A Compositional Exploration of Auditory-Visual Synaesthesia

Corin Anderson

A thesis submitted in partial fulfilment of the requirements of Edinburgh Napier University, for the award of Doctor of Philosophy

June 2023

Declaration

This thesis is the result of my own independent work. It has not been submitted for any other degree or professional qualification.

Signed:  .....

Date: 28/06/2023 .....

Corin Anderson
Edinburgh, Scotland

Contents

List of Figures

List of Music Compositions Submitted as Thesis

This thesis comprises this textual document and the music album *Photisms* (to be released in 2023), which contains the following compositions:

1. Mindscape
2. Glue
3. Infinity Pyramids
4. Intersect
5. Shiraga
6. Balloons
7. Expansion
8. Everest
9. A XXI
10. Rust
11. Fluorescent

The audio files of these compositions can be downloaded from the following link:

https://bit.ly/CorinAndersonPhDMusic

This link also contains an audio file of a continuous mix of the entire *Photisms* album, which preserves the intended transitions between compositions.

List of Appendices

The following Appendices are included with this thesis:

- Composition A XXI Animation
- Expansion Levels 1-3 Animation (Unfinished Draft)
- Glue Animation (Unfinished Draft)
- Infinity Pyramids (Alternative Version)
- Infinity Pyramids (Original Idea)
- Mindscape (Original Idea)

These audio and video files can be downloaded from the following link:

https://bit.ly/CorinAndersonPhDAppendices

Abstract

This thesis is an autoethnographic exploration of how my music composition practice is influenced by my auditory-visual synaesthesia. I perceive music as coloured and textured shapes – 'photisms' – in my mind's eye. There are few first-person accounts of synaesthesia's impact on music composition processes and outputs. The aim of the study is to investigate how my synaesthetic experiences affect the music I make, through the creation and analysis of an album of electronic music titled *Photisms*. The accompanying textual document employs an autoethnographic method proposed by Chang (2008), providing a first-person account of my own synaesthesia and analysing how it influences my composition processes and outputs.

Firstly, I consider the impact timbre has on the shape and colour of my photisms. I discuss how various timbral transformation techniques can result in photism multiplication and emergence, and composite photisms (terms I have coined to define previously uninvestigated phenomena). Secondly, I explain how my photisms also appear to have texture and weight, and materialise as solid, liquid, gaseous, or plasma substances. The perceived weight and state of matter of musically-induced photisms is a formerly unexplored topic in academic literature. Thirdly, the spatiality and temporality of my synaesthetic visualisations of music are examined. I explain how the perceived location of my photisms can be defined using the Cartesian coordinate system, and how tempo and speed manipulation affect my synaesthetic experiences. Finally, I explain how, through a process of audiation, I can translate visual images into music by reverse-engineering my synaesthesia. This innovative approach to music-making has not previously been investigated.

Through examination of these four areas, this study demonstrates how auditory-visual synaesthetic experiences can affect, and be exploited in, the composition of electronic music.

Acknowledgements

I would like to thank my supervisors Dr Zack Moir, Dr Tree Burton, and Bryden Stillie for their guidance and advice throughout this research project. I am so grateful for their invaluable words of wisdom and mentorship over the past few years. I would like to thank my parents for their encouragement of my musical interests and ambitions throughout my time at school and university; I wouldn't be where I am today without it. I would also like to acknowledge the support of the John Leishman Memorial Trust and the McGlashan Charitable Trust. Most importantly, a special thanks to my fiancée Helena for her endless patience, support, and love; without which I could not have completed this project.

1. Introduction

1.1. Overview

Synaesthesia is a perceptual phenomenon experienced by around 4.4% of the population (Simner et al. 2006) where the stimulation of one sensory modality elicits a response in another (Asher and Carmichael 2013). Auditory-visual synaesthesia is one type of the phenomenon, where the perception of sound induces a visual, as well as auditory, experience for the affected individual. As an auditory-visual synaesthete myself, all sounds automatically and involuntarily induce the visual perception of coloured and textured three-dimensional shapes in my mind's eye.

