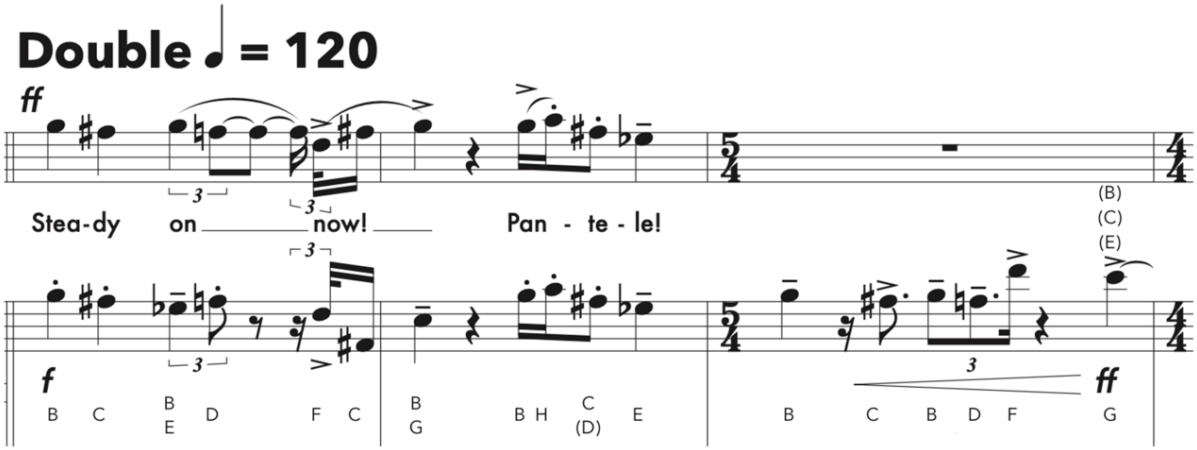

*Figure 10 - The Flowering Desert, Scene 1, Bars 134-136. Xoe (soprano) and flute: example of a melodic line that uses a rhythmic pattern generated with the distances between planets (in this case in diminution). Similarly to Figure 8 (**2.1.1.1.2 Rhythmic material**), each capital letter is the start of the rhythmic unit of a planet. In this case, as I will expand in **2.1.1.1.3.1 Banks of material** and **2.1.1.1.3.2 Isorhythm**, each rhythmic unit is associated with a specific pitch.*

2.1.1.1.3 Melodic material

All the melodic material for *The Flowering Desert* has been created by combining the harmonic and rhythmic material presented in the sections **2.1.1.1.1 Harmonic material** and **2.1.1.1.2 Rhythmic material**.

2.1.1.1.3.1 Banks of material

To represent melodically the TRAPPIST-1 planetary system and other concepts related to its discovery, I generated different banks of melodic material that combine the rhythmic units linked to each planet with their correspondent pitches in the music scales or in the chords. The banks are the result of joining seven individual lines, each with the specific material of a planet. They start with a full alignment of the 7 planets, generating a cycle of hundreds of thousands of bars until the next full alignment (Figure 11). The use of this technique recreates melodically the undulatory shape of the TRAPPIST-1 transits on the data plots[20]. This shape is the result of the cyclical repetition of notes associated with the shorter rhythmic units, which create a "bottom" line from which the other notes take off and come back.

In *The Flowering Desert* there are two main banks I generate melodic material from: the first (Figure 11) combines the rhythmic units based on distances (Table 5) with the music scales based on distances (Figure 3), and the second combines the rhythmic units based on rotations (Table 3) with the music scales based on distances

[20] A transit happens when a planet passes between a star and its observer. This passing casts a shadow that is often used to detect exoplanets. This technique is called transit photometry. The data plots used in the composition of *The Flowering Desert* correspond to the 500 hours of observations of the Spitzer telescope from the 19th of September to the 7th of October of 2016. They are available at: www.trappist.one/#system [Last accessed 2 October 2023].

(Figure 3). Each of these two banks has two different versions: one using the ascending music scale, and the second as its inversion, using the descending scale (Figure 3). The different resultant melodic shapes from these banks are useful to define characters in the piece. This can be seen, for example, in the character of Pantele in Scene 1, when her "Self" and "Shadow"[21] personalities are presented. The "Self" uses the material created using the descending scale, which sits in a higher register and is therefore brighter for the voice (Figure 12). The "Shadow" uses the material created using the ascending scale, which sits in a lower register and is darker for the voice (Figure 13).

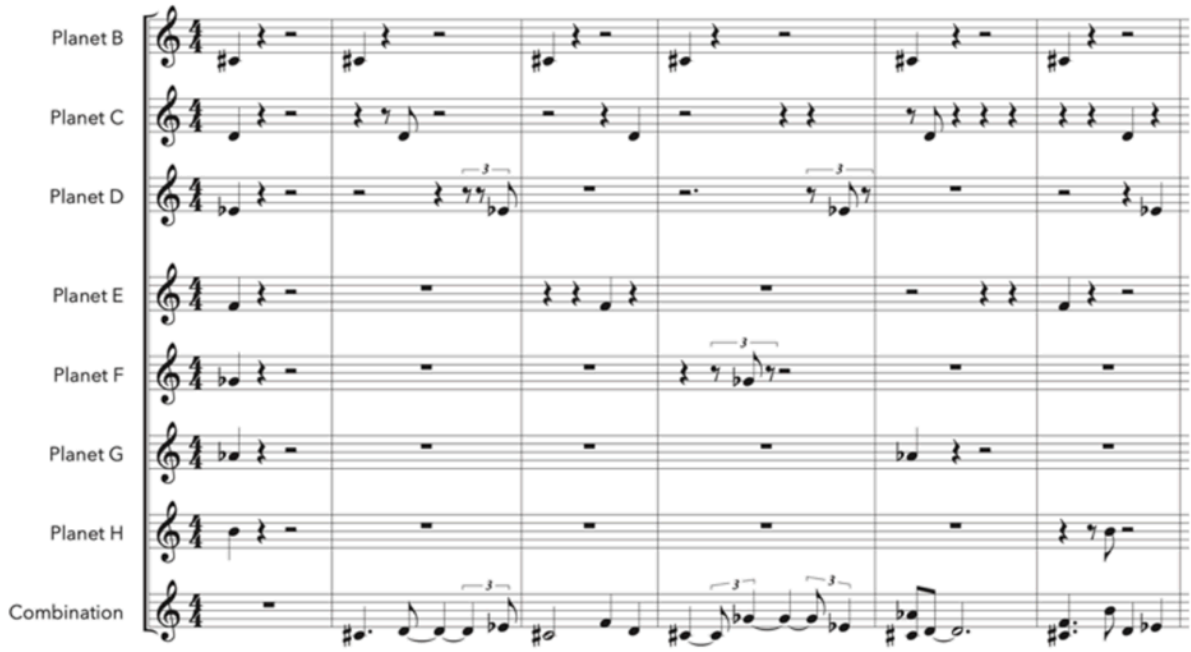

Figure 11 - Bank of material generated with distances. Rhythmic units from Table 5. Pitches from Figure 3. The melodic fragment at the bottom appears throughout the whole opera, especially in the Overture (e.g., bar 7 - Measurer) and in the four Mélodrame sections. Notice the repetition of C# and D and how the melodic shape undulates towards these two notes.

[21] Planet E is most likely tidally locked to its star (Lingam and Loeb, 2018). It means that one side of the planet is always lit by the star, and the other is always in shadows. This is what happens, for example, with the Earth and the Moon (and explains why the far side of the Moon exists).

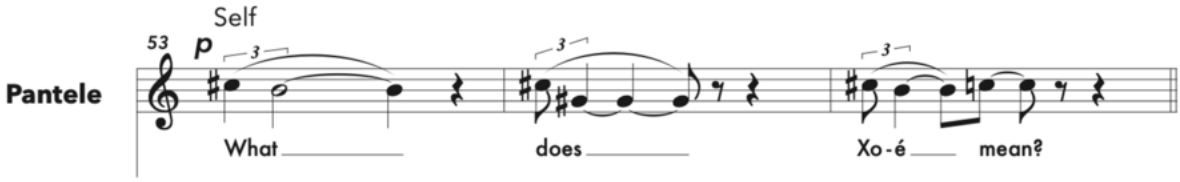

Figure 12 - The Flowering Desert, Scene 1, Bars 53-55. The melodic material sung by Pantele's "Self" uses melodic material generated with the descending music scale. The rhythmic pattern is derived from the distances of the planets to the star.

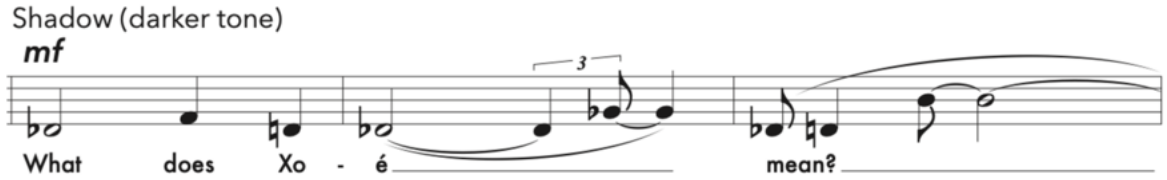

Figure 13 - The Flowering Desert, Scene 1, Bars 56-58. The melodic material sung by Pantele's "Shadow" uses melodic material generated with the ascending version of the music scale. The rhythmic pattern is derived from the distances of the planets to the star.

To choose melodic fragments from these banks, and due to the impossibility of going through all the generated material[22], I decided to use TRAPPIST-1 data. To detach myself from a personal arbitrary decision, I asked Dr Amaury Triaud to find a series of numbers specific to each planet or events related to the discovery of TRAPPIST-1 that I could use to determine where to get material from in the banks[23]. Each of those numbers marks the bar number in the banks to draw the melodic material from. Then, the melodic material will be associated with the specific planet or concept linked to the numbers Dr Triaud provided. Figures 12, 13, and 14 show, for example, melodic material associated with the character Pantele[24]. This

[22] Each bank contains thousands of bars of unique material.

[23] The numbers used to define each planet's musical material correspond to the transit duration of each planet expressed in seconds.

[24] See **3.2.2 *The Flowering Desert*** for a use of the musical material of Figure 14 juxtaposed to musical material associated with the star.

procedure, drawing on a certain indeterminacy and chance[25] as a composition technique, recalls the use of the *I Ching* by John Cage to determine musical parameters in *Music for Changes* (1951) and Xenakis' stochastic music[26], which was informed by scientific data and processes[27].

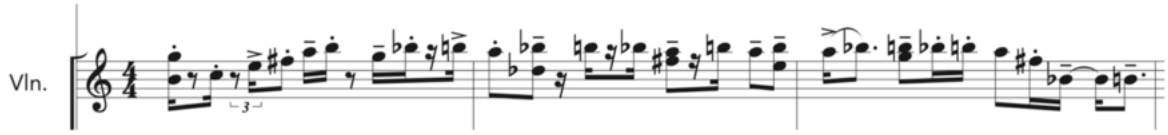

Figure 14 - The Flowering Desert, Scene 1, Bars 49-51. Melodic material also associated with Pantele. In this case it is generated from a bank different to Figures 12 and 13. In this bank, the rhythmic pattern is derived from the rotation of the planets, and the harmonic material is derived from the scales generated with the distances from the planets to the star.

2.1.1.1.3.2 Isorhythm

Another technique I used to combine rhythmic and harmonic material in *The Flowering Desert* and *TRAPPIST-1* is isorhythm[28]. I generated different *taleae* using

[25] In this situation, I did not have a preconceived idea of which melodic material I would find in the banks. The chosen material is determined by a series of numbers I had no control over and that, from my personal perspective, would be akin to rolling dice. However, I gave Amaury Triaud a stimulus to choose those numbers by asking him for numbers related to each planet.

[26] According to The Oxford Companion to Music (2011), stochastic music "refers to composition by the use of the laws of probability". It contrasts with indeterminate music composition (such as Cage's works using the *I Ching*) by being "fully composed". In stochastic music "chance enters only into the process of composition, the composer perhaps allowing the distribution of pitches, for example, to be determined by some concept from the mathematics of probability".

[27] Xenakis' *Pithoprakta* (1955-56) uses, for example, the statistical distribution of gases, following the Maxwell-Boltzmann law, to inform the composition (Randel, 1996).

[28] Isorhythm is a composition technique that consists of the combination of a rhythmic pattern (*talea*) with a melodic pitch pattern (*color*). It was extensively used in mediaeval music, notoriously in the

rhythmic units or combinations of them which I linked to a particular idea. For example, to represent the idea of the triple transit, a particular important moment in the discovery of the TRAPPIST-1 system, I combined the rhythmic units of the three planets responsible for this event (planets C, E, and F) into a *talea*. Similarly, I generated different *color* using pitch combinations from the harmonic material. Some examples of *color* are: the order of discovery of the planets (C, G, E, F, B, D, H), the triple transit (C, E, F), or the two planets theorised and spotted months later (D, H). We can consider that the generation of the banks of materials previously discussed is also a form of multi-layered isorhythm, as it combines the unique *taleae* and *color* of several independent lines, each of them linked to a planet.

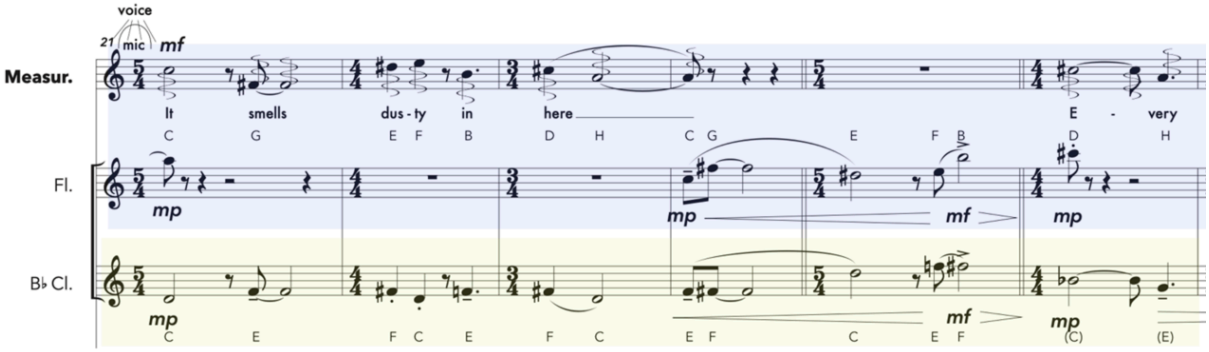

Figure 15 - The Flowering Desert, Mélodrame 3, Bars 21-26. Two examples of isorhythms. The vocal and flute parts (marked in blue in the score) use the "triple transit" talea and the "order of discovery" color (planets C-G-E-F-B-D-H, marked in capital letters). The clarinet part (marked in yellow in the score) uses the same talea, but the "triple transit" color (planets C-E-F, marked in capital letters). From bar 26, the clarinet uses the "triple transit" color, but inverted.

2.1.1.1.4 Structural material

I generated structural material from data to inform the composition of the sections that deal thematically with the process of discovery of the TRAPPIST-1 planetary system in both *The Flowering Desert* and *TRAPPIST-1*.

13th and 14th century French motet school, as well as by more recent composers such as Olivier Messiaen, George Crumb, or György Ligeti.

2.1.1.1.4.1 Tonal centres

In *The Flowering Desert*, the four *Mélodrame* sections (which represent the point of view of a scientist during the first observations of the system) are structured following the discovery of the seven planets of TRAPPIST-1. Each planet is associated with a tonal centre, which defines the harmonic transposition of a section. When we advance in the order of discovery of planets, we change the tonal centre, producing a harmonic shift that defines the structure of these numbers in *The Flowering Desert*:

- *Mélodrame* 1 - 2 sections: first record of planets C and G (September 2015).
- *Mélodrame* 2 - 3 sections: first record of planets E, F and B (October 2015).
- *Mélodrame* 3 – 3 sections: record of a triple transit of planets C, E and F (December 2015).
- *Mélodrame* 4 - 2 sections: first record of the last two planets, D and H (June and October 2016).

Example #6

Use of tonal centres as structure. The first section is in the tonal centre of G (marked in blue in the score), which corresponds to Planet E. From bar 33 to bar 38 there is a process of modulation in which both tonal centres (G and F#) overlap. In bar 39, the tonal centre of F# (marked in yellow in the score), which corresponds to Planet F, is established, and marks the start of the second section.

The Flowering Desert - Mélodrame 2.
Excerpt: Bars 24-46.
Score follower video.

Binaural audio (please use headphones to experience the audio surround effect).

2.1.1.1.4.2 Days between events as structure

In the piece *TRAPPIST-1*, the third scene, "Discovery", is structured following the timeline of the discovery of the planetary system. I used the number of days between different events to trigger musical elements. This scene has two main sections. The first section engages with the discovery of the first five planets of the system (C, G, E, F, and B). New pitch material is played in the electronics part and by the flautist[29] at the times corresponding to the discoveries of new planets. The second section starts at the moment corresponding to the detection of a triple transit of planets C, E, and F. In this moment, only the pitches linked to these three planets continue being played. This section is formed by a trio between the flautist and two pre-recorded flute melodic lines generated with melodic material related to the triple transit. The scene finishes at the moment that corresponds in the timeline with the acceptance by the scientific magazine Nature of an article about the TRAPPIST-1 system. In that moment, we trigger a recording of a public speech given at a NASA conference. That marks the start of Scene 4, "Announcement".

	Planet C	**Planet G**	**Planet E**	**Planet F**	**Planet B**	**Triple Transit**	**Article *Nature***
Date	17/09/15	29/09/15	17/10/15	26/10/15	27/10/15	11/12/15	18/02/16
Day	1	13	31	40	41	86	155
Time	Start	1'02"400	2'28'800	3'12"	3'16"800	6'52"800	End 12'24"

Table 6 - Structure of TRAPPIST-1, Scene 3, "Discovery".

[29] The pitches in the electronics part come from the chord generated with distances between planets to the star (Figure 2) adjusted to cents (Table 2). The pitches in the flute part come from the scales generated with distances between the planets and the star (Figure 5). Each pitch is linked to its correspondent planet.

Example #7

Use of the timeline of the discovery of planets as structure to determine the addition of new pitch material in relation to the first detection of each planet of the TRAPPIST-1 system.

TRAPPIST-1 – Scene 3, "Discovery".
Excerpt: [00:00:00] to [00:03:45].
Score follower video.
Binaural audio (please use headphones to experience the audio surround effect).

2.1.1.2 Embodiment of data

I consider the embodiment of data a composition strategy that creates a tangible musical representation of the ideas that a determined set of data represents. This strategy is often an extension or a variation of the techniques that deal with the transformation of data into musical parameters and may take the form of a musical process. This composition strategy is concerned with how these transformations are presented and experienced by the audience.

2.1.1.2.1 TRAPPIST-1

The composition strategy of embodiment of data informs most of the music-theatre piece for Kingma flute and electronics, *TRAPPIST-1*. In this work, each of the seven planets is represented by a determined pre-recorded flute pitch in the surround electronics part[30]. From the beginning of the piece, each pitch rotates around the

[30] Based on their distance to the star, as seen in Table 2.

audience according to the rotational period of the planet that it represents. The result is a tangible musical depiction of the planetary system, in which the audience is in the centre, taking the place of the star. Once this strategy has been established, there can be variations. In Scene 3, the audience experiences, in a similar manner, the discovery of the planetary system[31] and the triple transit event[32]. In Scene 4, the pre-recorded flute is substituted by pre-recorded explanations of the characteristics of each planet electronically tuned to the specific pitches of each planet, working as an operatic recitative, delivering a narrative within the harmony[33].

Example #8

Embodiment of data in TRAPPIST-1: The surround electronics and the performer's position are used to represent tangibly the planetary system's rotation.

TRAPPIST-1 - Scene 1: "Exoplanet hunter".
Excerpt [00:05:30] to [00:08:30].
Score follower video.
Binaural audio (please use headphones to experience the audio surround effect).

2.1.1.2.2 The Flowering Desert

As both *TRAPPIST-1* and *The Flowering Desert* were occasionally composed simultaneously, the strategy of data embodiment used in the first impacted the

[31] In this case, the planets are presented one by one with their associated pitch as they are discovered, as seen in Table 6 and **Example #7**.

[32] Using only the material from the three planets involved in the event.

[33] **Example #17** [00:01:15] in **2.1.2.2.2 *TRAPPIST-1***.

composition approach in the second. This can be seen in the second scene of *The Flowering Desert*, where there is a clear intention to showcase the rotation of the system as a process in a similar manner. This responds to the central idea of the scene: the helplessness of the planet Pantele against its Mother Star, which only cares about its own almost infinite process of burning hydrogen into helium and the generation of heavier elements at its core. In this case, the composition strategy of data embodiment is adapted to the instrumentation by distributing the musical material between the instruments placed in a circular arrangement. This engages as well with the site-specificity of the piece, as it was composed to be performed in planetariums (**Example #9**).

Similarly, several moments of the four *Mélodrame* sections in *The Flowering Desert* also showcase the rotation of the system using the embodiment of data strategy. This musical display is used, in this case, to depict the point of view of the scientist observing and discovering the planetary system, which narratively informs these sections. In these sections, I used the harmonic material associated with the character of the Measurer[34] to differentiate it from the harmony associated with the Mother Star used in **Example #9**. A clear example of the use of data embodiment in relation to the narrative in the *Mélodrame* sections can be found in *Mélodrame* 2. At one point (bar 47), the Measurer says, looking at the sky in the observatory of La Silla, "let me experience this moment a little more". This sentence triggers a section using the data embodiment strategy with the harmony associated with the Measurer (bars 54-66), associating the observation of the night sky in La Silla with the observation of the TRAPPIST-1 planetary system (**Example #10**).

[34] As seen in **2.1.1.1.1.1 Orbital period ratios**.

Although the representation of the data is not as precise mathematically in these last two examples as in the electronics of *TRAPPIST-1*, the use of the domed space of the planetarium with the instrumental ensemble positioned surrounding the audience helps to create a similar immersive experience that delivers tangibly the concept of the rotation of the planetary system to the audience. This is enhanced by the visuals projected in the dome, which also focus on rotation.

Example #9

Embodiment of data adapted to *The Flowering Desert*. The instrumental ensemble and the chorus are used to depict the sempiternal rotation of the system. The character Pantele stands against the Mother Star (chorus).

The Flowering Desert – Scene 2.
Excerpt: bars 1-63.
Video documentation from a dress rehearsal (available in **5.3 Appendix #3**).

Example #10

Embodiment of data adapted to *The Flowering Desert*. The instrumental ensemble represents the TRAPPIST-1 system being observed by the Measurer (marked in blue in the score). The harmonic material associated with the character (Figure 1) is distributed in the ensemble in a circular arrangement using the rhythmic material derived from the rotation of the planetary system of TRAPPIST-1 (Table 5).

The Flowering Desert - Mélodrame 2.

Excerpt: Bars 43-66.

Score follower video.

Binaural audio (please use headphones to experience the audio surround effect).

2.1.2 Qualitative

Similarly to the use of numerical data, we can inform creative decisions in music-theatre composition with qualitative data. Qualitative data can be present in many forms: interviews, writings, audio or visual recordings, responses to questions, etc. This material can be presented either rawly or using the results of its analysis or its conclusions. It will depend on the intentions of the piece.

In this portfolio, I engaged with qualitative data mainly in two manners: text setting and appropriation.

2.1.2.1 Text setting

Text setting is a composition technique that can be used to engage and deliver qualitative data in a direct manner. This can be seen in works in which text from interviews, quotes, and other forms of descriptive data are part of the musical discourse of a composition. In the context of music-theatre composition, works such as *Amaechi* (Wolters and Clancy, 2022), in which quotes about homosexuality in sports by the former NBA player John Amaechi are sung by a chorus and structure the piece, incorporate qualitative data in this manner.

2.1.2.1.1 Autohoodening: The Rise of Captain Swing

I used this technique in *Autohoodening: The Rise of Captain Swing*, a work informed by research on the working conditions at the international company Amazon, particularly during the COVID-19 pandemic. Part of the research for this piece included:

- Interviews with GMB Union representatives at the Rugeley and Coventry fulfilment centres.
- Quotes from a GMB Union worker survey at the Rugeley centre.
- Research on inequality from different online resources of workers and union voices, including the website The FACE of Amazon[35].
- Alan Selby's testimony after working undercover at Tilbury's Amazon warehouse[36].

This material has been analysed and distilled collectively[37] to inform elements such as the structure of the work[38], and has been used throughout the piece as text to be

---

[35] The FACE of Amazon (2023) The Former And Current Employees (FACE) of Amazon. Available at: https://sites.google.com/site/thefaceofamazon/ [Last accessed 30 September 2023].

[36] Selby, A. (2017) Timed toilet breaks, impossible targets and workers falling asleep on feet: Brutal life working in Amazon warehouse. *The Mirror*, 25 November. Available at: https://www.mirror.co.uk/news/uk-news/timed-toilet-breaks-impossible-targets-11587888 [Last accessed 30 September 2023].

[37] As seen in **1.3.2 *Autohoodening: The Rise of Captain Swing***, this work was created collaboratively by Infinite Opera and the design troupe Post Workers Theatre.

[38] The structure of this work is informed by the warning system used at Amazon: "They can have up to three warnings for absence and then it's potentially a disciplinary issue. (…) What it does is creates a culture of fear" (Perry and Gorton, partial transcript from an interview with Post Workers Theatre). The piece revolves around the three "punishments" a picker gets before getting fired.

spoken or sung[39]. Quotes such as "workers treated as slave robots, no respect, no rights"[40] or "we are not even treated as robots, we are treated as part of the data stream"[41] are taken directly from the data.

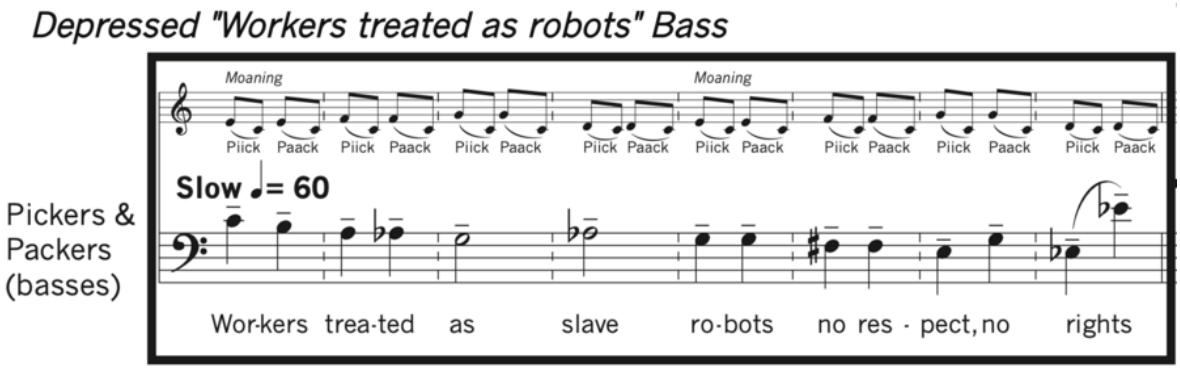

Figure 16 - Autohoodening: The Rise of Captain Swing, Corporate Duet. Example of a worker's quote used as a bass line for the chorus of Pickers and Packers during the love duet between Alexis the Scanner and the Molly Bot.

Other quotes have been reworked to be presented in rhyming couplets, a writing style derived from the hoodening songs[42] that informs the libretto. This is the case with quotes such as:

- "The worse place I did work for Stressful Not helpful Hard work[43]."

---

[39] As part of the writing process, some quotes have been adapted to fit in the rhyming couplet style that informs the whole piece.

[40] Organise platform (2018) Amazon: *What's it like where you work?*, p. 11. Available at: https://stylewise-blog.com/wp-content/uploads/2019/07/912fe-amazonwarehousestaffsurveyresults.pdf [Last accessed 2 October 2023].

[41] FRONTLINE PBS (2020) Amazon Empire: The Rise and Reign of Jeff Bezos, 00:35:53. [video] Available at: https://youtu.be/RVVfJVj5z8s?t=2153 [Last accessed 30 September 2023].

[42] A compilation of hoodening songs written using rhyming couplets is available at: hoodening.org.uk/hoodening-songs.html [Last accessed 30 September 2023].

[43] Indeed, *Amazon Workers Reviews* (compilation of reviews extracted by Post Workers Theatre from uk.indeed.com), p. 6. Available in **5.2 Appendix #2**.

- "Breaks are usually sad, we are trying to make the most of it but nobody is truly happy, you see people struggling to come with the demanding environment, soar back, feet, hands , headaches[44]."

These two quotes resulted, for example, in the line used in the *Poor Old Associate* song in the score:

Sore feet, back, hands, my head aches
Scores of sad people in every break
Stressful not helpful, hard work
Sore feet, back, my head aches[45].

The scene that features more prominently quotes from workers at Amazon integrated into the composition is the resurrection and coronation of Captain Swing. The quotes are presented in two manners: reworked and integrated into the lyrics of the hoodening song *Poor Old Associate*[46] and spoken in a ritualistic manner to provoke the resurrection of Captain Swing (**Example #11**).

Example #11

Quotes from workers at Amazon set as text in the composition. The scene features a version in D major of the song *Poor Old Associate* [00:00:50] and the reading of several quotes from workers at Amazon [00:01:08].

---

[44] Organise platform (2018) Amazon: *What's it like where you work?*, p. 11. Available at: https://stylewise-blog.com/wp-content/uploads/2019/07/912fe-amazonwarehousestaffsurveyresults.pdf [Last accessed 2 October 2023].

[45] These lines appear in pages 10 and 14 in the Songbook (**5.2 Appendix #2**).

[46] See **2.1.2.2.1 *Autohoodening: The Rise of Captain Swing***.

Autohoodening: The Rise of Captain Swing, "Captain Swing's Coronation Ritual".

Video excerpt from the full film available in **5.2 Appendix #2**.

2.1.2.1.2 In response to Naum Gabo: Linear Construction in Space No. 1

In the case of the site-specific music-theatre piece about Naum Gabo's *Linear Construction in Space No. 1*, Roxanne Korda and I used quotes from the Realistic Manifesto[47] (1920) to inform the composition of this work. The first scene is performed as a parade across the art gallery of the Barber Institute of Fine Arts. This parade follows the chronological evolution of the art displayed in the gallery. At certain points, corresponding to different artistic epochs, we contextualise the artworks on display with the ideas of a philosopher that relate to them. We used texts from Plato, Aristotle, Aquinas, Kant, Schopenhauer, and Einstein. After the ideas of these philosophers are delivered, they are confronted with a statement from Gabo's manifesto. About this, Roxanne Korda (2020: 4), librettist and collaborator in the piece, wrote:

> I decided to make use of the manifesto whilst also providing a chronological theoretical background of the philosophy that underpins the manifesto. (…) The text for this part has two interweaving sections. These are the "Manifesto Statements", which describe everything being renounced and affirmed by the artist, and

[47] Written by Naum Gabo and his brother Arthur Pevsner.

the introduction of different philosophers and their ideas to the audience[48].

Example #12

The singer freely sings Plato's ideas about form in the gallery's mediaeval and Renaissance section [00:00:30]. These ideas are refuted with a statement from Gabo's manifesto, spoken by the singer [00:01:35].

In response to Naum Gabo: Linear Construction in Space No. 1, "Scene".
Excerpt from Part 1 (Voice score in **5.1 Appendix #1**).
Video excerpt from the live performance at the Barber Institute of Fine Arts.

2.1.2.1.3 TRAPPIST-1

The text setting of qualitative data is employed in the second scene of *TRAPPIST-1*. Here, Gavin and I had an interest to explore the process of the discovery of the planetary system from the scientist's personal perspective. For that purpose, we interviewed Dr Amaury Triaud, asking him to recall for us his experience at the observatory of La Silla in the Atacama Desert (Chile) during the observations of the TRAPPIST-1 system. The transcript of this interview informed the composition of the scene, named "Atacama". In this case, the fragments from Amaury's quotes are not

[48] Extracted from an online resource commissioned by The Barber Institute of Fine Arts to Infinite Opera, reflecting on the performance and the creative process. Available at: www.barber.org.uk/wp-content/uploads/2020/12/Barber-Home-Infinite-Opera-Reflection.pdf [Last accessed 2 October 2023].

just sung or spoken, as in the previous two works, but delivered using the flute's extended technique of speaking/singing while playing. The scene explores the idea of the loneliness and isolation in the extreme conditions of the desert. In contrast with the other scenes of this work, in which the electronics part is very active showcasing the rotation of the planetary system, in this section the electronics only play a still drone, representing the star. They also support the flute part by slowly adding effects to the sounds produced by the flautist[49].

In this scene, the text is used as a stimulus for an improvisation. The sentences chosen from the interview are descriptive of Amaury's experience at the observatory and in the desert. Through the flautist's improvisation, we want to engage not only with his words, but also, sonically, with the soundscape that they depict. The words become, therefore, onomatopoeic through the performance.

Example #13

> The flautist speaks/sings, while playing the flute, fragments of text extracted from the interview with Dr Amaury Triaud about his experience in the observatory of La Silla. In this performance, Gavin focuses on depicting sonically Dr Triaud's words by using small phonic gestures: "I knew that I wanted to break down the text into phonics so that I could play more gesturally in my improvising and use these vocal sounds as impulses as either articulation, or in the case of "static electricity" using a rolled r to blend from speech into flute sounds" (Stewart, 2023: 207).

[49] In transit photometry, we observe and measure the star's brightness. From this data, we can infer the presence of planets rotating. Therefore, this second scene of TRAPPIST-1 can be considered a duet between the star and the scientist observing it.

TRAPPIST-1 - Scene 2.

Excerpt: [00:03:30] to [00:05:30].

Score follower video.

Binaural audio (please use headphones to experience the audio surround effect).

2.1.2.2 Appropriation

Appropriation is a common practice used in every single artform. A paradigmatic example is Duchamp's readymade *Fountain* (1917), a urinal resignified as a piece of art. In music composition, for example, folk music has been appropriated as the basis for uncountable compositions. I, for instance, used local melodies and songs from the Aliste region in Spain, such as the "Jota del Molacillo", to inform the composition of the operatic masquerade *La Obisparra* (2016) after attending their local masquerades. In that case, I also used the theatrical rituals of their custom to structure the piece. Another clear example of appropriation in music composition is borrowing works from other composers. This is the basis of Stravinsky's commedia dell'arte ballet *Pulcinella* (1920), in which the composer reworked and reorganised a compilation of music by several baroque composers such as Giovanni Battista Pergolesi or Domenico Gallo. Another example is the third movement of Berio's *Sinfonia* (1968), in which the composer musically quotes fragments from pieces by a number of composers including Mahler, Debussy, or Ravel. This practice informs, for example, the work of DJs, who create "sets" by curating, combining, and remixing music from different artists. Curation is a paradigmatic practice of postmodernism in art, according to Fredric Jameson (2012).

Appropriation techniques include, amongst others, borrowing, citation, allusion, referencing, pastiche, or resignification. These techniques are frequent in the

postmodern artist toolset, as discussed in the works of Fredric Jameson (1991), Lawrence Lessig (2008), or Jonathan D. Kramer (2002). In the work of the last author, the focus is on musical composition.

Appropriation is a strategy that can be applied to the integration of qualitative data into a music-theatre piece. In this portfolio, *Autohoodening: The Rise of Captain Swing* is heavily infused with this practice. I also employ it in *TRAPPIST-1*. In fact, we can consider that in *TRAPPIST-1* and *The Flowering Desert*, the data I used to inform the two compositions has also been appropriated.

2.1.2.2.1 Autohoodening: The Rise of Captain Swing

In *Autohoodening: The Rise of Captain Swing*, borrowing is used to represent each of the two entities in conflict: the exploited workers and the Amazon corporation. With this technique, we engage with both research about the folk custom of hoodening[50], and research on the workers' conditions at Amazon[51].

As a collective, Infinite Opera and Post Workers Theatre[52] borrowed many elements from the custom of hoodening for this production. This includes themes, script-

[50] Hoodening is a custom from East Kent (UK). It can be encompassed in the context of the European winter masquerades, sharing elements such as the theme of death and resurrection or the collection of money for charity. Usually containing references to recent events, the setting of the performances is based on a 19th-century ploughing team.

[51] *Autohoodening: The Rise of Captain Swing* updates the setting of the hoodening custom from a 19th century ploughing team to a 21st century picking and packing team at Amazon.

[52] As seen in **1.3.2 Autohoodening: The Rise of Captain Swing**, this work is the result of the collaboration between these two performing arts companies. Infinite Opera, the company for which I work as a composer, was brought into the *Autohoodening* project to help in its development. This project was initially conceived by Post Workers Theatre as a research project at Goldsmiths University.

writing style in rhyming couplets, costumes, Morris dance choreographies, or theatrical rituals. From the composition perspective, I engaged with the custom of hoodening by borrowing a song performed in the past by the hoodeners, "Poor Ole Hoss"[53]. In the song, there are two points of view: the owner complaining about a horse not fit to work anymore, wanting to get rid of it or letting it die, and the horse reflecting upon its decay and its fate. This song seemed fit to represent the workers in conflict, being forced to work relentlessly to not be replaced. I transcribed the song, changed the lyrics[54], and slightly modified it at certain points in response to the plot[55] (**Example #14**).

Example #14

Borrowing of a hoodening song. Comparison of the hoodeners 1983 version of *Poor Ole Hoss*[56] with a version of *Poor Old Associate*, from *Autohoodening: The Rise of Captain Swing*.

Poor Ole Hoss, sung by George', of the St Nicholas-at-Wade with Sarre Hoodeners - [00:00:00] to [00:00:30].
Poor Old Associate, from *Autohoodening: The Rise of Captain Swing* - [00:00:30] to [00:01:00].
Audio file.

[53] The lyrics to the consulted version of the song are available at: hoodening.org.uk/hoodening-songs.html [Last accessed 30 September 2023].

[54] As seen in **2.1.2.1.1 *Autohoodening: The Rise of Captain Swing***.

[55] The harmonic changes of this song are discussed in **3.1.1.1 *Autohoodening: The Rise of Captain Swing***.

[56] Due to the lack of documentation in 1983, this is a new recording of the song. Sung in 2023 by George', of the St Nicholas-at-Wade with Sarre Hoodeners.

I also used pastiche, as a technique of imitation or borrowing of a particular music style, to compose a reel tune and a riff to be used in some Morris dance numbers of the piece. This also informed the instrumentation choice for this work: an extended folk band with a fiddle, pipes, horns, accordion, and percussion[57].

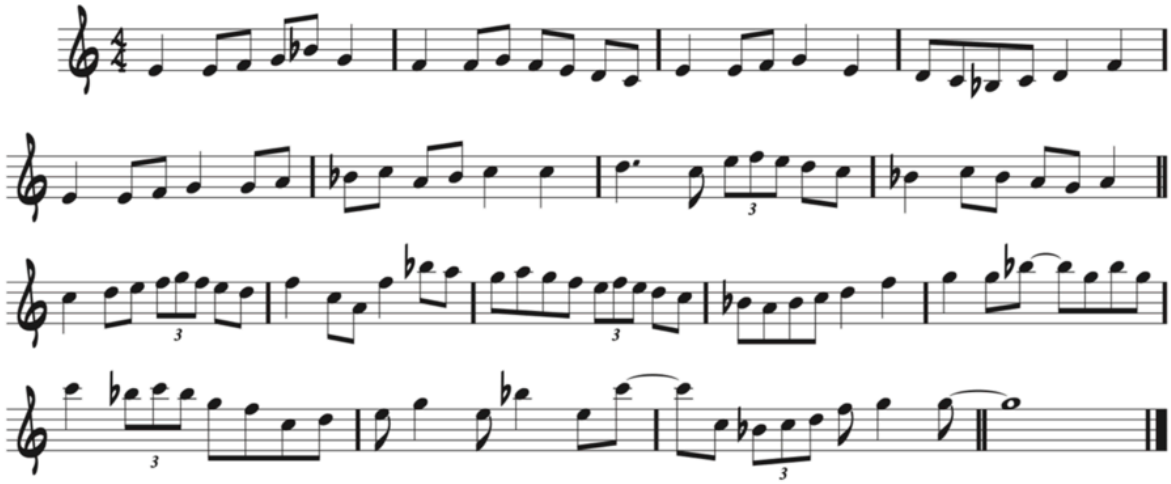

Figure 17 - Reel composed for Autohoodening: The Rise of Captain Swing. It appears in C and in D throughout the piece (as seen in ***3.1.1.1*** **Autohoodening: The Rise of Captain Swing***).*

In relation to the research on workers' conditions at Amazon, we decided to engage with the recurrent idea of inhuman repetitiveness and relentlessness at work from the interviews, represented in the answers seen in **2.1.2.1.1** ***Autohoodening: The Rise of Captain Swing***, such as "we are not treated as humans, not even as robots". To represent the corporate giant in the piece, I decided to appropriate a sample from an Amazon commercial that featured a minimalist soundtrack in C[58]. This music seemed fitting to the company, especially if we look at the use of minimalist music in media "as a sign for the machine and rationality" (2014, Eaton: 3). My idea was,

[57] The accordion also doubles as a keyboard. Note the use of Amazon boxes as toms in the percussion.

[58] Inside Amazon (2014) *Amazon services recruiting video*. [video] Available at: youtu.be/KRdn71yG9Lk [Last accessed 30 September 2023].

however, to use it more as a representation of "dehumanised assembly-line labour" (1975, Gottwald), an idea derived from early reviews of minimalist music. Therefore, this short motif in C is resignified from the positiveness of the corporate video that it accompanies to representing the idea of relentlessness, also associated with the company[59]. This melodic gesture is then used as the main musical material for the whole work.

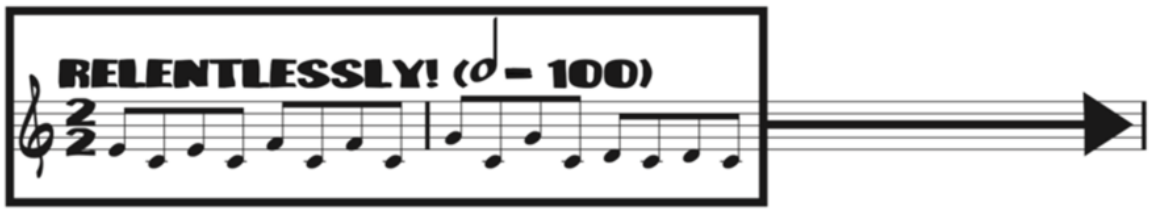

Figure 18 - Autohoodening: The Rise of Captain Swing, Introductory Song. Presentation of the motif in the accordion and the violin.