My synaesthesia would be described as genuine and developmental since I have always experienced it: it has not been learned or acquired later in life (Johnson et al. 2013). My synaesthesia meets the five diagnostic criteria for genuine synaesthesia proposed by Cytowic (2002, pp67-69): it is (1) "involuntary but elicited", in that it occurs automatically, induced by a specific stimulus; (2) "spatially extended", in that the synaesthetic percepts are experienced in some kind of mental space; (3) "consistent and discrete", in that a specific inducer will consistently evoke the same identifiable percept over time; (4) "memorable", in that synaesthetic percepts are more vivid and better remembered than their inducing stimuli; and (5) "emotional", in that the link between inducer and concurrent synaesthetic percept is felt to be irrefutable and authentic. The third criterion is particularly important here: the consistency of my synaesthesia enables me to examine my visual responses to music.

Synaesthetic visual percepts are often called photisms (Colman 2008, Cytowic 2018). I find that musical sounds induce particularly vibrant, definable photisms. The appearance of each photism in my mind's eye can be described in terms of the following visual characteristics:

- The shape/form of each photism: determined exclusively by the inducing sound's timbre.

- The colour of each photism: determined by the inducing sound's timbre, musical key (if known) and musical note (if known).
- The brightness of each photism: determined exclusively by the inducing sound's pitch.
- The size of each photism: determined by the inducing sound's pitch and loudness.
- The surface texture of each photism: determined exclusively by the inducing sound's timbre.
- The state of matter of each photism: determined exclusively by the inducing sound's timbre.
- The weight of each photism: determined by the inducing sound's timbre, pitch, and loudness.
- The location of each photism: determined by the inducing sound's stereo position, pitch, loudness, and reverberation.
- The flickering, flashing, and pulsation of each photism: determined by the inducing sound's rhythm.

Sound timbre is the musical parameter with the biggest impact on the appearance of my photisms. Due to the infinite number of timbres that can be synthesised in the making of electronic music, there is no upper limit on the number of synaesthetic visual possibilities that might be induced. I compose and produce electronic music, perhaps in part due to this very reason; the photisms induced by the constantly-evolving timbres of electronic music make for a profoundly dynamic and unpredictable visual accompaniment to the music.

I wanted to discover how my auditory-visual synaesthesia affected my music composition processes and outputs, and so conducted autoethnographic research into my creative practice. This thesis is the product of that research and comprises an album of electronic compositions titled *Photisms*, the practice-based component, and this written component. It will explore: (1) how timbre can affect my visualisations of shape and colour; (2) how timbre can affect my visualisations of texture, state of matter, and weight; (3) the spatiality and temporality of my synaesthetic visualisations of music; and (4) how I am able to translate visual images into music by reverse-engineering my synaesthetic experiences. This is not a

traditional artistic PhD, where the music is paramount and the document is a separate critique; in my case, the music and document combine to create the thesis. The written component is of equal importance, as it provides an autoethnographic account of how I draw upon my synaesthetic experiences when creating music, and synaesthetically perceive the music I create. This thesis makes an original contribution to knowledge on the impact auditory-visual synaesthesia can have on music composition processes and outputs.

1.2. Personal Background and Rationale

I discovered in 2016 that I experienced synaesthesia, during the third year of my undergraduate Popular Music degree (a more detailed explanation of the phenomenon follows). In one composition class, my classmates and I were asked to describe the images that came to mind when listening to a specific work of music. While my classmates described realistic scenes such as “boats in a harbour” and “the sun setting behind trees”, I instead reported experiencing abstract coloured and textured shapes in my mind’s eye. I was surprised to learn that the perception of musically-induced visualisations – something I had always considered to be a normal, universal trait – was actually a very uncommon perceptual phenomenon. Synaesthetes are often surprised to learn that others do not perceive the world in the same way as them (Cavallaro 2013). Certainly, my experiences were so normal to me that I had always just assumed that everyone could “see” sound. The purpose of this PhD is to learn more about my synaesthesia, why my visualisations of music look the way they do, whether the phenomenon plays a role in my composition processes, and, if so, how it influences the music I compose.

1.3. Scholarly and Artistic Context

Auditory-visual synaesthesia is a type of synaesthesia where hearing sounds induces the visual perception of coloured and often textured shapes, usually in three dimensions (Chiou et al. 2013, Ward 2017). Synaesthetes are often defined as associators if their photisms are visualised internally in the mind’s eye, or projectors

if their photisms are ‘seen’ in space around them (Dixon et al. 2004, Mohr 2013, Smilek et al. 2001). My photisms appear in my mind’s eye and so I would normally be defined as an associator synaesthete.