[59] In the book *The Warehouse: Workers and Robots at Amazon*, Delfanti (2021: 6) describes:

> Amazon prides itself on being relentless. This is a recurring word in Amazon's corporate history and it appears over and over again in Bezos' speeches and annual letters to investors. In fact, Bezos once envisioned naming the company Relentless, and if you type in "relentless.com" in your browser, it will redirect you to amazon.com: the company still owns the domain.

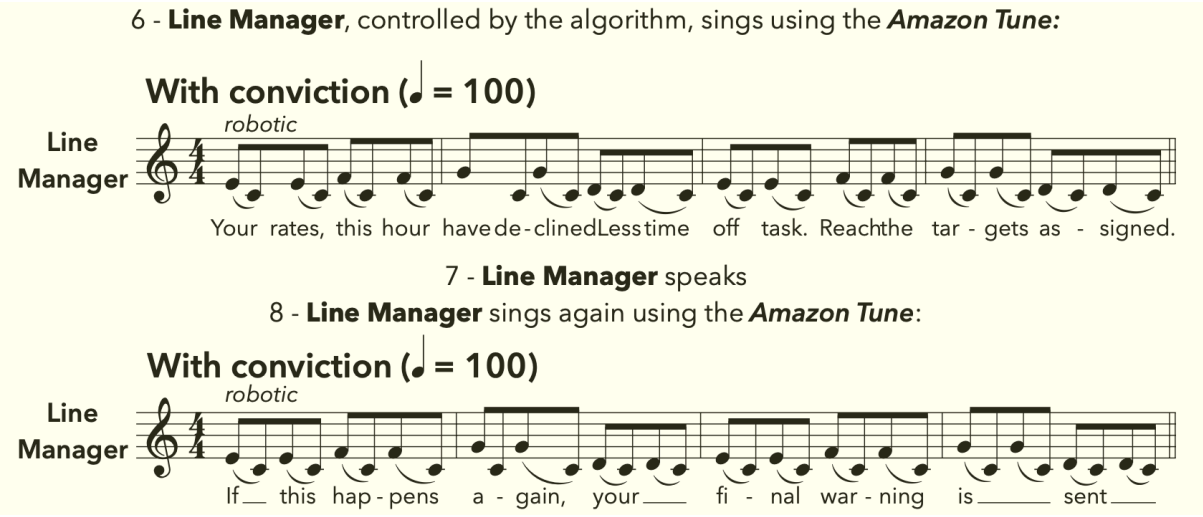

Figure 19 - Autohoodening: The Rise of Captain Swing, Corporate Strength and 1st Punishment. Motif sung by the Line Manager, controlled by the computer, giving the first warning to the Lead Picker.

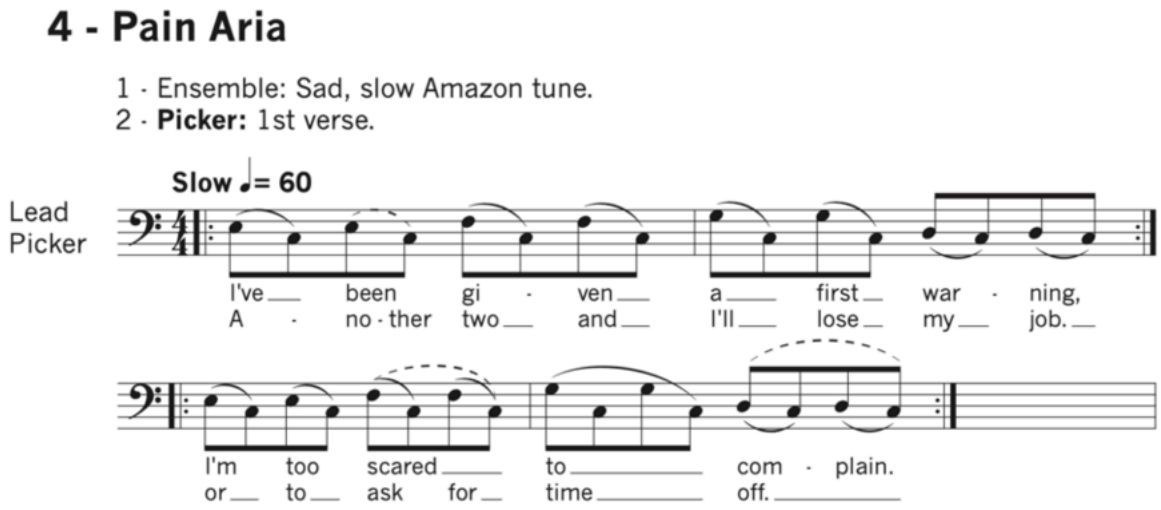

Figure 20 - Autohoodening: The Rise of Captain Swing, Pain Aria. The Lead Picker, being punished and under control by the company, also sings with the Amazon tune.

Similarly, I transcribed the sound of an Amazon scanner from another commercial to inform the composition of the character Alexis the Scanner[60]. The transcription results in an, approximately, ascending C#-E-B quick gesture. However, I decided to

[60] Amazon (2016) *Introducing Amazon Go and the world's most advanced shopping technology*. [video] Available at: youtu.be/NrmMk1Myrxc [Last accessed 30 September 2023].

keep just the ascending shape and the quick gesture, slightly modifying the harmonic aspect to match tonally the Amazon gesture presented in Figure 18.

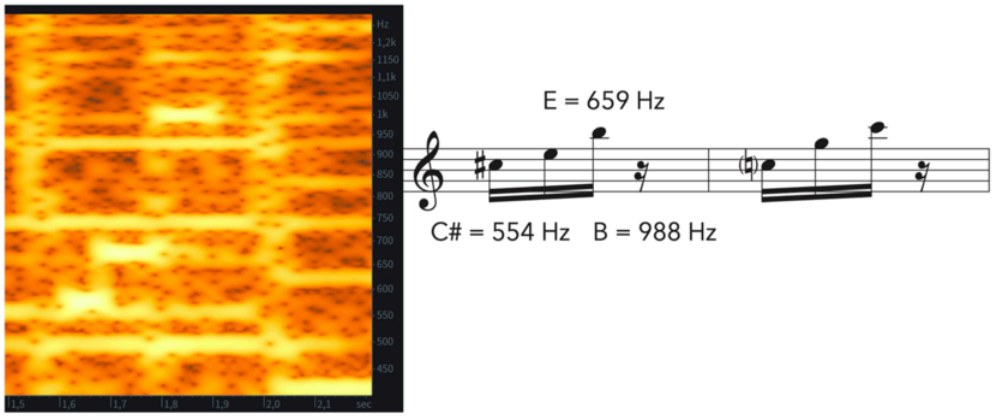

Figure 21 - Spectrogram of the scanner sound from the commercial. Approximate transcription of the musical gesture (bar 1) and harmonic variation to fit the C major tonal centre of the Amazon motif of Figure 18 (bar 2).

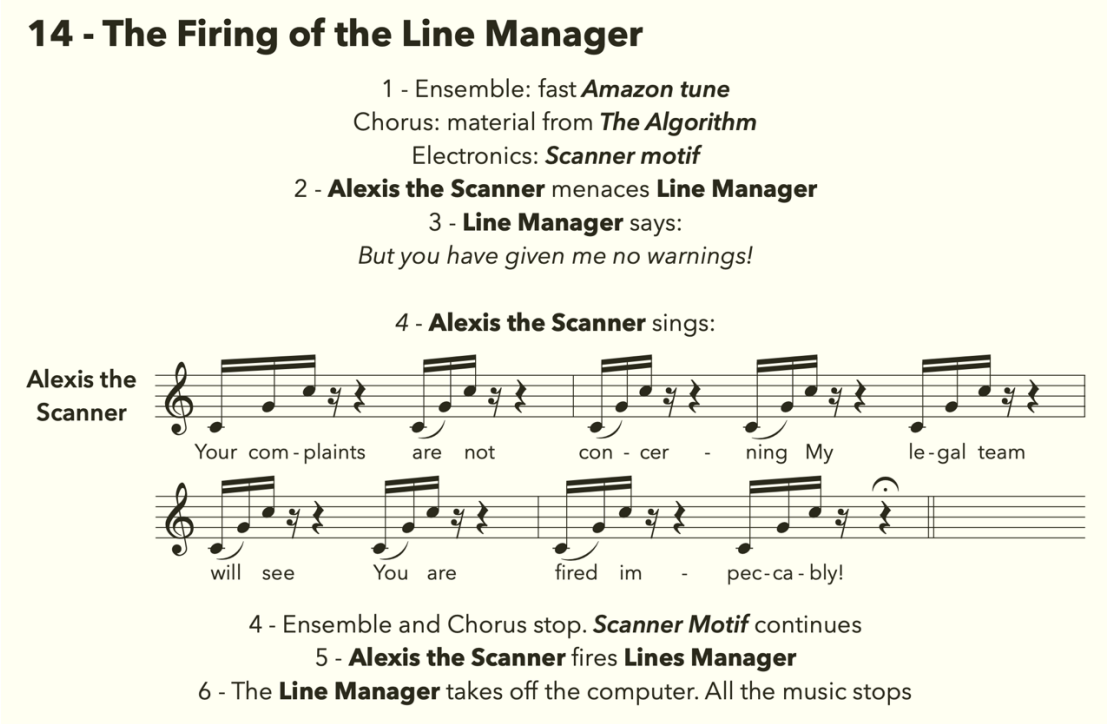

Figure 22 - Autohoodening: The Rise of Captain Swing, The Firing of the Line Manager. Alexis the Scanner sings using the scanner motif.

This idea of subverting a commercial, corporate symbols or icons to make a political statement has been widely used, for example, famously by the artist Banksy or, notoriously in Birmingham, by the artist Foka Wolf.

Figure 23 - On the left, artwork by the artist Foka Wolf (2021). On the right, artwork by the artist Banksy (2018). Both artworks were shared on their Instagram social media public accounts.

An example of the use of the appropriated "Amazon tune" and the scanner motif is the main aria of Alexis the Scanner. In this scene, the machine, preoccupied by the resurrection of Captain Swing, resolves to fire the Lead Picker (**Example #15**).

Example #15

Alexis starts the aria using the scanner motif [00:00:01] and the pitch contour of the Amazon tune [00:00:09]. The chorus loops a short motif created with the pitch material of the Amazon tune divided in two voices [00:00:16]. Alexis then sings using the Amazon tune with a rhythmic design derived from the Poor Old Associate hoodening song [00:00:39]. The climax of the aria uses the same pitch and rhythmic material with octave changes to expand the vocal register to increase the lyricism, showcasing the preoccupation of the scanner with the resurrection of Swing [00:01:23]. After Alexis' aria, during its speech to the Line Manager, the chorus slightly varies their line to be more static, still using the same pitch material [00:02:05]. The melodic line from the climactic point of the aria will also be replicated by the Line Manager, following the termination orders of the machine [00:02:50].

Autohoodening: The Rise of Captain Swing, The third punishment (Songbook, pages 15-16 in **5.2 Appendix #2**).
Video excerpt from the film in **5.2 Appendix #2**.

The "Introductory Song" of *Autohoodening: The Rise of Captain Swing* (**Example #16**) presents the borrowed musical materials mentioned before (hoodening song, Autohoodening reel, Amazon tune, and the scanner motif) in combination with other borrowed elements relevant to the piece such as:

- Hoodening style costumes[61] - The iconic hoodening wooden horse is, for example, reconverted into an equine scanner in this piece.
- Morris dancing – The workers dance repetitively with simple Morris dance steps around Molly Bot, using this character as a maypole. We also embrace the typical sound of the ankle bells.
- Folk theatre character introduction style – Each character is presented using the folk theatre formula "in comes I…". We also borrowed the languages from the performers, stressing Amazon's use of vulnerable immigrants in their warehouses.
- Hoodening rhyming couplets – All the characters speak and sing using this writing style, typical of hoodening[62].

[61] Designed by the hoodening costume and prop designer James Frost.

[62] As described by Ben Jones (n.d.) at hoodening.org [Last accessed 30 September 2023]:

> A new play is written each year in rhyming couplets by one of the troupe, and references to recent events (local, national and international) are frequently included, although the setting is based on a ploughing team from the 19th Century.

- Background factory noises and machine beeps from Amazon fulfilment centres[63].

Example #16

Presentation of different borrowed materials in combination in the Introductory Song. The Amazon tune is presented from the start [00:00:03] and is played throughout the whole scene. After an introductory narration contextualising the film, the Autohoodening reel starts a Morris dancing section [00:00:55]. During this introduction number, the reel tune and the dancing are used structurally to precede the introduction of the different characters. The scanner motif is present in these introductions [00:01:14]. The hoodening song *Poor Old Associate* appears first in C major [00:04:30] before the introduction of the mechanic characters, and then in D minor [00:07:33]. This harmonic change is explained in **3.1.1.1 *Autohoodening: The Rise of Captain Swing***.

Autohoodening: The Rise of Captain Swing, Introductory Song (Songbook, pages 3-4 in **5.2 Appendix #2**).
Video excerpt from the film in **5.2 Appendix #2**.

2.1.2.2.2 TRAPPIST-1

Appropriation is employed in the composition of the last scene of *TRAPPIST-1*, "Announcement". This scene deals with the idea of science dissemination and the rapid impact TRAPPIST-1's research had on society. One of the reasons for this rapid

[63] Soundscapes designed by Nicholas Mortimer, from Post Workers Theatre.

impact is that three of the planets in the system are in the habitable zone. This fact also led to scientific clickbait, which Gavin and I found interesting. To directly engage with this, the scene starts with a borrowed recording from the NASA official announcement of the discovery of the planetary system, triggered at the very end of the previous scene. We then pitched this recording to the harmonic material associated with the planetary system, fragmented it, and sampled it[64]. With this material, we created celebratory music that reflects the moment of euphoria after the discovery and the noise generated by it. Once this euphoric section fades, we then proceed to present the system more calmly, as an extension of the press conference. We borrowed accurate descriptions from the characteristics of the star and the seven planets of TRAPPIST-1, and we delivered them with computer-generated voices that imitate a spokesman and a spokeswoman. These computer-generated voices are pitched accurately to the notes associated with each planet and the star, and they rotate in the electronics according to the orbital periods of each planet. With this technique, we recreate the musical material from the beginning of the piece (**Example #8** in **2.1.1.2.1** ***TRAPPIST-1***), but with the explanations behaving sonically as the celestial body that they depict.

Example #17

Use of the appropriated NASA press conference announcing the discovery of the TRAPPIST-1 planetary system, and use of a series of descriptions of the star and the seven planets. The audio from the press conference appears first in its original form [00:00:03], and then

[64] Similarly to how in many clickbait articles the main information is fragmented, stressing a specific aspect that can generate hype. This happens in articles such as: "Shock Alien discovery: TRAPPIST-1 planets ARE habitable to extraterrestrials" (Daily Express, 2018), or "Aliens nearby? Planets TRAPPIST-1 are suitable for alien life" (Great-spacing, 2019).

remixed [00:00:26]. The description of the planetary system imitates the format of a press conference [00:01:15].

TRAPPIST-1 – Scene 3, "Discovery"; and Scene 4, "Announcement".
Excerpts:
Scene 3 – [00:11:58] to [00:12:24].
Scene 4 - [00:00:00] to [00:02:34].
Score follower video.
Binaural audio (please use headphones to experience the audio surround effect).

2.2 Representation of ideas

The representation of ideas in music has been widely explored, especially in program music. In this research project, I focus specifically on the representation of science-based ideas, knowledge, phenomena, or events.

This section is divided into two main strategies: the use of process-based representation and the use of timbre.

2.2.1 Process-based representation

Process in composition can be very useful to depict or represent an idea or a subject matter. Coming back to the example of Clancy and Wolters' *Amaechi* (2022), they, for example, inform different sections of the piece with some well-known basketball plays or strategies such as the "triangle offense", famously used by coach Phil

Jackson in the Chicago Bulls of Michael Jordan, linked to Amaechi's professional basketball career. Similarly, Seán Clancy informed the composition of his *Forty-Five Minutes of Music on the Subject of Football* (2014) with the events of the Ireland vs Italy football match in the group stage of the World Cup USA '94. In Clancy's words, "with each possession, I chipped away at two respective blocks of material, and events in the match determined the tempo, texture, and timbre of the material" (2020). The translation into compositional parameters of these ideas creates processes that define the pieces.

I informed the composition of my physics-inspired opera *Entanglement! An Entropic Tale* (2018) by constantly reducing the pitch material the closer we get in the story to the thermodynamic death of the universe. This parallels the hypothesis of a total dissipation of energy and matter, and therefore the lack of interactions, at the final stage of the life of our universe. A state of maximum entropy. Also, as seen before in **2.1.1.2 Embodiment of data**, the composition of *TRAPPIST-1* and some sections of *The Flowering Desert* are informed by the rotation of the planetary system, using a process as a compositional tool.

In a music-theatre interdisciplinary collaborative environment, processes can be helpful to tie together the different disciplines involved in the creation of a piece.

2.2.1.1 The Flowering Desert

In *The Flowering Desert,* different compositional processes structure the different events represented in the script, tying them to the astrophysical phenomena that they accompany. This is the case, for example, of the Doppler effect in Scene 1, tidal heating in Scene 3, and the collision between the comet Xoe and the planet Pantele in Scene 4.

2.2.1.1.1 Doppler effect in Scene 1

The first scene of *The Flowering De*sert focuses on the meeting of the planet Pantele and the exocomet Xoe, two astronomical bodies in motion. To represent this event, I used the Doppler effect, which is the apparent change in frequency resulting from the relative motion between the observer and the source. It is widely used as a tool in astrophysics research. As observers of the system, we see the comet first passing towards meeting Pantele, and then leaving the system. I represented musically the fictional Doppler effect we would perceive as observers of that action with a decrease in frequency (33. 5Hz every 3,3 seconds) and with the elongation of rhythmic patterns (1 quaver longer every 3,3 seconds)[65]. This fictional interaction was calculated, with certain malleability, using data from TRAPPIST-1 and the Doppler effect formula.

[65] The sequence F4-Eb4-Db4-B3-G#3-F3-C#3-G#2-D2-D1 lowers approximately 33.5 Hz per note. The rhythmic sequence elongates a quaver every 3.3 seconds (The Flowering Desert, Scene 1, Bars 1-9).

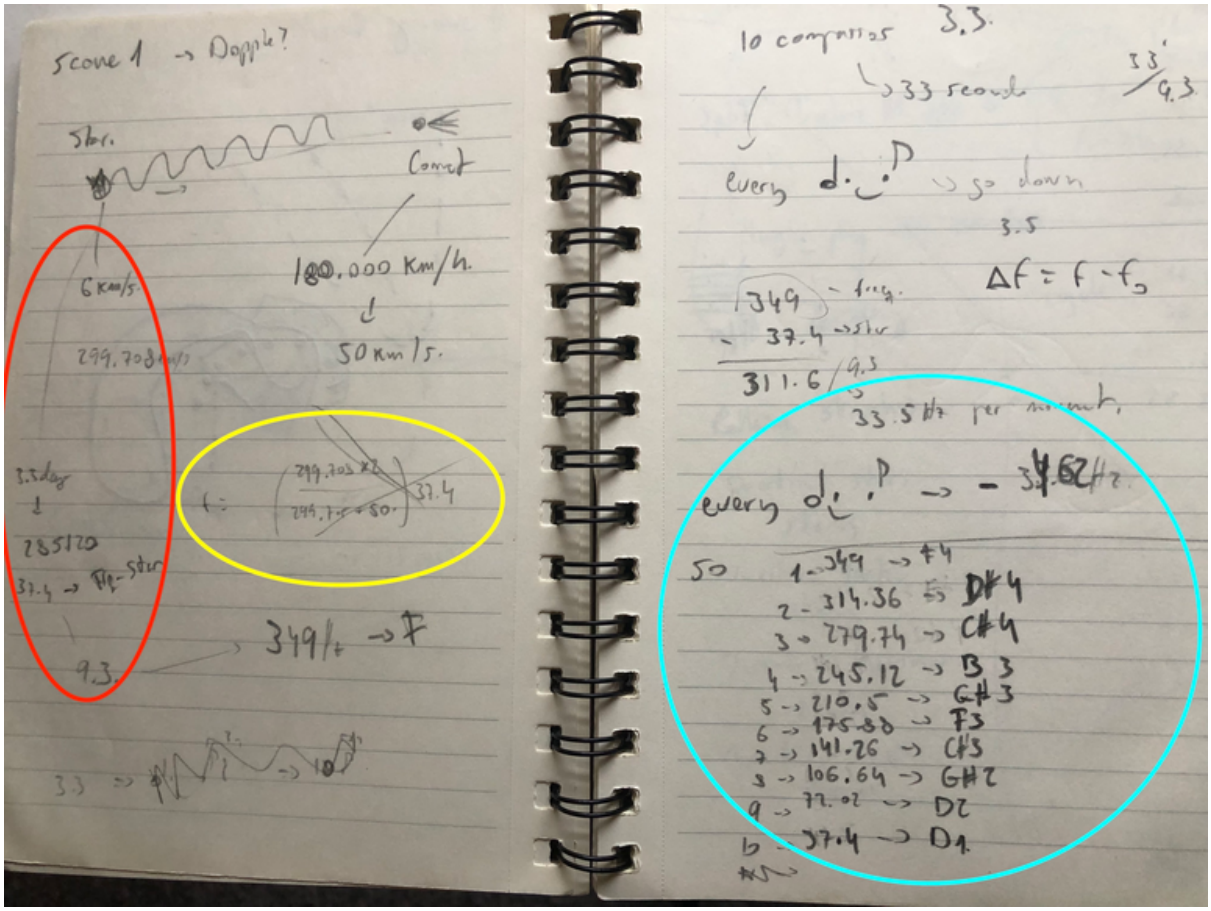

Figure 24 - Sketch for The Flowering Desert looking to integrate a fictional Doppler effect in the composition. Marked in red, there is data related to the TRAPPIST-1 star. Marked in yellow, there is a test using the Doppler effect formula, which was finally discarded. Marked in blue, there is the final calculation used in the piece.

Example #18

Use of the Doppler effect to represent the arrival of Xoe to the planetary system to meet Pantele. The instrumental ensemble slowly morphs from F4 played in quavers (bar 1: flute and piano) to a D2 played in dotted minims tied to a dotted crotchet (bar 7: piano – right hand). This process is marked in blue in the score.

The Flowering Desert - Scene 1.

Excerpt: Bars 1-9.

Score follower video.

Binaural audio (please use headphones to experience the audio surround effect).

2.2.1.1.2 Tidal heating in Scene 3

The overarching idea in the third scene of *The Flowering Desert* is Pantele's development of a magnetic field that would protect the planet from the star's radiation. The process that would make this possible in the script is tidal heating. The gravitational pull of the star and its neighbouring planets in the planet's orbit, and how the dissipation of this energy affects the inner core of the planet, can create a magnetic field that protects it from the stellar winds. This is the case, for example, of Mercury and the Sun in our solar system. Research shows that tidal heating happens in the TRAPPIST-1 system planets (Barr et al., 2018; Dobos, 2019). This idea of tidal heating is translated musically in the scene in the form of pulsation, showcasing the pull and release effect that the planet's inside experiences.

Pulsation is featured in this scene as two different processes. The first consists of a musical motif that repeats with cyclical changes in orchestration and volume (Figure 25).

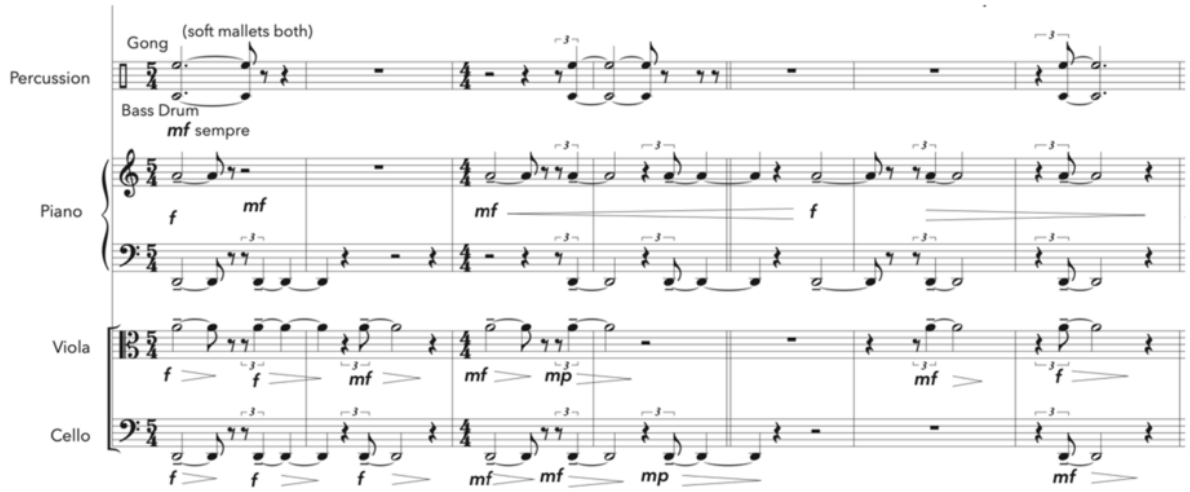

Figure 25 - The Flowering Desert, Scene 3, Bars 1-7. Pulsating musical gesture with cyclical changes in instrumentation and dynamics.

The second process consists of applying the idea of pull and release structurally with tempo changes. This second process starts with the appearance of the Mother Star to confront Pantele (bar 109). It is divided into two subsections: the "Tidal heating trio", and the "Proton bombardment".

- Tidal heating trio - When the star sings, the tempo is pulled back. Then, it is released when Xoe or Pantele sing. As if it was a pendulum, the span of the tempo changes dissipate over time. This is the tempo change sequence:

  ♩=75 (bar 109), ♩= 150 (bar 123), ♩= 90 (bar 156), ♩= 120 (bar 176), ♩= 100 (bar 201)

- Proton bombardment – Towards the end of the scene, to mark the change of Pantele (who develops a magnetic field that protects her from the radiation of the star[66]), the process changes. It is Pantele who pulls back the tempo, being the character in control and taming the star. The pull of Pantele is

[66] The radiation of the star is represented by the "proton bombardment" in the Mother Star (from bar 217), with the chorus singing "Paah, paah, ha ha ha".

released by the comet Xoe (who is still a mentor figure for Pantele). This is the tempo change sequence:

♩ = 120 (bar 217), ♩ = 135 (bar 225), ♩ = 90 (bar 244), ♩ = 75 (bar 254), ♩ = 150 (bar 261)

Example #19

Use of pulsation structurally with tempo changes (marked in blue in the score) and of the pulsating musical motif (marked in yellow in the score). These two processes inform the representation of Pantele's magnetic field development at the end of Scene 3.

The Flowering Desert - Scene 3.
Excerpt: Bars 109-253.
Score follower video.
Binaural audio (please use headphones to experience the audio surround effect).

2.2.1.1.3 Collision in Scene 4

The last scene of *The Flowering Desert* revolves around the collision of the exocomet Xoe into Pantele in order to make the planet habitable. This engages with the theories that stress the importance of comets in the development of life. They are rich in organic materials, which, in the event of a collision, can recombine into more complex molecules, such as amino acids, proteins, or sugars (Kaiser et al., 2013). The scene therefore showcases the final approach of Xoe towards Pantele, speeding up propelled by the burning of its material caused by passing nearby the

star[67]. This is represented musically as a process of a constant acceleration from the beginning of the scene until the cataclysmic event. This process is supported with four sung interventions of the Mother Star, each shorter than the previous one, depicting the stellar propulsion of the comet towards the planet. The main acceleration process in this scene is applied to the melodic material associated with Xoe, as the body that accelerates towards Pantele. The tempo change sequence is as follows:

♩ = 60 (bar 1), ♩ = 80 (bar 15), ♩ = 90 (bar 29), ♩ = 100 (bar 45), ♩ = 120 (bar 51)

// rhythmical diminution in Xoe's material //

♩ = 60 (bar 53), ♩ = 80 (bar 57), ♩ = 90 (bar 65), ♩ = 100 (bar 80), ♩ = 110 (bar 91),

♩ = 120 (bar 104), ♩ = 135 (bar 138), ♩ = 150 (bar 160), ♩ = 180 (bar 170)

Example #20

Use of a constant acceleration process to inform the composition of Scene 4, representing the approach of the comet Xoe towards Pantele and their collision. Xoe's melodic material, which is present throughout the acceleration process, is marked in blue in the score. The Mother Star interventions are marked in yellow in the score.

The Flowering Desert - Scene 4.

Excerpt: Bars 1-183.

Score follower video.

Binaural audio (please use headphones to experience the audio surround effect).

[67] In a similar manner to how the famous interstellar comet 'Oumuamua accelerated when passed near the sun in 2017, or how the Halley comet does every time it approaches our star.

2.2.1.2 In response to Naum Gabo: Linear Construction in Space No. 1

Process-based musical representation is also used in the composition of the music-theatre piece *In response to Naum Gabo: Linear Construction in Space No. 1*. In this case, to engage with the particularities of Naum Gabo's eponymous sculpture. This sculpture is the result of the process of looping a nylon thread in a Perspex[68] structural frame, creating "an illusion of a continuous parabolic form"[69].

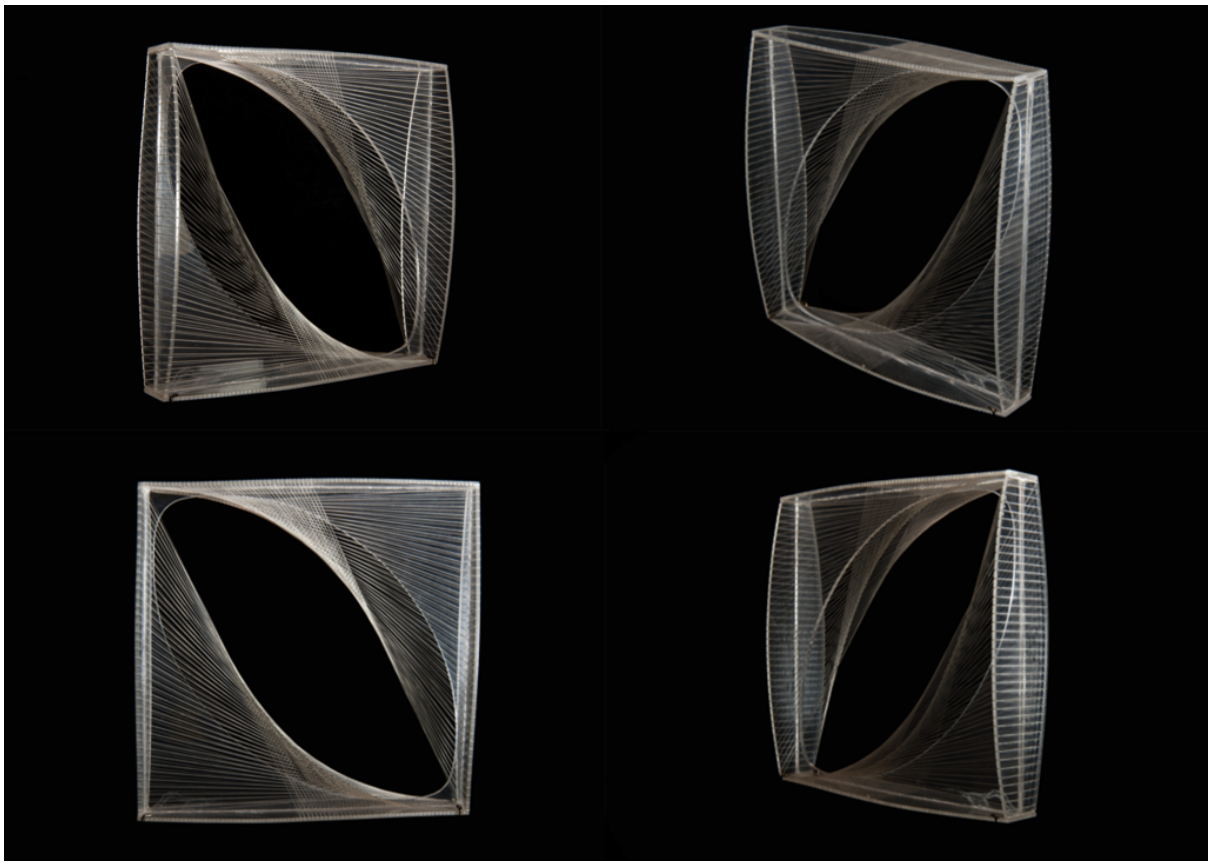

Figure 26 - Four views of Naum Gabo's Linear Construction in Space No. 1. St Ives, 1942/43. Photographic material provided by the Barber Institute of Fine Arts for the composition of the piece.

[68] Perspex is a plastic: polymethyl methacrylate.

[69] Williams and WIlliams (n.d.) *NAUM GABO (1890 - 1977)*. Available at barber.org.uk/naum-gabo-1890-1977 [Last accessed 30 September 2023].

In the piece, this process is recreated by associating the rectangular shape of the sculpture's plastic frame with the rectangular shape of the art gallery and then associating the line of nylon thread with the singer. Therefore, akin to the sculpture, the performance "threads" the singer across the art gallery, in this case in the form of a parade. The main musical material for this composition also responds to a process. It is a melodic line that slowly unfolds and elongates in a parabolical shape, imitating Gabo's sculpture. Two different versions of the melodic parabolic line are performed, one by the singer during the parade and the other by the trumpet in a static position. The trumpet's melodic line starts with a fourth and then a fifth down to then slowly moderating semitone by semitone. The voice, instead, goes first a fifth and a minor third up, moderating the shape with a major second before the semitone steps. This responds to the different perceptions of the parabolic shapes of the sculpture from different angles, as we can see in the four different perspectives shown in Figure 26.

The flute and the violin, placed in different positions in the gallery, also have complementary material that responds to the parabolic melody or to the sculpture itself[70]. As the different instrumental parts resonate in the gallery, the singer, in its movement across the gallery, will be interacting with the echoes of the different melodical lines or musical gestures. This represents the interaction of the nylon thread with its own previous loops in the sculpture, which is what creates the sensation of spatial depth in Gabo's work.

Example #21

Unfolding parabolic melodic lines in the trumpet and the voice, interacting with the echoes of the violin and the flute during the

[70] See **2.2.2.1** ***Linear Construction in Space No. 1***.

parade across the art gallery. This musical process represents the construction process of Naum Gabo's sculpture.

In response to Naum Gabo: Linear Construction in Space No. 1, "Scene".
Excerpt: end of Section 1 and beginning of Section 2.
Video fragment from a live performance at the Barber Institute of Fine Arts, available in **5.1 Appendix #1**.

2.2.1.3 Autohoodening: The Rise of Captain Swing

Process-based composition strategies are equally present in *Autohoodening: The Rise of Captain Swing*. This is the case, for example, of the scene in which we depict how the algorithm controls and punishes the workers after the death of Captain Swing[71]. This is represented as a series of "musical tasks", short melodic motifs based on the musical material of the piece[72], that need to be performed relentlessly following the snaps of Alexis the Scanner[73]. These motifs are designed in response to a text written imitating an algorithmic language (Figure 27). This text is informed by qualitative data from the interviews, generating sentences such as "loo time is equal to zero", or "else efficiency must be equal to efficiency plus one" by mixing the

[71] The indiscriminate use of artificial intelligence in the working environment to maximise profit regardless of how it affects the employees' health is one of the main criticisms of the work.

[72] See **2.1.2.2.1 *Autohoodening: The Rise of Captain Swing***.

[73] Alexis the Scanner is a variation on the wooden horse of the hoodening custom, combined with the scanner that Amazon workers must use at work (that determines the tasks they need to do, the time they have to complete them, or their efficiency compared to other workers). The wooden horse can snap using a mechanism that closes its mouth. This is replicated by the character of Alexis the Scanner, used in this case as a repressive gesture of the scanner towards the pickers and packers.

algorithmic language with the workers' complaints. The chorus will sing these words, whereas the folk band will just play the musical motif, or just play its rhythmic component in the case of the percussion (**Example #22**).

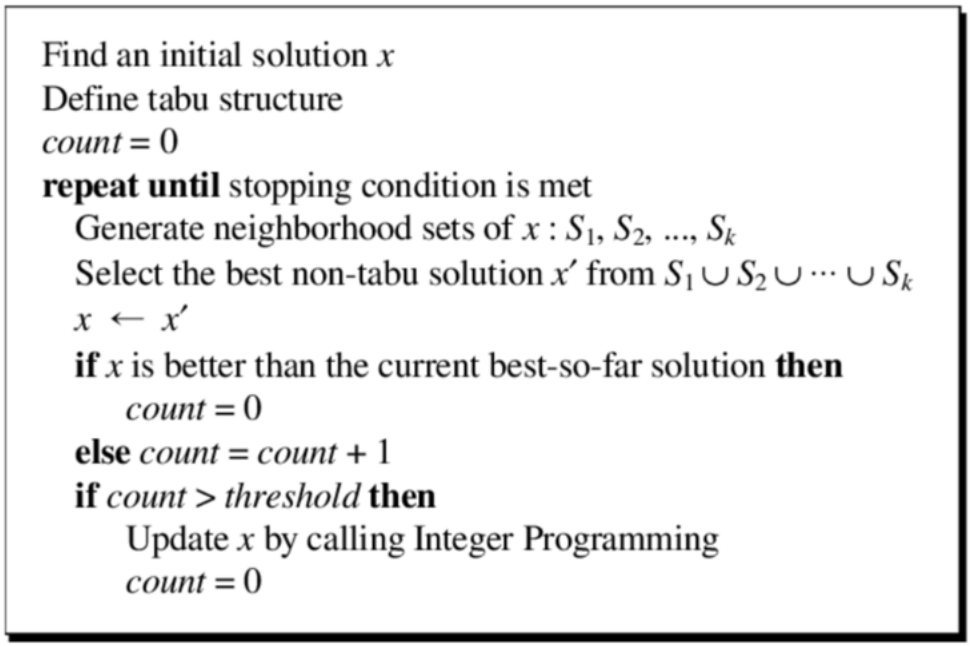

Figure 27 - Model of algorithmic language used to generate the text material for the algorithm section in Autohoodening: The Rise of Captain Swing.

The performance instructions are simple but repetitive (as working as a picker or packer in a fulfilment centre): each performer starts playing or singing one of the "musical tasks" when Alexis snaps directly at the person. Each motif is repeated as many times as the performer wants before jumping to a different "musical task", in any order. The motifs must be performed fully as written, with the idea of completing a task. This process is repeated relentlessly until the next snap of Alexis the Scanner at a performer, marking them to stop. When all performers have been stopped, the scene finishes[74].

[74] In the film version of *Autohoodening: The Rise of Captain Swing* presented in **Example #22**, and fully available in **5.2 Appendix 2**, this scene has been adapted. It features a theatrical ritual based

The result of this composition resembles a sort of factory-assembly-line version of Terry Riley's minimalist work *In C* (1964). The performers, however, in comparison, are deprived of most of the freedom Riley gives in his score, especially the agency he gives to move forward in the piece. In this case, this agency does not exist as the performers jump between fragments relentlessly until the character of Alexis the Scanner marks the end of their "shift". Also, instead of the gradual morphing of musical fragments achieved in Riley's work, in this case we have a direct layering of different tasks happening simultaneously, akin to the reality of a factory (or a fulfilment centre in this case).

Example #22

Representation of the algorithm's control over the workers by a process: the relentless playing and repetition of different motifs associated in the piece to Amazon and the workers. The scene is introduced and ended by a sung short line describing how the algorithm continuously analyses the workers' performance.

Autohoodening: The Rise of Captain Swing, "The Algorithm".
Video excerpt from the film in **5.2 Appendix #2**.
Instrumental version of "The Algorithm" from [00:00:13].
Vocal version of "The Algorithm" from [00:03:45].

on a similar idea (a repetitive task controlled by Alexis the Scanner). The music of this scene was recorded separately (as for most of the film) and used to accompany the action.

2.2.2 Use of timbre

The depiction of an object or a living being by imitating musically the sound they produce is a technique used all over the history of music. The imitation of the sound of animals is a very good example of this, present in numerous compositions of all eras, such as the erotic song in the Cancionero Musical de Palacio by Juan del Encina *¡Cucu, cucu!* (XV century)[75], Messiaen's *Catalogue d'oiseaux* (1958)[76], or Richard Ayres' No. 42 - *In the Alps (an animated concert)* (2008)[77]. Similarly, the use of timbre can be applied to depict objects or concepts, as seen in the transcription of the Amazon scanner sound used in *Autohoodening: The Rise of Captain Swing*[78].

I applied this technique in *In response to Naum Gabo: Linear Construction in Space No. 1*, *The Flowering Desert*, and *TRAPPIST-1*.

---

[75] In this piece, the imitation of the cuckoo bird, according to Francisco Asenjo Barbieri (1890: 210), editor of a publication of the Cancionero Musical de Palacio, must be associated with the French word *cocu*, a cheated person.

[76] Messiaen's *Catalogue d'oiseaux* is divided into thirteen cahiers distributed in seven books. Each cahier is informed by the sound of a bird representative of a region of France, accompanied by the sounds of other birds from that region.

[77] In Ayres' melodrama, in Act 1, Scene 1, he presents the "stillness" of an alpine mountain, represented with the sound of its inhabitants. He includes a nightingale, a cicada, an owl, toads, doves, an eagle, a swine, goats, or a bear. Their sounds are imitated by the instrumental ensemble. Later, in Act 1, Scene 3, he presents a stranded girl learning to sing with the sound of these animals. The soprano then imitates their sound in an operatic style.

[78] As seen in **2.1.2.2.1 *Autohoodening: The Rise of Captain Swing***.

2.2.2.1 In response to Naum Gabo: Linear Construction in Space No. 1

In the work *In response to Naum Gabo: Linear Construction in Space No. 1,* I used this approach to engage with Naum Gabo's sculpture sonically. This is the case of the motifs used in the violin (3a, 3a', and 3b) and in the flute (3). These musical gestures were composed in imitation of the sounds the original sculpture would make, using a faithful replica as a model we were able to touch and play with. The result was short, plucked sounds and high-register ricochets.

Example #23

Imitation of the nylon sounds that Gabo's sculpture would produce in the violin and flute parts.

In response to Naum Gabo: Linear Construction in Space No. 1.
Excerpt: Section 3.
Video excerpt from the live performance at the Barber Institute of Fine Arts available in **5.1 Appendix #1**.

2.2.2.2 The Flowering Desert

In the case of *The Flowering Desert*, I used the technique of representing an idea with a related timbre to stress the difference between the *Scenes* and the *Mélodrames*. Structurally, the Scenes tell the story of the planet, the comet, and the star. The operatic singing supports their non-realistic setting. The *Mélodrames* (and the *Overture*), showcase the point of view of the Measurer, a scientist witnessing the discovery. The text in the Measurer-centred sections depicts his/her thoughts at that time. There is no dialogue or direct interaction with any other characters. Therefore,

to stress the difference, Roxanne (librettist and singer) and I decided to engage with the idea of representing the Measurer's thoughts musically with a specific timbre. We decided to imitate the thought process by using sounds that would trigger an ASMR[79] response, in relation to the Measurer's feelings of astonishment while observing the sky and the discovery, but also to a feeling experienced while watching a show in a planetarium.

The timbral design for the Measurer was then informed by some ASMR triggers, such as soft speaking, exhaling sounds, whispering, or mouth sounds. In the piece, the scientist's thoughts are represented with what we called "whispered singing". This singing technique appears in two forms: "full" and "half" whispered. Full-whispered singing is a variation on whispering in which the airy sounds are pitched. Half-whispered singing is a variation on singing in which there is a conscious addition of airy noise in the vocal sound. The Measurer's part is presented pre-recorded[80] and played in the rear speakers of the dome's 5.1 system[81] to be experienced as a whisper in the back of the audience's heads, representing the Measurer's thinking.

---

[79] ASMR, abbreviation for autonomous sensory meridian response: "a pleasant tingling feeling that some people experience on their skin, especially on the head and neck, especially when they hear certain soft sounds such as whispering or brushing". Definition from the Cambridge Advanced Learner's Dictionary & Thesaurus.

[80] Full-whispered singing should be recorded with the microphone placed very close to the singer, to make the pitching and the mouth sounds (which can also trigger ASMR) more noticeable. Half-whispered singing can be recorded with the microphone placed at a normal distance.

[81] It can also be performed live with the singer portraying the Measurer's character using a microphone. The output of the live amplified whispered singing would still be the rear speakers of the 5.1 system.

Example #24

Use of the ASMR-based singing timbre to represent the thoughts of the Measurer in the *Overture*. Inhaling and exhaling sounds are used to introduce the technique before the start of the text. Full-whispered sounds are marked in blue in the score. Half-whispered sounds are marked in yellow in the score.

The Flowering Desert, Overture.
Excerpt: Bars 7-36.
Score follower video.
Binaural audio (please use headphones to experience the audio surround effect).

2.2.2.3 TRAPPIST-1

Depiction through timbre is also used in the music-theatre piece *TRAPPIST-1*. During Scene 2 - "Atacama", we focus on Amaury's experience in the Chilean observatory of La Silla, in the Atacama Desert[82]. One of the descriptions we took from the interview informed timbrically the last section of this scene. Related to the scene's main theme, isolation, he described to us that his stay at the observatory was like a "monastic experience".

This concept is represented in the piece by imitating a composition practice from the mediaeval monasteries: the organum. It consists of adding an extra voice to a plainchant melody, mostly in parallel motion, and transposing a perfect fifth or a fourth. In the piece, the flautist performs an organum by combining playing a series

[82] See **2.1.2.1.3 *TRAPPIST-1***.

of notes and singing simultaneously a fifth above on the bass flute[83]. The pitch material for this effect is taken from one of the banks of material used during the semi-improvised "Sudden Storm" section of the scene[84]. The pitches in this bank, "out of the usual world"[85], correspond to the scales presented in Figure 5, generated with the distance of the planets to the star. The symbols accompanying the notes are a stimulus for an improvised variation of these notes[86]. They are based on borrowed river plots that show the transits of the planets over 1600 days. The different wavy shapes are the result of the interactions between the different planets, which affect each other's respective transits, some being early and others late.

Example #25

Simultaneous playing and singing on the flute to imitate the sound of a mediaeval organum. This timbre represents the idea of "monastic experience" described by Dr Amaury Triaud.

TRAPPIST-1 - Scene 2, "Atacama".
Excerpt: [00:11:00] to [00:13:00].
Score follower video.
Binaural audio (please use headphones to experience the audio surround effect).

[83] Similarly to singing and playing simultaneously on brass instruments, this technique is achieved more easily and effectively on lower instruments, thus using the bass flute for this section.

[84] This section (from [00:06:00] to [00:11:00] in Scene 2) depicts a sudden violent storm, inspired by one lived by Dr Amaury Triaud during his stay at the observatory of La Silla.

[85] Named and composed inspired by a sentence from the interview.

[86] These variations can affect different parameters such as intonation, dynamics, or ornamentation.

3 How can you communicate a subject matter on many compositional levels in a piece of music theatre?

In this section, I will present a compilation of compositional strategies I employed to communicate different ideas from the subject matters of the works included in the portfolio on different levels. These are organised in four sections: musical association, layering, performativity, and engagement with the space.

3.1 Musical association

The association of a concept with a musical idea is a common strategy in the music composed with a narrative or about a specific topic. We can see this clearly in Wagner's use of leitmotivs, melodic lines or fragments composed to represent a concept (many times abstract, such as love, anger, or passion), or a determined character, used to interweave the musical discourse in his operas. This is a practice currently present in most music for films or series[1].

Musical association can be applied in different manners, not relying on just melodic fragments or narrative. We can use chord progressions, rhythms, tonalities, processes, or any other combination of musical parameters that we can associate with different concepts or ideas. In different sections of **2 How can**

[1] As seen in TV series franchises such as *Game of Thrones*, and movies franchises such as *The Lord of the Rings* or *Star Wars*. Many of their leitmotivs have become iconic and part of pop culture.

interdisciplinary collaboration (...) we have seen how, for example, different rhythmic units are associated with different planets, a series of chords with a planetary system, or an appropriated folk tune with exploited workers. How this associated material is presented or developed in a composition can be used to communicate elements related to a subject matter on different levels.

In the research, the overarching idea is to directly interweave the subject matter within the composition and communicate it on different levels, accounting for other factors such as how (performativity) and where the composition is performed (engagement with the space). In this context, musical association can be useful to directly showcase musically an idea working in conjunction with other compositional layers and with the work of other artistic collaborators.

I will now present some examples of strategic development or presentation of musically associated harmonic and melodic materials.

3.1.1 Harmonic

Harmonic associations can be used as a compositional level to present an idea related to the subject matter of a piece. Changes in harmony or the juxtaposition of different harmonic elements can be used to communicate an idea. I explored this on a macro-structural level in *Autohoodening: The Rise of Captain Swing* to communicate musically the "rise" of Captain Swing, and in *TRAPPIST-1* to engage with the process of discovery of the eponymous planetary system.

3.1.1.1 Autohoodening: The Rise of Captain Swing

In *Autohoodening: The Rise of Captain Swing* I used harmony to showcase on a macro-structural level the main plot development of the piece: the rebellion of the exploited workers against their algorithmically-controlled mechanic bosses. In the piece's narrative, this is represented by the death, resurrection, and "rise" of Captain Swing, a fictional character that inspires and helps the pickers, packers, and eventually the line manager to change their initial situation. In the composition, this idea of "rising" is associated with harmonic changes in the Songbook[2].

At the beginning, the main tonal centre in the songbook is C major, which is derived from the relentless appropriated Amazon tune present in the whole piece[3]. Within that harmonic centre of C, the chorus of pickers and packers would occasionally sing the borrowed hoodening song in D minor (as in the original *Ole Poor Hoss* song seen in **Example #14** in **2.1.2.2.1 *Autohoodening: The Rise of Captain Swing***), or material derived from it. The C major key is, then, associated with the public

---

[2] The *Songbook* is the main score for this work. This responds to the tradition of protest songs in the UK, a topic that Roxanne and I (as Infinite Opera) explored in our previous collaborative project with Post Workers Theatre, "Protesteroo" (2019). In that project, we updated protest songs from a socialist protest song compilation, the Clarion Songbook (1906), delivering protests by bike around the city of Liverpool as if we were a delivery company such as Deliveroo. Due to the workers-in-conflict theme of *Autohoodening: The Rise of Captain Swing*, this score format seemed fit to inform and structure the composition. The folk band plays in response to the songbook, and although for the performance documented in the portfolio I composed some supporting material for the band, the folk band's role in the piece can be workshopped from scratch in every iteration of this piece. Therefore, the harmonic changes discussed in this section may or may not affect in their entirety the folk band (an example is the use of chromatic harmonies, shown below, that the band plays in the "Corporate Love" scene, **5.2 Appendix #2** [00:11:45]).

[3] See Figures 18, 19, and 20 in **2.1.2.2.1 *Autohoodening: The Rise of Captain Swing***.

image of success of Amazon, whereas the song in D minor is associated with the actual reality in the fulfilment centres. This also affects the material in the folk band: the reel tune, for example, written to represent the workers, is played in C[4], a tonal centre less common in the British and Irish folk traditions[5].

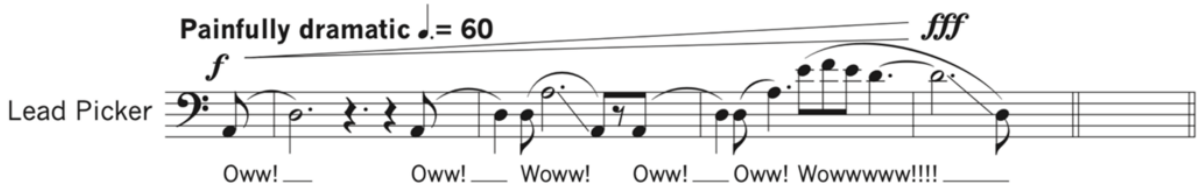

Figure 1 - Autohoodening: The Rise of Captain Swing, Corporate Strength and 1st Punishment. Example of singing material associated with the workers derived from the Poor Ole Hoss song in D minor. This is sung against a motif written in C, the "Depressed Pick Pack Motif" (Page 3 in the Songbook - Appendix #2).

From the first appearance of Captain Swing, there are hints of singing in D major (Figure 2). This key starts to be established from the resurrection and coronation of Captain Swing, a scene written in D (**Example #11** in **2.1.2.1.1 *Autohoodening: The Rise of Captain Swing***). From that point, the workers abandon the D minor material to, at the end, after their victory, fully use D major as their main tonal centre, harmonically rising up. This is evident in the last scene, a recapitulation of the Introductory Song, with the return of the reel. The reel is played now in the more idiomatic, and typical in folk music, tonal centre of D[6]. The hoodening song is also played and sung now in D major (**Example #1**).

---

[4] As seen in Figure 17 in **2.1.2.2.1 *Autohoodening: The Rise of Captain Swing***.

[5] Due to the particularities of the fiddle, most British and Irish folk tunes are written in keys that are more idiomatic for the instrument, such as G, D, or A. This can be seen in online collaborative compilations of British and Irish folk music, such as TheSession.org. A quick search shows over 6,000 tunes in D major and also in G major, for less than 900 in C major.

[6] The material derived from the reel is played or sung now in D Mixolydian. This also affects the "Folk Song", a borrowed Hungarian song, a reference to the central-eastern European origin of many factory workers in the UK.

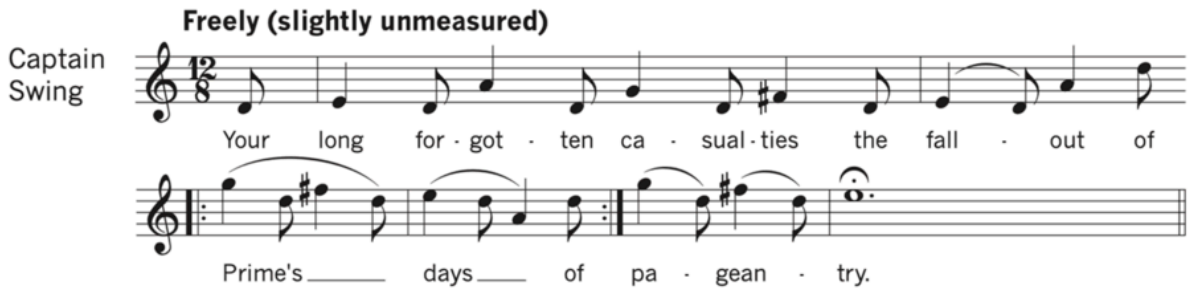

*Figure 2 - Autohoodening: The Rise of Captain Swing, Captain Swing vs Molly Bot. Fragment foreshadowing the rise of the workers against the machines that exploit them by being sung in D major, the future harmonic risen tonal centre of the workers. The chorus of pickers and packers in this moment still sing in the tonal centre of C (Page 8 in the Songbook – **5.2 Appendix #2**).*

In this work, the idea of the workers' rise is therefore associated musically with harmonic rising. It happens in two forms: the general harmonic shift from C to D[7] as tonal centres, and the workers' rise in the hoodening song from the minor mode to the major mode.

Example #1

Final scene in the tonal centre of D, stressing harmonically the rising of Captain Swing and the workers. The reel tune [00:00:23], the trumpet improvisation [00:02:52], and the "folk song" [00:00:45] are performed in D Mixolydian. The hoodening song is played and sung in D major [00:02:18]. Compare with the "Introductory Song" presented in **Example #16** (in which the tonal centre is C major, with the hoodening song being sung and played first in C major and, at the end, in D minor).

Autohoodening: The Rise of Captain Swing, "Epilogue B. Final Chorus". Video excerpt from the film in **5.2 Appendix #2**.

[7] In the film's final credits (**5.2 Appendix #2** [01:18:00]), the music returns to the tonal centre of C, in reference to the actual reality of workers at Amazon.

3.1.1.2 TRAPPIST-1

Another use of harmony to communicate an idea on a different compositional level in a composition can be found in the third scene of *TRAPPIST-1*, "Discovery". As seen before[8], the musical events in this scene are organised depending on the number of days passed between important events, such as the detection of a specific planet for the first time or the detection of the triple transit. Harmonically, especially in the first half of the piece, the electronics trigger the notes associated with each planet at the time corresponding to their first detection.

However, in reality, the first detection does not mean that they know which planet they are detecting yet. For example, the first recorded transit of TRAPPIST-1g was mistaken for TRAPPIST-1d and announced as such[9]. This fact has a direct impact in the piece. In the electronics, we hear a version of the system with the chords generated by transforming distances into frequencies[10], associated with the system in its natural state. However, in the flute part, which represents an astrophysicist, the pitch material is different, associated in this case with how we transform reality into data in order to comprehend it. These notes correspond, then, to a different transformation of distances into musical parameters, in this case into music scales[11], engaging with the flute as a melodic instrument. I will use again the video presented in **Example #7** in **2.1.1.1.4.2 Days between events as structure** to illustrate this idea.

---

[8] In **2.1.1.1.4.2 Days between events as structure**.

[9] More information about how the TRAPPIST-1 planetary system was discovered is available at www.trappist.one/#timeline [Last accessed 30 September 2023].

[10] See Table 2 and Figure 2 in **2.1.1.1.1.2 Distance from the planets to the star**.

[11] See Figure 5 in **2.1.1.1.1.2 Distance from the planets to the star**.

Example #2

In Scene 3, "Discovery", the harmonic material associated with the planetary system in its natural state (distances between the planets and the star transformed as frequencies forming a chord) is juxtaposed with the harmonic material associated with the astrophysicist (distances between the planets and the star transformed as distances between pitches in a music scale and its inversion). This symbolises how we transform a reality into an abstract construct (for example, data) that we can use to comprehend it or experience it. In this example, this happens with every planet in the following order (announced by the flautist): Planet C, Planet G, Planet E, Planet F, Planet B.

TRAPPIST-1 – Scene 3, "Discovery".
Excerpt: [00:00:00] to [00:03:45].
Score follower video.
Binaural audio (please use headphones to experience the audio surround effect).

3.1.2 Melodic

Similarly to how the use of determined harmonic associations and their variations can convey an idea on a different compositional level, thus can melodic associations. I explored this idea applying it to the change in power dynamics in *Autohoodening: The Rise of Captain Swing*.

3.1.2.1 Autohoodening: The Rise of Captain Swing

Besides associating the idea of the workers' rise to a harmonic shift, as explored in **3.1.1.1 *Autohoodening: The Rise of Captain Swing***, I also used variations on the Amazon tune to deliver a similar idea. In this case, to stress the revolt of the workers against the algorithmically-controlled scanner, the Amazon tune is rewritten in a retrograde configuration[12]. The use of this technique is connected to the etymological origin of the word "revolt", from Latin *revolvere*, which means to "roll back"[13]. The melody is, therefore, rolled back. This version of the tune is sung by the chorus of pickers and packers in the slow numbers (Figures 3 and 4). For the fast numbers, the ensemble and the singers perform a shortened version of the melody in which the inner repetition has been removed (Figures 5 and 6).

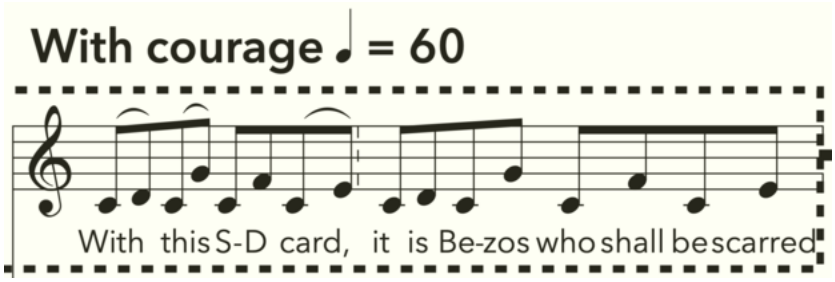

Figure 3 - Autohoodening: The Rise of Captain Swing, Line Manager's Doubt Aria. Example of a retrograde variation of the Amazon tune. Sung by the chorus of pickers and packers.

[12] Played melodically backwards.

[13] Merrian-Webster (2023) Revolt. Merrian-Webster.com Dictionary. Available at: https://www.merriam-webster.com/dictionary/revolt [Last accessed 2 October 2023].

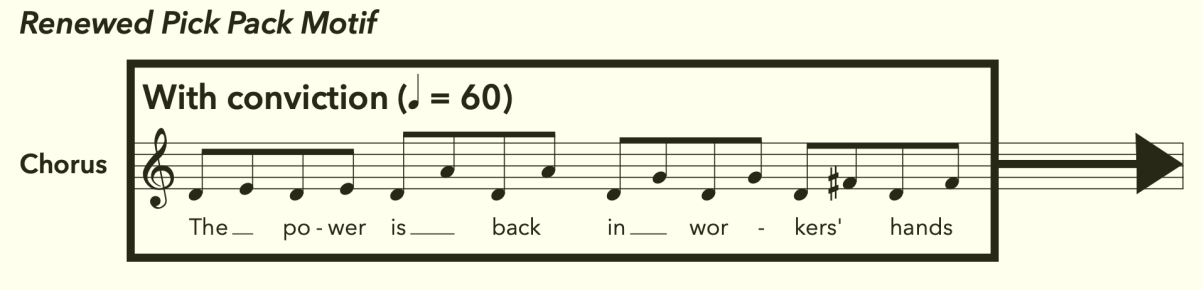

Figure 4 - Autohoodening: The Rise of Captain Swing, The New Corporate Love. Example of a retrograde variation of the Amazon tune, in this case transposed to D. Sung by the chorus of pickers and packers and played in the folk band.

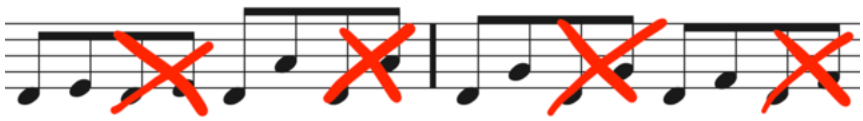

Figure 5 - Shortening process of the retrograde version of the Amazon tune by avoiding the repetition of each of the 2-note cells.

Figure 6 - Autohoodening: The Rise of Captain Swing, Captain Swing's Coronation Ritual. Example of the short version of the retrograde variation of the Amazon tune, in this case transposed to D. Played by the folk band.

This idea is connected to the harmonic "rise". Similarly to the use of the tonal centre of D, the retrograde Amazon tune is established on the workers' side from the resurrection of Captain Swing. Also, it was equally hinted at for the first time in the defeat of Swing against Molly Bot, as seen in Figure 2 in **3.1.1.1 *Autohoodening: The Rise of Captain Swing***, as the first sign of rebellion against the machines in the piece (**Example #3**).

Example #3

Three examples of the use of the retrograde musical material in the scenes depicting the rebellion of the pickers and packers. Fragments from "Captain Swing rises" ([00:00:00] to [00:00:45]), "Line Manager's Doubt Aria" ([00:00:45] to [00:01:30]), and "The Line Manager Fights Alexis" ([00:01:30] to [00:02:15]).

Autohoodening: The Rise of Captain Swing.
Selected fragments from the film:
- "Captain Swing rises" ([00:00:00] to [00:00:45]).
- "Line Manager's Doubt Aria" ([00:00:45] to [00:01:30]).
- "The Line Manager Fights Alexis" ([00:01:30] to [00:02:15]).

Fictional appropriation is also a variation that can convey metaphorical information. This means that, depending on who or what plays or sings a musical material associated with a determined idea, this may have a specific change in its meaning. In *Autohoodening: The Rise of Captain Swing,* this is reflected in the fact that the machines appropriate the hoodening song and sing it in their associated key of C major, showcasing their control over the workers[14]. We can see this in the "Corporate Duet" (page 3 in the Songbook), after the defeat of Swing in "Captain Swing vs Molly Bot" (page 9), and as part of the materials in "The Algorithm" (pages 11 and 12). From the pivotal point of the resurrection of Captain Swing (page 14), the hoodening song is reappropriated by the workers, never being sung again by the machines until they have been hacked and are part of the workers' side (pages 25 and 26). First, the Line Manager, in her change of sides when she is fired (Figure

[14] Swing, in fact, tries to reappropriate it in "Captain Swing's Introduction" (Page 7 of the Songbook) but fails.

7), takes the song from the machines singing it in C major (Pages 21-23), to, at the end, being sung by everybody in D major.

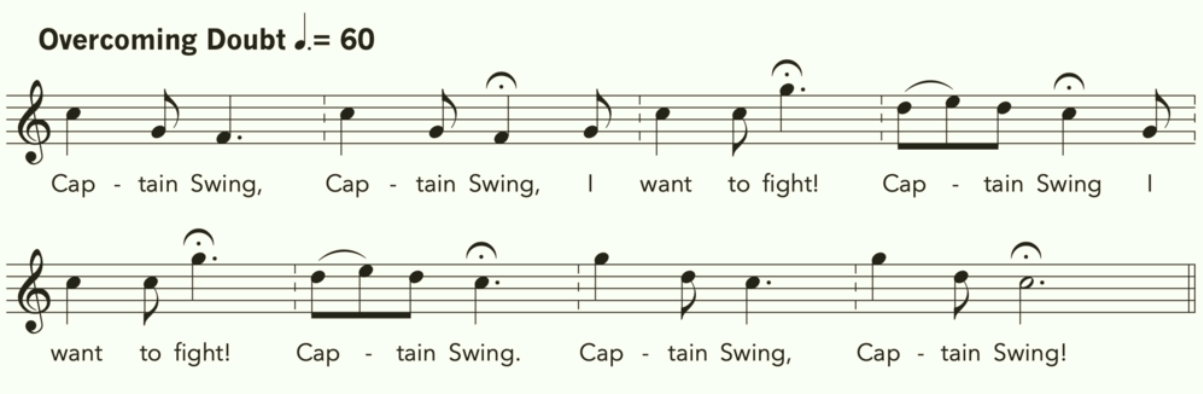

Figure 7 - Autohoodening: The Rise of Captain Swing, Line Manager's Doubt Aria. The Line Manager calls for Captain Swing with the material from the hoodening song in C, reappropriating it from the machines.

This is similar to how the pickers and packers appropriate and resignify the Amazon tune by playing it "rolled back" and in D major, as seen in **Example #3**, or to the redemption of the Line Manager, who sings a combined version of the reel tune with the Amazon tune in her fight against Alexis the Scanner (Figure 8).

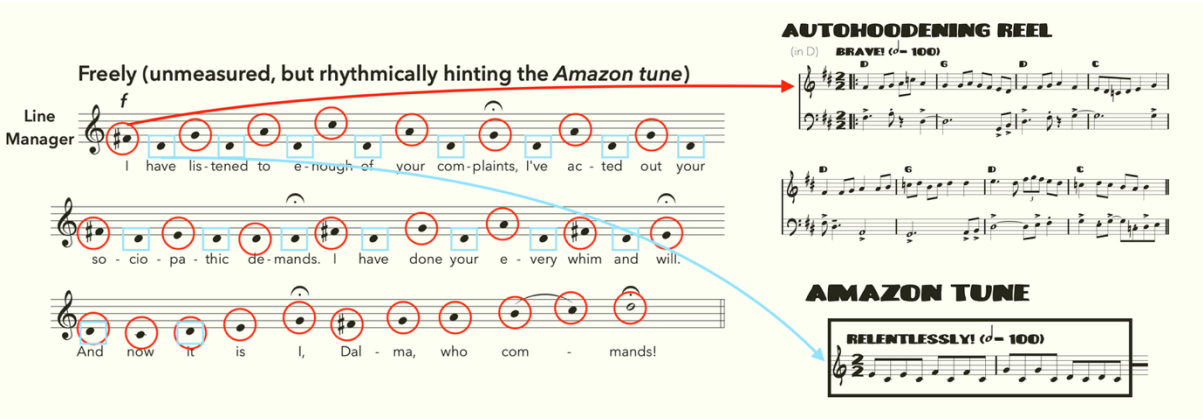

Figure 8 - Autohoodening: The Rise of Captain Swing, The Line Manager Fights Alexis. The Line Manager combines the reel tune (in D) with the Amazon Tune.

3.2 Layering

Layering in composition can be used to engage simultaneously with different elements and concepts, being a very useful strategy in a collaborative interdisciplinary environment. It allows each material to work or to develop independently, but also in relation to others. The interactions and interrelations provoked by the clash or combination of different layers can be used to deliver specific ideas, metaphors, or symbolisms.

3.2.1 Autohoodening: The Rise of Captain Swing

Layering is present throughout the whole work of *Autohoodening: The Rise of Captain Swing*. Musically, there was first a practical reason behind it. The piece was collectively created during the COVID-19 lockdowns in late 2020 and early 2021[15]. The interdisciplinary collaborative creative process for this piece needed to happen online. We used techniques of Zoom-theatre such as the use of effects in the background of the videocall, the connection of external musical software through virtual audio inputs, or the strategic manipulation of the layout of the videoconference[16]. In order to embrace the unavoidable latency (or sound delay) in

[15] During these lockdowns, non-essential workers had to stay home in the UK (as well as in most countries). Therefore, creative meetings or rehearsals in person were not permitted at that time.

[16] Roxanne Korda and I explored these techniques by participating in several Zoom-theatre projects during lockdown with the Brazilian company *Os Satyros* and with the theatre director Aleksandar Dundjerovic. *Os Satyros* are experts in digital theatre and pioneers in the use of the virtual digital space (and therefore the video call software Zoom) as a platform for live theatre (Dundjerovic, 2023).

the video calls during rehearsals[17], I decided to design the composition of the music as a series of independent blocks of material stacked in layers that would not necessarily need to be synchronised to be effective. This allowed us to create the first version of this work in the form of a Zoom-theatre extended trailer for the project[18].

In this first creative cycle[19] we found this technique effective to present simultaneously the hoodening folk traditions, the automated world of Amazon, and the dramatic action of the play, deciding to use it in the final development of the work.

Figure 9 - Autohoodening II The Rise of Captain Swing Trailer. Still from the Zoom theatre cycle of development of Autohoodening: The Rise of Captain Swing. In the image, Morris dancing steps danced in front of Amazon backgrounds while singing the hoodening song. The full video is available in ***5.2 Appendix #2****.*

---

[17] Latency is "the delay between a packet being sent and received. (...) Higher latency values will result in noticeable delays between video and audio. For example, the time between you speaking and the other user receiving the audio on their end" (Zoom Support, 2023).

[18] Included in **5.2 Appendix #2**.

[19] We used creation in cycles as a methodology for collaboration, using Halprin's RSVP cycles (1970) as a reference. I also applied this methodology to inform the collaboration with different practitioners in the creation of *The Flowering Desert* and *TRAPPIST-1*.

Layering is therefore a technique that I used to organise all the blocks of material created for this piece. On a musical macro-structural level, we have three main interconnected layers: the chorus of pickers and packers, who showcase the relentlessness associated with Amazon[20] by repeating the music material contained in boxes (how appropriate) in the score; the main characters, who deliver the spoken text and move forward the musical discourse with their operatic interventions and lead the game of appropriation and reappropriation of music material, as well as the harmonic shifts (as seen in **3.1.2.1 *Autohoodening: The Rise of Captain Swing***); and the folk band, which supports the action by establishing the melodic themes associated with an idea and its variations. On an interdisciplinary level, we can use other layers, such as performativity[21] or the engagement with the space[22] to communicate on different compositional levels other ideas related to the subject matter of the piece.

Example #4

Example of layering. The chorus sings material derived from the Amazon tune in a repetition box. Over this, Captain Swing sings freely a melodic line based on the reel tune. The band plays the "revolted" Amazon tune. The three layers are connected harmonically and thematically.

Autohoodening: The Rise of Captain Swing, Captain Swing Rises.
Video excerpt from the film included in **5.2 Appendix #2**.

[20] As explained in Footnote 59 in **2.1.2.2.1 Autohoodening: The Rise of Captan Swing**.

[21] Discussed in **3.3 Performativity**.

[22] Discussed in **3.4 Engagement with the space**.

3.2.2 The Flowering Desert

Layering is also used strategically in *The Flowering Desert*. A clear example is its second scene. As we have seen previously[23], the embodiment of data technique is used to showcase the burning process of the Mother Star and the sempiternal rotation of the system. This acts as one of the two musical layers in the scene. The second layer features Pantele trying to helplessly communicate with the Mother Star by singing a completely different musical material[24] against the constant musical process that represents the star. As Pantele's anxiety against this situation grows, its musical material is more present, being joined by other instruments, rhythmically first, and then also melodically (score follower video). This is accompanied by the visuals, which showcase the musical growth of Pantele on the screen (as a growing planet) against the process of stelar burning featured in the projections. The result of the overly red visuals also creates a soothing luminous environment in the planetarium, which stresses the solitude of Pantele against the inhospitality of the star.

Example #5

Use of layering in *The Flowering Desert*. In this excerpt from Scene 2, we see Pantele's anxiety growing both musically and visually against the Mother Star. Musically, the layer corresponding to Pantele (marked in yellow in the score follower video) is more present over time with changes in instrumentation, dynamics, and doubling in the ensemble. The musical material related to the Mother Star (marked in blue in the

[23] In **Example #9** in **2.1.1.2.2 *The Flowering Desert***.

[24] In this case, one of its associated materials, a melodic pattern created with rhythmic units derived from the orbital rotation of the system, featured in Figure 8 in **2.1.1.1.2 Rythmic material**.

score follower video) also grows in volume, fighting against Pantele's material. Visually, the projections show a planet growing against the red backdrop of the star, showing Pantele standing against the Mother Star (dress rehearsal documentation).

Score follower video (Example #5a)

The Flowering Desert - Scene 2.

Excerpt: Bars 100-166.

Score follower video.

Binaural audio (please use headphones to experience the audio surround effect).

Dress rehearsal documentation (Example #5b)

The Flowering Desert, Scene 2.

Video excerpt from the film included in **5.3 Appendix #3**.

3.3 Performativity

A key development in music composition is the gradual realisation that writing music is beyond the stave manuscript and the musical notes and that how the music is presented is also a compositional layer that the composer can design and that can be scored. We can see this clearly in works by John Cage (*Theatre Piece No. 1*, 1952) or Mauricio Kagel (*Match*, 1966), imbued very often with theatricality at their core (Griffiths, 1985:181). We can consider Karlheinz Stockhausen's *Helikopter-Streichquartett* (1992/1993) a clear example of performativity in composition, in which a string quartet plays the music from four helicopters. How the piece is performed is a key element that defines this work (in this case, with the engagement with the space also being a key factor that impacts the performativity).

In an interdisciplinary collaborative music-theatre context, the performativity of the compositional material can be helpful to communicate specific ideas in a direct manner. The composed theatricality can inform the musical result, and vice versa.

3.3.1 Autohoodening: The Rise of Captain Swing

Performativity became very important in the creation of *Autohoodening: The Rise of Captain Swing*. From the first creative cycle of this piece, in its Zoom-theatre format, we realised that how we performed the musical material could reinforce the communication of important ideas on different levels. In that first cycle (Figure 9 in **3.2.1 *Autohoodening: The Rise of Captain Swing***), we performed the hoodening song alongside a series of repetitive actions linked to hoodening or to Amazon (such as Morris Dance dancing steps or picking boxes) in a Zoom environment. By having each performer confined to a square on the screen doing these actions and singing words such as "we are not even treated as robots", we aimed to stress the isolation of the workers and the constant surveillance and control they suffer at their workplace[25].

A clear example of the use of performativity in this work can be seen in "The 2nd Punishment". The composition for this scene takes the form of a musical game. A group of workers start performing the Amazon tune, slowly. Every time Alexis the Scanner snaps directly at a worker, this will perform the musical motif faster. When a worker gets to a speed impossible to perform, the worker collapses. The game keeps going on until all the workers have collapsed. This is accompanied by the Line

[25] Especially during the time of the COVID-19 pandemic.

Manager and Alexis' "motivational" speeches[26]. The Line Manager sings the speech with the Amazon tune and the Scanner with the scanner motif. The performativity informs the musical result, which showcases the constant push to work faster that the Amazon workers described in the data collected in the research:

- "Targets are twice as much as they were before, people give their all and by that, I mean even their lives. Several people died in BHX1, and hundreds more collapsed during work"[27].
- "For the 10 hours you're working, you're practically a robot. The targets they give you , even robots cannot do"[28].

In the film version of this work, the scene features this game differently[29]. We applied the same principle to a repeated step of Morris dancing that represents picking and packing boxes. Every time Alexis snaps at a worker, the dancing goes faster. The soundtrack of this section was still produced as described above and can be seen in the post-credits scene.

---

[26] The quote "Work hard, have fun. Make history" sung by the Line Manager is Amazon's internal slogan. As described by Delfanti, "this slogan adorns the interiors of each and every Amazon fulfilment centre" (2021: 30).

[27] Organise platform (2018) *Amazon: What's it like where you work?*, p. 12. Available at: https://stylewise-blog.com/wp-content/uploads/2019/07/912fe-amazonwarehousestaffsurveyresults.pdf

[28] Indeed, *Amazon Workers Reviews* (compilation of reviews extracted by Post Workers Theatre from uk.indeed.com), p. 5. Available in **5.2 Appendix #2**.

[29] The production team for this film was not big enough to have both the folk band and the chorus performing at the same time. In fact, in the film, they perform both roles, with the folk band being recorded separately. In an ideal live performance, which was not possible during this research project due to the 2020 and 2021 COVID-19 lockdowns and restrictions, the folk band would play alongside the chorus.

Example #6

Comparison between the "Post-credits" scene and "The 2nd Punishment" scene. The first features a musical game being performed and recorded to be used in the film. The second showcases the visual adaptation of the same game in a Morris dance setting. The soundtrack of the second uses the recording heard in the first, with the "motivational" speeches of the Line Manager and Alexis the Scanner sung on top.

Autohoodening: The Rise of Captain Swing.
Video excerpts:
"Post-credits Scene" [00:00:00] to [00:02:15].
“The 2nd Punishment” [00:02:15] to [00:04:49].

3.3.2 TRAPPIST-1

TRAPPIST-1, being a relatively long music-theatre piece for a solo flautist (50’), relies heavily on performativity. How the material is presented and performed was discussed with the collaborator, Gavin Stewart, from the early stages of its creation. The surround system defines a performance space where sonic events are happening that the performer can respond to and that can have a metaphorical meaning. This is established from the very beginning of the piece, with the presentation of the system rotating around the audience. The strategy of “embodiment of data” discussed previously[30] is performative. The absence of the flautist at the very beginning of the piece, as well.

[30] In **2.1.1.2.1 *TRAPPIST-1***.

This first scene of *TRAPPIST-1*, "Exoplanet hunter", is a metaphor for the scientific method. First, we experience the system by itself. It is there, naturally. Eventually the flautist, representing an astrophysicist, enters the space, moves to position 1 (in front of the audience), and starts observing the rotation of the system and making hypotheses. This is reflected in the accurate playing of notes representing planets at the exact time they pass above the flautist. This passive attitude is followed by an active process of "catching" the planets. This reflects the experimental part of the scientific method. The flautist moves between positions, predicting when and where each planet is going to be and playing the exact note with the most adequate instrument. This carries on until the last note of the scene, in which the flautist is playing and moving between positions following the rotation of one of the planets.

The rest of the piece is a continuation of this metaphorical process of the discovery: Scene 2 focuses on the human experience (in this case, Dr Amaury Triaud's) during the observations[31], Scene 3 represents the analysis and understanding of the data[32], and Scene 4 deals with the announcement and the publication of new knowledge[33].

Example #7

Example of the changes in position of the flautist in Scene 1, "Exoplanet hunter". The movement between positions is marked in the score and responds to a specific floorplan.

TRAPPIST 1, Scene 1, "Exoplanet hunter".
Excerpt: [00:07:00] to [00:10:30].
Score follower video.

[31] As seen in **2.1.2.1.3 *TRAPPIST-1***.

[32] As seen in **3.1.1.2 *TRAPPIST-1***.

[33] As seen in **2.1.2.2.2 *TRAPPIST-1***.

Binaural audio (please use headphones to experience the audio surround effect).

3.4 Engagement with the space

In a similar manner to how performativity can be used as a compositional device by the composer in the creation of a piece, informing the final result of the music composition, so can space. A pioneering example would be the use of projections of colours by the Russian composer Scriabin in his tone poem *Prometheus: Poem of Fire* (1910) to accompany the music, showcasing the composer's associations of colour with music[34]. In this case, the instrument producing the colour projections, a keyboard designed originally for the piece (*Tastiéra per Luce*), changes the space of the symphony hall, and impacts the audience's response to the music.

The influence of ideas and practices from different artistic disciplines, such as site-specific theatre and installations or performance art, has also impacted music composition in this sense. In fact, this cross-disciplinary approach with the engagement with space in mind is even now demanded from publicly funded institutions. A clear example is Arts Council of England CEO's words, giving "opera in car parks, opera in pubs", or "opera on your tablet" as examples for the Arts Council of England "to be focused on the future of opera"[35].

---

[34] Whether this association was synesthetic or a representation of Scriabin's interest in theosophy is still in debate.

[35] Henley, D. (2022) We don't want to bring down the curtain on ENO, but opera has to change. *The Guardian*, 14 November. Available at: https://www.theguardian.com/commentisfree/2022/nov/14/eno-opera-funding-arts-council-audiences [Last accessed 30 September 2023].

The use of a determined space and the strategic design of the compositional material to engage with it can enhance the communication of the subject matter of a piece. This can be seen clearly again in Wolters and Clancy's work *Amaechi* about the eponymous basketball player, performed in a basketball court during the 2022 Commonwealth Games in Birmingham; or in Brian Irvine's street art operas *The Scorched Earth Trilogy* (2022), mixing and engaging with both the digital and the street art worlds by projecting operatic films designed to act as murals, or *Things We Throw Away* (2014), performed in different locations, capturing "forgotten 'thrown away' moments from the streets of Dublin"[36]. I also engaged with this practice in my 2019 beer opera, *Besse*, created in collaboration with the (now closed) craft brewery Digbrew Co., and performed engaging with the taproom and its particularities (fermenting tanks, mashers, boilers, or taps) as a performance space.

The four pieces in the portfolio were created having some spatial conditions or specificities in mind. *TRAPPIST-1* is designed to be performed in a space defined by the surround electronics, as the piece relies on the interaction of the flautist with the sonic location of the sounds associated with the different planets. In the case of *Autohoodening: The Rise of Captain Swing*, the creation of the piece was influenced by the virtual space[37], but it was still designed to be a piece of street theatre, engaging with its original masquerading source[38]. In this case, the composition in

---

[36] Publicart.ie (n.d.) *Things we throw away*. Available at: www.publicart.ie/main/directory/directory/view/things-we-throw-away/ab71ec16b3385c5370412c82b0b5281f/ [Last accessed 30 September 2023].

[37] As mentioned in **3.2.1 *Autohoodening: The Rise of Captain Swing***.

[38] *Autohoodening: The Rise of Captain Swing* was due to be performed in the streets of Birmingham for Black Friday 2020 (Friday, 27th November 2020). A second lockdown, in late autumn 2020, forced us to change plans, first creating a Zoom theatre trailer (available in **5.2 Appendix #2**), and eventually documenting the work as a film recorded in a controlled and safe environment.

layers and the freedom given to the folk band to interact and respond musically to the action embed the piece with the necessary flexibility to perform in the street and to engage with the improvisatory nature of the winter masquerades[39].

In this section, I will focus on the engagement with the space in the other two pieces: *Linear Construction in Space No. 1* and *The Flowering Desert*.

3.4.1 In response to Naum Gabo: Linear Construction in Space No. 1

Linear Construction in Space No. 1 is a site-specific music-theatre piece designed specifically to happen at the Barber Institute of Fine Arts (Birmingham) as part of the activities accompanying the exhibition "Cornwall as Crucible". This exhibition was

[39] In "El Carnaval" (1979), Caro Baroja marks the origin of the European Winter Masquerades in the ancient Roman *Kalandae*, in honour of the god of beginnings and endings (amongst other things), Janus. As mentioned in footnote 50 in **2.1.2.2.1 *Autohoodening: The Rise of Captain Swing***, these customs tend to share elements such as rituals of death and resurrection, but also of fertility or for scaring beasts (wolves on many occasions). These rituals structure the performance, and the different masked characters, in a state of trance (Johnstone, 1979), would incarnate or represent each character following a ritualistic narrative but improvising their actions, especially in those involving interaction with the space or the audience. I explored these ideas in the orchestral masquerade La Obisparra (2016) and furthered them in its chamber opera adaptation in 2022, after witnessing the winter masquerade of Los Carochos de Riofrío and working in collaboration with the local museum and the winter masquerades researcher Juan Francisco Blanco. In this masquerade and other neighbouring traditions, we can find deaths and resurrections of different characters or animals and the collection of money (these two events are present in the hoodening custom), the use of bells as a wolf-scaring strategy (the use of bells in masquerades can be found in many countries such as Bulgaria, Germany, Greece, France, and even in the Morris dancing tradition), or face painting with soot and ash-throwing as fertility rituals (ashes are used to fertilise the farming fields).

curated around the Gabo sculpture that names the music-theatre piece, which at the time was recently acquired by the museum. Alongside Gabo's work, it presented "art produced in and around St Ives from the 1930s to the 1960s"[40], considering "the relationships and networks between artists who lived and worked in Cornwall"[41]. This exhibition was displayed in an auxiliary room next to the main gallery.

As mentioned in **2.1.2.1.2 *In response to Naum Gabo* (...)** and in **2.2.1.2 *In response to Naum Gabo* (...)**, the piece, in its first part ("Scene"), establishes a parallel between the rectangular frame structure of the sculpture and the rectangular disposition of the art gallery's rooms. Another parallel is established by considering the singer and her promenade as a representation of the nylon being threaded across the sculpture's frame. The singer interacts with the different sections of the gallery, organised chronologically, questioning the philosophical ideas behind the pieces displayed in the art gallery with the aesthetic ideas of Gabo, present in his sculpture. The echoes coming from the instruments placed in the different rooms not only represent the continuous threading of the sculpture, but also metaphorically link the art of the different eras with Gabo's work. On top of these micro-structural associations, on a macro-structural, level this section works as a general contextualisation of the new sculpture and the ideas behind it in relation to the works of the permanent collection.

---

[40] Naum Gabo lived in St. Ives, where he created *Linear Construction in Space No. 1* (1942-1943), amongst many other works.

[41] The Barber Institute of Fine Arts (n.d.) *CORNWALL AS CRUCIBLE – Modernity and Internationalism in Mid-century Britain*. Available at: https://barber.org.uk/cornwall-as-crucible-modernity-and-internationalism-in-mid-century-britain/ [Last accessed 30 September 2023].

Figure 10 – Figure 10a (top left): Performance of the "Scene" in the gallery's section displaying works from the 15th century and earlier. In the image, we can see The Master of the Griselda Legend's work "Alexander the Great" (Siena, about 1494). Figure 10b (top right): Performance of the "Scene" in the gallery's section displaying works from the 17th century. In the image, we can see behind the singer Jan Davidsz de Heem's work "A Still Life with a Nautilus Cup" (Leiden, Holland, 1632). Figure 10c (bottom left): Performance of the "Scene" in the gallery's section displaying works from the 18th century. In the image, we can see Francesco Solimena's work "The Holy Trinity, with the Madonna and Saints" (Naples, about 1705). Figure 10d (bottom right): Performance of the "Scene" in the gallery's section displaying works from the 19th century. In the image (at the back), we can see Edouard Manet's work "A Portrait of Carolus-Duran" (Montgeron, near Paris, 1876). Photographs courtesy of Marcin Sz.

Similarly, in its second part, "Variation", the piece responds to the specific space where the "Cornwall as Crucible" exhibition was displayed. The performance happens in front of the sculpture in the middle of the room, stressing the mutual influence of this community of artists. The piece uses the same original musical material, but in this case modified in response to the variations Naum Gabo made of the same sculpture[42]. Similarly to him, I kept only the elements I considered essential: those related to the line (trumpet and flute), the sound of the sculpture

[42] Some of these sculptures would add the term "Variation" to their name, indicating "that it differs from the original version in having a stepped-back (or winged) treatment on two sides instead of having all four sides the same" (Alley, 1981).

(violin), and its structure (voice), that also engaged closely with the voice. The voice part is informed by the rearrangement of a print of Gabo's sculpture reconverted into a jigsaw, which marks the use of singing or spoken voice and affects the musical response of the ensemble. This was influenced by an artwork in the exhibition, Barbara Hepworth's study "Oval Form with Strings" (1960), which Roxanne and I found very closely related to Gabo's sculpture[43]. Therefore, this second part of the work focuses on the space of the exhibition and the artworks that accompany the sculpture, contextualising it and establishing links with the works of his contemporaries.

Therefore, this music-theatre piece, by interacting with the specificities of the different spaces of the art gallery[44], brings the audience on a journey of understanding the sculpture and confronting the ideas behind it, first in relation to its past and then to its own present.

Example #8

Performance of "Variation" in the space where the exhibition "Cornwall as Crucible" was displayed. The singer responds to the sculpture as marked in the voice score. The ensemble responds to the singer's sung and recited material.

---

[43] Online Collections at University of Birmingham (2013) *Oval Form with Strings*. Available at: https://mimsy.bham.ac.uk/detail.php?t=objects&type=all&f=&s=barbara+hepworth&record=1 [Last accessed 1 October 2023].

[44] In this case, the specificities of the Barber Institute of Fine Arts for this piece include, amongst others: the artworks displayed in the main gallery, how the permanent collection was curated in the moment of the performance, the architectural organisation of the building, or the artworks chosen to accompany Gabo's sculpture in the "Cornwall as Crucible" exhibition.

In response to Naum Gabo: Linear Construction in Space No. 1, "Variation".

Video excerpt from the live performance at the Barber Institute of Fine Arts, available in **5.1 Appendix #1**.

3.4.2 The Flowering Desert

In The Flowering Desert, the interaction with the space it was designed for, a planetarium, not only informs the compositional approach, but it also opens the possibility of using it as a vehicle to communicate the subject matter of the piece on a different experiential level. In this situation, the collaboration with the planetarium lead, Colin Hutcheson, was crucial to understanding the technical and practical possibilities of the space. For example, the dome and the limited space for performance push the musical performance, and therefore the musical discourse, into a surround setting, spreading the instrumentalists into a circular disposition[45]. This favours engaging with the transformations of the rotation of the planetary system into musical material and delivering experientially the general idea of rotation and the concept of harmony of the spheres.

The dome also pushes the theatrical action to the ceiling, to the visuals. This affects the approach to the operatic composition, as in this case the main point of attention of the narrative is reflected in the projections rather than in the theatrical action of the singers[46]. The composition is therefore informed by the different techniques and

[45] As specified in the floor plan included in the full score of *The Flowering Desert* (page XV).

[46] The singers also have a performative theatrical role, which, in some cases, can affect the composition. This happens, for example, in Scene 2: the chorus members representing the Mother Star move in the space as they rotate Pantele, combining the timbre of their voices with the timbre of the instruments they encounter.

strategies explored previously, such as the use of layers[47] or processes[48]. They interact with the visuals to drive the dynamism of the piece. The theatrical action that cannot be communicated by the direct performance of the singers, as they are not in the central point of the visual field of the audience, needs to be communicated in this case by the musical elements in relation to the space.

Another important element of the engagement with the space that defines, from the composition perspective, the interaction with the other elements of the production is the strategic use of the specific acoustic elements of the dome. For instance, the main character of the piece, Pantele, is placed in the acoustic sweet spot of the dome, where it gets natural amplification, stressing its importance in the narrative. By making this piece "Pantele-centric", the other two characters (the star and the comet) therefore rotate around it[49], which is reflected in their theatrical and musical performances from different positions in the space[50]. In the case of the character of the Measurer, as seen in **2.2.2.2 *The Flowering Desert***, the use of the 5.1 audio system in the planetarium allows to play the pre-recorded whispered singing representative of the character from the rear speakers. The resultant effect helps to enhance the sensation of somebody whispering behind our ears while we focus on the visuals projected in front of us[51], helping to represent the idea that we are hearing the character's thoughts.

---

[47] As seen in **3.2.2 *The Flowering Desert***.

[48] As seen in **2.2.1.1.1 Doppler effect in Scene 1**, **2.2.1.1.2 Tidal heating in Scene 3**, and **2.2.1.1.3 Collision in Scene 4**.

[49] As we may perceive the Sun rotating around the Earth, which was reflected in the geocentric models from antiquity (such as the Ptolemaic system in the 2nd century AD).

[50] We have seen in **Example #9** in **2.1.1.2.2 *The Flowering Desert***, for example, how the character of the Mother Star rotates around Pantele.

[51] Both the *Overture* and the *Mélodrame* sections, which feature the whispering vocal technique, have no theatrical performance; they only have music and visuals.

The fact that this piece is performed in a planetarium helps already to communicate the subject matter of astronomy and astrophysics thanks to the cultural association of the space with a specific theme, as it happens in *Besse* by being performed in a brewery[52]. However, the use of the specific characteristics of the space as a compositional layer that dialogues with the different disciplines involved in the creation of the piece can have a direct impact on communicating, in an experiential manner, the specific ideas explored in the piece beyond its overarching thematic.

Example #9

Compilation of examples from the documentation of a dress rehearsal of *The Flowering Desert* showcasing the relation of the work with the space:

- Scene 1 (bars 140 to 167): Xoe the exocomet passes close to Pantele in the visuals and in person. Xoe sings in different positions in the space as she leaves the system. Please note the use of the Doppler effect material (as seen in **2.2.1.1.1 Doppler effect in Scene 1**) dispersing in the score as Xoe leaves.

- *Mélodrame* 1 (bars 28 to 43): The Measurer describes being at the Atacama Desert in the night. The pre-recorded whispered singing is played through the rear speakers. In the moment the Measurer says "cold air currents" [00:01:12], the half-whispering technique morphs into whispered singing. This is replicated by the ensemble: the flute, the clarinet, and the French horn play

[52] *Besse*, as mentioned previously, is an opera about beer I created in collaboration in 2019 with the librettist Roxanne Korda and the local Birmingham brewery, Digbrew Co.

air sounds (placed in three different positions in the space) in addition to the whispering.

- Scene 4 (rehearsal mark 4 to rehearsal mark 8): Xoe is on a course to collide with Pantele. The Mother Star is burning the ice in the comet, accelerating it towards the planet. The chorus representing the Mother Star sings from behind the screen of the planetarium, pushing Xoe and accelerating the music. Xoe sings from one position, slowly getting closer to Pantele.

The Flowering Desert.

Video excerpts:

- "Scene 1" [00:00:00] to [00:01:00].
- “Mélodrame 1” [00:01:00] to [00:02:00].
- “Scene 4” [00:02:00] to [00:04:10].

4 Conclusion

Through the exploration and development of different composition strategies and techniques in collaboration with practitioners from different disciplines and their application in the creation of science-based new work, I found that it is possible to engage deeply with the subject matter of a music-theatre piece and communicate it directly to an audience on more than one level. The collision of the crafts and aesthetic tastes of different practitioners proved to generate new paths of creative exploration, as many more aspects of a subject matter (that individually might not be considered) could be engaged with in the creation of new work. By working through an interactive collaborative interdisciplinary approach, I can therefore explore new ways to associate and map different resources and ideas within the compositional process. This is evident in the eclecticism shown in the portfolio: each work showcases very different outcomes with similar compositional strategies and focuses on different compositional aspects and mechanisms of mapping to tackle the different subject matters and the technical considerations that arose in integrating and communicating them in the works.

The Flowering Desert and *TRAPPIST-1* are significative in this research, as they share the same subject matter: the discovery of the TRAPPIST-1 planetary system. The impact of the practitioners' varied interests and backgrounds and the idiosyncrasy of each collaboration resulted in the exploration of similar elements but with different ways of engaging with them in each piece. Both works use techniques for transforming data into musical parameters, but the fact that in *TRAPPIST-1* we could engage easily with microtonality[1], and therefore be more accurate in the

[1] Thanks to the use of the Kingma system flute.

transformations of data into pitches than in *The Flowering Desert*, generated several questions about fidelity and accuracy in data transformation. What is the threshold at which we are faithful to the data? Is it more faithful to transform the distances from the planets to the star into frequencies than to assign a note from a diatonic scale to each of the seven planets? Is it more faithful to approximate a transformation of data into pitches to cents than to semitones? Does being more accurate in a transformation communicate the subject matter better? I did not find an objective answer to these questions, just personal subjective assumptions, as all the transformations were ultimately informed by personal arbitrary decisions. What is true is that in any of those transformations, we experience, in this case, aspects of the real planetary system[2]. I found that what we could experience and understand is how these planets (or any other kind of data) relate to each other and to us. This can be seen, for example, in *TRAPPIST-1*: by generating a rotational soundscape with the electronics, we can experience the planetary system at work, to which we can then layer other elements, such as the flautist representing an astrophysicist during its discovery, generating meaningful relationships that can help to communicate ideas on different compositional levels.

As a result of this research project, I also started considering many more aspects and parameters in my approach to composition. I found myself developing an equal interest in how, where, when, and why the pieces were performed than in what was performed. These questions are interconnected and inform each other and can be used to generate associations on different levels between the different resources that are used to inform a composition. I also found this holistic approach key to my personal engagement with the concepts of integration and communication. During the initial stages of this research project, influenced by the work with numerical data

[2] The same questions can be applied to any kind of transformed data.

from the TRAPPIST-1 system, I was especially focused on the integration of elements such as data into the musical discourse without considering how its integration in the composition would ultimately communicate the subject matter. I was focusing on integration just applied to the "what" (the musical material, in this case). This eventually led to a creative block in the composition of *The Flowering Desert*, as I felt the piece was not conveying the subject matter as much as I tried to integrate data into the piece. This was also fuelled by the COVID-19 lockdowns and the difficulties they generated in working with other collaborators. However, with projects such as *In response to Naum Gabo: Linear Construction in Space No. 1* and especially *Autohoodening: The Rise of Captain Swing*, in which I had to work mostly with qualitative data, I started developing different approaches to composition to focus more directly on the communication of their subject matters. It was the moment in which I started considering the musical material in relation to where, how, when, and why it was performed that I was able to harmonise better integration and communication.

In relation to these ideas:

- *In Response to Naum Gabo: Linear Construction in Space No. 1* succeeded in integrating Gabo's sculpture into the performance by using different processes of melodic stretching (that replicate the nylon threading process in the sculpture) that engaged with the performance space[3]. Those melodic processes generated echoes that accompanied the promenade in the "Scene", helping to recreate sonically the visual appearance of Gabo's work. However, this representation works on a macro-structural level, making it difficult for the audience to experience it directly. The communication of the

[3] The Barber Institute of Fine Arts.

subject matter of the piece was happening mainly through the text delivery and the promenade across the galleries by juxtaposing Gabo's ideas with the pieces of past artists. As a first case study, it showed me how the engagement with the space can be a key parameter to consider in both the integration and the communication of a subject matter.

- *Autohoodening: The Rise of Captain Swing*, with a musical language that combines folk traditions and minimalist techniques with performative actions, generally succeeds in communicating on many levels the situation of exploitation suffered by many workers at Amazon. In this sense, I think scenes such as "The Algorithm" or "The 2nd Punishment" succeeded particularly. Not only is the musical material designed to be relentless, but the performativity that the musical material implies also showcases it visually. However, the fact that this piece was filmed also gave us agency during the editing process to highlight these elements. This is also a valid practice, as in fact, the film became an artefact by itself, being showcased as a piece of visual art at the Luleå Biennial 2022 (Sweden). Still, I would be curious to see this work performed as it was intended, as a street masquerade with a chorus of workers protesting by re-embodying their situation through the cathartic lens of the mask and the ritual.

- I think that the sections composed in *The Flowering* Desert after the creative block mentioned above (*Mélodrames* 2-4, and scenes 3 and 4) succeeded much better in communicating their subject matter than the *Overture* or Scene 1 (which were composed in the early stages of the COVID-19 pandemic). Those sections were more focused on conveying ideas through simple processes (e.g., acceleration or rotations) and considering how they related to the space. I am pleased with the *Mélodrames,* as with these

sections I was finally able to both integrate and communicate the rotation of the system and its harmonicity (purely transformed data). This was the result of starting to consider not just the musical material by itself, but how it relates to the space (the planetarium), how it was performed (the disposition of the musicians and the use of the pre-recorded material), and how it relates to the visuals and the text ("when") and to the subject matter ("why").

- *TRAPPIST-1* was created very slowly in very distinctive creative cycles, being the last piece to be fully completed. The more Gavin Stewart and I delved into our respective research projects, the more distilled ideas we were able to apply to the composition of this piece. Theoretically, and guided by the result of the mock recording, in this piece, most of the ideas showcased in this research crystallised. The planetary system is communicated both directly and faithfully, taking into account how and what is performed in relation to a space that is created by the same musical material (the sonic rotation of the electronics determines the performance space). Furthermore, we also integrated the human side of the discovery by engaging with Dr Amaury Triaud's experiences and by delivering the knowledge that we currently have about this subject matter. We are looking forward to eventually performing this piece, as it was not possible for us during this research project due to the delays caused by the COVID-19 pandemic. Once it is performed live, we will be able to assess properly if the performativity and the elements of engagement with the performance space are effectively communicating the subject matter of this work.

To finish, and considering the interdisciplinary approach of this research project, I am confident that the techniques and strategies presented in the portfolio are transferrable to other artistic practices in the art and science context. Techniques

such as appropriation, transformation of data, or text setting are common practices in many artforms. However, their use in an interdisciplinary setting, considering how they relate to each other and if they are effective in communicating an idea, can help to engage and intertwine deeply with a specific subject matter and to operate at more meaningful levels. In a socioeconomic context in which fake news, lies, global warming, radicalisation, or virtuality are impacting our society so strongly, engaging with truthful research in art and trying to communicate truthful ideas and statements is, I believe, capital to help showcase the different realities we live in and raise the necessary awareness to promote positive changes in our communities.

5 Appendices

5.1 Appendix 1: In response to Naum Gabo: Linear Construction in Space No. 1

In response to Naum Gabo: Linear Construction in Space No. 1, site-specific music-theatre piece for voice, flute, trumpet, and violin. March 2020.

Performance materials:

- Voice score (PDF)
- Trumpet score (PDF)
- Flute score (PDF)
- Violin (PDF)

Video documentation of a performance of *In response to Naum Gabo: Linear Construction in Space No. 1* at the Barber Institute of Fine Arts on the 3rd of March 2020.

5.2 Appendix 2: Autohoodening: The Rise of Captain Swing

Autohoodening: The Rise of Captain Swing, operatic folk protest masquerade for voices and folk band. August 2021.

Songbook (PDF)

Folk band support materials (PDF)

Research materials (PDF).

Film version of *Autohoodening: The Rise of Captain Swing*, as shown at the 2022 Lulea Biennalen at the Havremagasinet Länskonsthall in Boden (Sweden).

Digital theatre trailer to *Autohoodening: The Rise of Captain Swing* filmed and recorded during the COVID-19 lockdown in late 2020.
https://youtu.be/vjnBxD50kLQ

5.3 Appendix 3: The Flowering Desert

The Flowering Desert, opera for planetariums for soprano, mezzo-soprano, SATB chorus, violin, viola, cello, flute, clarinet, French horn, piano, percussion, and optional electronics. April 2022.

Full score (PDF)

Video documentation of a dress rehearsal of *The Flowering Desert* at the Birmingham Think Tank Planetarium on the 18th of January 2023.

Full studio binaural recording of *The Flowering Desert* (please use headphones to experience the surround effect):

- 1 – Overture
- 2 – Scene 1
- 3 – *Mélodrame* 1
- 4 – Scene 2
- 5 – *Mélodrame* 2
- 6 – Scene 3
- 7 – *Mélodrame* 3
- 8 – Scene 4
- 9 – *Mélodrame* 4

5.4 Appendix 4: TRAPPIST-1

TRAPPIST-1, music-theatre piece for Kingma system flute and electronics. July 2023.

Full score (PDF)

Mock binaural recording of *TRAPPIST-1* (please use headphones to experience the surround effect):

- 1 – Scene 1 – "Exoplanet hunter"
- 2 – Scene 2 – "Atacama"
- 3 – Scene 3 – "Discovery"
- 4 – Scene 4 – "Announcement"

Score follower video (binaural recording)

6 References / Bibliography / Discography

Alley, R. (1981) *Catalogue of the Tate Gallery's Collection of Modern Art other than Works by British Artists*, London: Tate Gallery and Sotheby Parke-Bernet, pp.231, 251.

Amazon (2016) *Introducing Amazon Go and the world's most advanced shopping technology*. [video] Available at: youtu.be/NrmMk1Myrxc [Last accessed 30 September 2023].

Arends, B. and Thackara, D., eds. (2003) *Experiment: conversations in art and science*. London: Wellcome Trust.

Ayres, R. (2010) *In the Alps. Nederlands Blazers Ensemble,* Barbara Hannigan (soprano). [CD] (NBECD026).

Bankes-Jones, B. (2008) Time to sing a new tune. *The Guardian*, 25 July. Available at: https://www.theguardian.com/music/2008/jul/25/classicalmusicandopera [Last accessed 1 October 2023].

Banksy (2018) I've made a flag for the big match… *Instagram*, 6 July. Available at: https://www.instagram.com/p/Bk5Pqp6hW-V/?hl=en [Last accesses 2 October 2023].

Barbieri F. A. (1890) *Cancionero Musical de los Siglos XV y XVI*. Madrid: Real Academia de Bellas Artes de San Fernando.

Baroja, C. J. (1979) *El Carnaval.* Madrid: Alianza Editorial.

Barone, J. (2023) Prototype, an Essential New York Opera Festival, Turns 10. *New York Times,* 4 January. Available at: https://www.nytimes.com/2023/01/04/arts/music/prototype-festival-10-years.html [Last accessed 1 October 2023].

Barr, A. C., Dobos, V. and Kiss, L. L. (2018) Interior structures and tidal heating in the TRAPPIST-1 planets. *Astronomy and Astrophysics*, 613(A37). Available at https://doi.org/10.1051/0004-6361/201731992 [Last accessed 2 October 2023].

Barry, A. and Born, G. (2014) *Interdisciplinarity: Reconfigurations of the Social and Natural Sciences*. Abingdon: Routledge.

Benitez, G. (2017) Catalogue d'oiseaux de Oliver Messiaen. *Melómano Digital.* Available at: https://www.melomanodigital.com/catalogue-oiseaux-messiaen/ [Last accessed 2 October 2023].

Bowler, S. (2023) Planet Opera. *Astronomy & Geophysics,* 64(2). Available at: https://doi.org/10.1093/astrogeo/atad008 [Last accessed 2 October 2023].

British Music Collection (2004)

Britten Pears Arts (2023) *Woman at Point Zero, at The Royal Opera House*. Available at: https://brittenpearsarts.org/events/woman-at-point-zero [Last accessed 1 October 2023].

Cagney, L. (2022) Amaechi: Composers Wolters and Clancy tackle basketball & gay rights. *Raidió Teilifís Éireann*, 3 November. Available at: https://www.rte.ie/culture/2022/1017/1329713-amaechi-composer-wolters-clancy-tackle-basketball-gay-rights/ [Last accessed 2 October 2023].

Cambridge Advanced Learner's Dictionary & Thesaurus (2023) *ASMR.* Cambridge University Press. Available at: https://dictionary.cambridge.org/dictionary/english/asmr [Last accessed 2 October 2023].

Clancy, S. (2020) Translation as a Compositional Strategy. *Research Catalogue*. Available at: https://www.researchcatalogue.net/view/947247/947248/0/0 [Last accessed 2 October 2023].

Croasdale, R. (2022) A pint at the opera. *Ferment Magazine,* 83, pp. 58-61.

Drake, G. W.F. (2023) Thermodynamics. In *Encyclopaedia Britannica*. Available at: https://www.britannica.com/science/thermodynamics [Last accessed 2 October 2023].

Delfanti, A. (2021) *The Warehouse: Workers and Robots at Amazon*. London: Pluto Press, pp. 6, 30.

Dobos, V., Barr, A. C. and Kiss, L. L. (2019) Tidal heating and the habitability of the TRAPPIST-1 exoplanets. *Astronomy & Astrophysics,* 624(A2). Available at: https://doi.org/10.1051/0004-6361/201834254 [Last accessed 2 October 2023].

Dumbworld (2022) *The Scorched Earth Trilogy*. Available at: https://dumbworld.co.uk/project/the-scorched-earth-trilogy/ [Last accessed 2 October 2023].

Dundjerović, A. S. (2023) *Live Digital Theatre: Interdisciplinary Performative Pedagogies*. Abingdon: Routledge.

Dundjerović, A.S. (2009) *Robert Lepage*. Abingdon: Routledge.

Eaton, R. M. D. (2014) Marking Minimalism: Minimal Music as a Sign of Machines and Mathematics in Multimedia. *Music and the Moving Image*, 7(1), 3-23. Available at: https://doi.org/10.5406/musimoviimag.7.1.0003 [Last accessed 2 October 2023].

Ede, S., ed. (2000) *Strange and charmed*. London: Calouste Gulbenkian Foundation, pp. 56, 65.

Ede, S. (2005) *Art and science*. London: I.B. Tauris, p. 3.

Eldred, S. (2016) Art–science collaborations: Change of perspective. *Nature*, 537, pp.125-126. Available at: https://doi.org/10.1038/nj7618-125a [Last accessed 2 October 2023].

Foka Wolf (2023) From 2021, but here we go again… *Instagram,* 17 January. Available at: https://www.instagram.com/p/CnhiIgxjXSp/?hl=en [Last accessed 2 October 2023].

FRONTLINE PBS (2020) *Amazon Empire: The Rise and Reign of Jeff Bezos,* 00:35:53. [video] Available at: https://youtu.be/RVVfJVj5z8s?t=2153 [Last accessed 30 September 2023].

Gabo and Pevsner (1920) *Realistic Manifesto.* Available at: https://www.arthistoryproject.com/artists/naum-gabo/realistic-manifesto/ [Last accessed 2 October 2023].

Glass, P. (2023) *Galileo Galilei.* Available at: https://philipglass.com/compositions/galileo_galilei/ [Last accessed 2 October 2023].

Glass, P. (2008) Philip Glass and the roots of reform opera. In Tick, J. and Beaudoin, P.E., ed. *Music in the USA a documentary companion*. Oxford: Oxford University Press, p. 723.

Great-spacing (2019) *Aliens nearby? Planets TRAPPIST-1 are suitable for alien life.* Available at: https://great-spacing.com/publication/398/ [Last accessed 2 October 2023].

Griffiths, P. (1995) *Modern music and after.* Oxford: Oxford University Press, p. 181.

Griffiths, P. (2011) Stochastic Music. In: Latham, A. ed. *The Oxford Companion to Music.* Oxford: Oxford University Press. Available at: https://www.oxfordreference.com/display/10.1093/acref/9780199579037.001.0001/acref-9780199579037-e-6472 [Last accessed 2 October 2023].

Hall, G. (2008) An Inconvenient Truth: Opera in tune with the political climate. *The Guardian,* 2 June. Available at: https://www.theguardian.com/music/musicblog/2008/jun/02/operaintunewiththepolitic [Last accessed 1 October 2023].

Halprin, L. (1970) *The RSVP Cycles: Creative Processes in the Human Environment*. New York: George Braziller, inc.

Henley, D. (2022) We don't want to bring down the curtain on ENO, but opera has to change. *The Guardian,* 14 November. Availableat: https://www.theguardian.com/commentisfree/2022/nov/14/eno-opera-funding-arts-council-audiences [Last accessed 30 September 2023].

HOLO (2023) *HOLO.* Available at: https://www.holo.mg/ [Last accessed 2 October 2023].

Hoodening.org (2023) *Hoodening songs.* Available at: https://hoodening.org.uk/hoodening-songs.html [Last accessed 2 October 2023].

Indie Opera Toronto (n.d.) *Indie Opera Toronto.* Available at: http://indieoperatoronto.ca/ [Last accessed 1 October 2023].

Infinite Opera (n.d.) *Infinite Opera.* Available at http://infiniteopera.com [Last accessed 1 October 2023].

Inside Amazon (2014) *Amazon services recruiting video*. [video] Available at: youtu.be/KRdn71yG9Lk [Last accessed 30 September 2023].

Irvine, B. (2014) *Things We Throw Away: reinventing urban spaces through street art opera (70')*. Composition, Dublin. Available at: https://pure.ulster.ac.uk/en/publications/things-we-throw-away-reinventing-urban-spaces-through-street-art- [Last accessed 2 October 2023].

Jameson, F. (2012) *El postmodernismo revisado*. Madrid: Abada Editores.

Jameson, F. (1991) *Postmodernism or, the Cultural Logic of Late Capitalism*. Durham: Duke University Press.

Johnstone, K. (1979) *IMPRO, Improvisation and The Theatre*. London: Faber and Faber Ltd.

Jones, B. (n.d.) *Introduction to Hoodening*. Available at: https://hoodening.org.uk/index.html [2 October 2023].

Kaiser, R. I., Stockton, A. M., Kim, Y. S., Jensen, E. C. and Mathies, R. A. (2013) On the formation of dipeptides in interstellar model ices. *The Astrophysics Journal,* 765(2). Available at: https://iopscience.iop.org/article/10.1088/0004-637X/765/2/111 [Last accessed 2 October 2023].

Kemp, M. (2000) *Visualizations: the nature book of art and science*. New York: Oxford University Press, p. v.

Kennedy, S. (2003) Lighting conductor: IHOS' Tesla. *Realtime,* 53. Available at: https://www.realtimearts.net/article/issue53/7005 [Last accessed 2 October 2023].

Kessel, D. E.(2018) *The Kingma System Flute: Redesigning The Nineteenth-Century Flute For The Twenty-First Century*. Ph.D. Thesis. University of South California. Available at: https://scholarcommons.sc.edu/etd/4741 [Last accessed 2 October 2023].

Korda, R. (2020) *Infinite Opera Reflection,* p.4. Available at: https://barber.org.uk/wp-content/uploads/2020/12/Barber-Home-Infinite-Opera-Reflection.pdf

Korda, R. (2023) *'LIBRETTISING' SCIENCE: Using operatic narrative and performance to re-present scientific thought in an investigation of new methods towards developing contemporary opera*. Ph.D. Thesis. Birmingham City University.

Kramer, J. D. (2002) The nature and origins of musical postmodernism. In: J. I. Lochhead and J. H. Auner, eds. *Postmodern Music/Postmodern Thought*. New York: Routledge, pp. 13-26.

Lehmann, J. and Gaskins, B. (2019) Learning scientific creativity from the arts. *Palgrave Communications*, 5(96). Available at: https://doi.org/10.1057/s41599-019-0308-8 [Last accessed 2 October 2023].

Lessig, L. (2008) *Remix: Making Art and Commerce Thrive in the Hybrid Economy*. London: Bloomsbury Academic.

Lingam and Loeb (2018) Implications of Tides for Life on Exoplanets. *Astrobiology*, 18(7), pp. 967-982. Available at: https://doi.org/10.1089/ast.2017.1718

Lockwood, J. (2018) *Entomological Storytelling: Why We Wrote an Opera About Locusts (Really!).* Available at https://entomologytoday.org/2018/10/16/entomological-storytelling-opera-locusts/ [Last accessed 1 October 2023].

Luger, R., Sestovic, M., Kruse, E., Grimm, S. L., Demory, B., Agol, E., Bolmont, E., Fabrycky, D., Fernandes, C. S., Van Grootel, V., et al. (2017) A seven-planet resonant chain in TRAPPIST-1. *Nature Astronomy,* 1(0129). Available at: https://doi.org/10.1038/s41550-017-0129 [Last accessed 2 October 2023].

Maat Extended (2021) *Theatre Piece No. 1*. Available at: https://ext.maat.pt/bulletin/theater-piece-no-1 [Last accessed 2 October 2023].

Martin, S. (2018) Shock Alien discovery: TRAPPIST-1 planets ARE habitable to extraterrestrials. *Daily Express,* 7 September. Available at: https://www.express.co.uk/news/science/1014442/alien-discovery-trappist-1-solar-system-extraterrestrials-nasa [Last accessed 2 October 2023].

Merrian-Webster (2023) *Revolt.* Merrian-Webster.com Dictionary. Available at: https://www.merriam-webster.com/dictionary/revolt [Last accessed 2 October 2023].

Mortimer, N., Macdonald, D. Kargotis, D. (2021) *Autohoodening: The Rise of Captain Swing.* In: "Autohoodening: The Rise of Captain Swing", Lulea Arts and Crafts International Bienalle, Sweden, October 2022 - January 2023. [Performance]

NATUREVOLVE (2023) *NATUREVOLVE.* Available at: https://www.naturevolve.com/ [Last accessed 2 October 2023].

NASA Jet Propulsion Laboratory (2017) *NASA TRAPPIST-1 News.* [video] Available at: https://www.youtube.com/watch?v=cURfn6FH1Hs [Last accessed 2 October 2023].

Online Collections at University of Birmingham (2013) *Oval Form with Strings*. Available at: https://mimsy.bham.ac.uk/detail.php?t=objects&type=all&f=&s=barbara+hepworth&record=1 [Last accessed 1 October 2023].

Operabase (2023) *Statistics.* Available at: https://www.operabase.com/statistics/en [Accessed 29 September 2023].

Operomanija (2022) *About the Festival.* Available at: https://noa.lt/en/about-the-festival/ [Last accessed 1 October 2023].

Operomanija (2022) *NOA 8th Contemporary Opera Festival.* Available at: https://noa.lt/en/ [Last accessed 1 October 2023].

Organise platform (2018) *Amazon: What's it like where you work?,* p. 11-12. Available at: https://stylewise-blog.com/wp-content/uploads/2019/07/912fe-amazonwarehousestaffsurveyresults.pdf

Parra, H. (2013) Hypermusic Prologue A projective opera in seven planes. *Sonograma,* 18, pp. 1-17. Available at: http://sonograma.org/so/hector-

parra/Sonograma-Magazine-018-Hector-Parra-Hypermusic-Prologue.pdf [Last accessed 1 October 2023].

Pasachoff, J. and Pasachoff, N. (2009) Third physics opera for Philip Glass. *Nature,* 462(10), p. 724.

Payle, T. (2017) *Making music from exoplanets*. Available at: https://www.spitzer.caltech.edu/blog/making-music-from-exoplanets [Last accessed 29 February 2023].

Pearce, G. ed. (1906) *The Clarion Songbook*. London: The Clarion Press. Available at: https://archive.org/details/clarionsongbook00unse/page/n3/mode/2up [Last accessed 2 October 2023].

Pellegrinelli, P. (2009) *The Fat Alien Sings: A Klingon-Language Opera.* Available at: https://www.npr.org/2009/05/07/103903810/the-fat-alien-sings-a-klingon-language-opera [Last accessed 1 October 2023].

Polskie Wydawnictwo Muzyczne (2011) *Madame Curie*. Available at: https://pwm.com.pl/en/wypozyczenia/utwory-wg-kategorii/publikacja/madame-curie,elzbieta-sikora,17481,hirelibrary.htm [Last accessed 2 October 2023].

Powell, A. (2009) *Physics for the musical masses.* Available at: https://news.harvard.edu/gazette/story/2009/06/physics-for-the-musical-masses/ [Last accessed 1 October 2023].

Powers, K. (2018) *'PermaDeath,' An Opera About Playing A Video Game, Reveals Truths About How We Want To Live*. Available at: https://www.wbur.org/news/2018/09/26/permadeath-white-snake-opera [Last accessed 1 October 2023].

Post Workers Theatre (2021) *Autohoodening: The Rise of Captain Swing*. Available at: https://www.postworkerstheatre.com/swing [Last accessed 2 October 2023].

Prototype (n.d.) *Protype*. Available at: https://prototypefestival.org/ [Last accessed 1 October 2023].

Publicart.ie (n.d.) *Things we throw away*. Available at: www.publicart.ie/main/directory/directory/view/things-we-throw-away/ab71ec16b3385c5370412c82b0b5281f/ [Last accessed 30 September 2023].

Quinn, S. (2019) Shakespeare and Opera in the Twenty-first Century. *The University of Sidney,* 24 July. Available at: https://www.sydney.edu.au/news-opinion/news/2019/07/24/shakespeare-and-opera-in-the-twenty-first-century.html [Last accessed 1 October 2023].

Randel, D.M. (1996) *The Harvard Biographical Dictionary of Music*, p.999. Cambridge: Harvard University Press.

Reichle, I. (2009) *Art in the age of technoscience*. Wien: SpringerWienNewYork.

Scottish Opera (2019) *Spotlight on… Anthropocene*. Available at: https://www.scottishopera.org.uk/discover-opera/spotlight-on/spotlight-on-anthropocene/ [Last accessed 1 October 2023].

Scruton, R. (2001) Programme music. In: Root, D., ed. *Grove Music Online*. Available at: https://doi.org/10.1093/gmo/9781561592630.article.22394 [Last accessed 2 October 2023].

Selby, A. (2017) Timed toilet breaks, impossible targets and workers falling asleep on feet: Brutal life working in Amazon warehouse. *The Mirror*, 25 November. Available at: https://www.mirror.co.uk/news/uk-news/timed-toilet-breaks-impossible-targets-11587888 [Last accessed 30 September 2023].

Serpentine (2019) *Jennifer Walshe & Timothy Morton: TIME TIME TIME*. Available at: https://www.serpentinegalleries.org/whats-on/jennifer-walshe-timothy-morton-time-time-time/ [Last accessed 2 October 2023].

Seymour, C. (2019) Bill Bankes-Jones on the twelfth Tête à Tête Opera Festival. *Opera Today,* 21 July. Available at: https://www.operatoday.com/content/2019/07/bill_bankes-jon.php [Last accessed 1 October 2023].

Stewart, G. (2023) *The Shakuhachi retranslated: an exploration, expansion, and evaluation of new instrumental capabilities through the collaborative creation of new works for the Kingma System C flute*. Ph.D. Thesis. Royal Holloway, University of London.

Strosberg, E. (2015) *Art and science*. New York: Abbeville Press.

SYSTEM Sounds (2017) *TRAPPIST Sounds.* Available at: https://www.system-sounds.com/trappist-sounds/ [Last accessed 2 October 2023].

TATE (2023) *Naum Gabo.* Available at: https://www.tate.org.uk/whats-on/tate-st-ives/naum-gabo/naum-gabo [Last accessed 2 October 2023].

Tête à Tête (2018) *WEAR.* Available at: https://www.tete-a-tete.org.uk/event/wear/ [Last accessed 1 October 2023].

The Barber Institute of Fine Arts (2023) *CORNWALL AS CRUCIBLE – Modernity and Internationalism in Mid-century Britain.* Available at: https://barber.org.uk/cornwall-as-crucible-modernity-and-internationalism-in-mid-century-britain/ [Last accessed 30 September 2023].

The Barber Institute of Fine Arts (2023) *Edouard Manet (1832 – 1883).* Available at: https://barber.org.uk/edouard-manet-1832-1883/ [Last accessed 2 October 2023].

The Barber Institute of Fine Arts (2023) *Francisco Solimena (1657 - 1747).* Available at: https://barber.org.uk/francesco-solimena-1657-1747/ [Last accessed 2 October 2023].

The Barber Institute of Fine Arts (2023) *Jan Davidsz de Heem (1606 – 1683/4).* Available at: https://barber.org.uk/jan-davidsz-de-heem-1606-16834/ [Last accessed 2 October 2023].

The Barber Institute of Fine Arts (2023) *The Master of the Griselda Legend (worked around 1490 – 1500)*. Available at: https://barber.org.uk/the-master-of-the-griselda-legend-worked-around-1490-1500/ [Last accessed 2 October 2023].

The FACE of Amazon (2023) *The Former And Current Employees (FACE) of Amazon*. Available at: https://sites.google.com/site/thefaceofamazon/ [Last accessed 30 September 2023].

The Metropolitan Opera (2020) *John Adam's Doctor Atomic.* Available at: https://www.metopera.org/discover/education/educator-guides/doctor-atomic/ [Last accessed 2 October 2023].

TheSession.org (2023) *Searching tunes*. Available at: https://thesession.org/tunes/search [2 October 2023].

TRAPPIST-1 (2018) *SYSTEM.* Available at: http://www.trappist.one/#system [Last accessed 2 October 2023].

TRAPPIST-1 (2018) *TIMELINE.* Available at: http://www.trappist.one/#timeline [Last accessed 2 October 2023].

TRAPPIST-1 (2018) *TRAPPIST-1.* Available at: http://www.trappist.one/# [Last accessed 2 October 2023].

Triaud, A. and Gillon, M. (2017) *Dwarf planetary systems will transform the hunt for alien life.* Available at: https://aeon.co/ideas/dwarf-planetary-systems-will-transform-the-hunt-for-alien-life [Last accessed 2 October 2023].

Vivid Projects (2021) *Autohoodening: The Rise of captain Swing.* Available at: https://www.vividprojects.org.uk/programme/post-workers-theatre-autohoodening-the-rise-of-captain-swing/ [Last accessed 2 October 2023].

Walshe, J. (2016) *The New Discipline by Jennifer Walshe.* Available at: http://milker.org/the-new-discipline/ [Last accessed 2 October 2023].

Welsh National Opera (2022) *Migrations.* Available at: https://wno.org.uk/archive/2022-2023/migrations-will-todd [Last accessed 1 October 2023].

White Snake Projects (2018) *PermaDeath.* Available at: https://www.whitesnakeprojects.org/productions/permadeath-boston-2018/ [Last accessed 1 October 2023].

Wilson, S. (2010) *Art + science now*. London: Thames & Hudson.

Williams and WIlliams (n.d.) *NAUM GABO (1890 - 1977).* Available at barber.org.uk/naum-gabo-1890-1977 [Last accessed 30 September 2023].

WiseMusicClassical (2006) *Man on the Moon.* Available at: https://www.wisemusicclassical.com/work/69174/Man-on-the-Moon--Jonathan-Dove/ [Last accessed 2 October 2023].

Wolters, M. (2003) *Antarctica Duet.* Available at: https://wolters.co.uk/work/antarctica-duet [Last accessed 2 October 2023].

Wolters, M. (2004) *Kathryn und Peter durchqueren die Antarktis.* Available at: https://wolters.co.uk/work/kathryn-und-peter-durchqueren-die-antarktis

Wolters, M. and Taylor, A. (2015) *Ava's Wedding*. Available at: https://www.avaswedding.co.uk/ [Last Accessed 2 October 2023].

Zoom Support (2023) *Accessing meeting and phone statistics.* Available at: https://support.zoom.us/hc/en-us/articles/202920719-Accessing-meeting-and-phone-statistics [Last accessed 2 October 2023].