Most auditory-visual synaesthetes’ photisms have both colour and shape (Adeli et al. 2014, Menouti et al. 2015, Ward 2017). A study by Jacobs et al. (1981) found that the visual appearance of auditory-visual synaesthetes’ photisms varied considerably from person to person, with reports ranging from kaleidoscopic images to flames, plaids, lightbulbs, and flashes and sprays of white and coloured light. Dependent on the inducing sound’s timbre, pitch, and dynamics, my photisms can take on any of these forms. Timbre, in particular, has a major impact on the visual appearance of my photisms.

Eagleman and Goodale (2009) found that some synaesthetes’ photisms also appeared to be textured, while a small number have also reported their photisms appearing to be made of a particular state of matter (e.g., solid, liquid, or gaseous substances) (Sinha 2009, Sulser 2009, Zigler 1930). My photisms also have texture and appear in my mind’s eye as solid, liquid, gaseous, or plasma objects.

I find that my synaesthetic visual experiences induced by music can be equally as enjoyable and fascinating as the music itself. I am therefore particularly drawn to electronic music due to the unlimited timbral possibilities that can be created, and the infinite assortment of photisms that these sounds will induce. I particularly enjoy, for both their sonic and synaesthetic visual qualities, the works of electronic composer/producers such as:

- Jon Hopkins, e.g., *Insides* (2009), *Immunity* (2013), *Singularity* (2018a);
- Nathan Fake, e.g., *Providence* (2017), *Blizzards* (2020), *Crystal Vision* (2023);
- Rival Consoles, e.g., *Persona* (2018), *Now Is* (2022);
- Bicep, e.g., *Bicep* (2017a), *Isles* (2021);
- Burial, e.g., *Untrue* (2007), *Nova/Moth* (2022);
- Four Tet, e.g., *New Energy* (2017), *Sixteen Oceans* (2020a);
- George FitzGerald, e.g., *Stellar Drifting* (2022);
- Boards of Canada, e.g., *Tomorrow’s Harvest* (2013);
- and Max Cooper, e.g., *Yearning for the Infinite* (2019).

As an electronic music composer/producer myself, I work with sound: manipulating timbres and sequencing synthesised sounds and recorded and processed audio in my Digital Audio Workstation (DAW), Logic Pro (Apple 2021). I make the music I want to hear and, as a result, my work is not sonically dissimilar to that of the artists listed above. Like with some of these artists, I often record “found sounds” that I come across in my everyday life that I find to be sonically and synaesthetically-visually appealing, and use these as the bases of new compositions. These are combined with synthesised sounds, created and processed with software and hardware synthesisers and effects units to be sonically and synaesthetically-visually congruous with existing material.

The music I compose is not audiovisual since there is no (physical) visual component to them (other than the synaesthetic visualisations they induce for me). However, my crossmodal approach to music composition could still be compared with those of audiovisual composers. Harris (2022, p84) defines composing audiovisually as “to consistently think about and account for both the sonic and visual components of the work, not as isolated elements but as part of a cohesive whole”. While the “visual component” of my work exists only in my mind’s eye, my synaesthetic visualisations play an important part of my composition process, as the following chapters will go on to discuss. When thinking about my compositions and how they sound, it is impossible to not also visualise them by picturing the synaesthetic photisms they induce. The sonic and (synaesthetic) visual components of my compositions are therefore, in my mind at least, “part of a cohesive whole” (ibid.).

Garro (2020, p7), meanwhile, points out that audiovisual composers may choose to construct their own “audiovisual language […] using association strategies relating one or more parameters of audio material to one or more parameters of the visual, including the profile of their behaviour in time”, noting that mappings between the two domains are idiosyncratic and may not always be obvious to the viewer/listener. Unlike these audiovisual composers, the construction of an audiovisual language is not a part of my own creative process: my auditory-visual correspondences (how I map sound properties to visual properties) are instinctive, inevitable, and incessant. My awareness of my auditory-visual correspondences has enabled me to reverse-

engineer my synaesthesia, thus allowing me to translate visual stimuli into musical ideas, as discussed in Chapter 5.

1.4. Original Contribution to Knowledge

Several contemporary musicians have identified themselves as synaesthetes and discussed the influences their experiences have on their creative processes. Pharrell Williams claims to have been inspired by his synaesthetic experiences when writing lyrics (Seaberg 2011), while Lorde visualises her ideas for new songs in her mind's eye and describes the songwriting process as "getting the actual thing to sound like what I've been seeing" (as quoted in Weiner 2017). Meanwhile, Kanye West compares his composition/production work with creating visual art, stating in an interview: "I have a condition called synaesthesia where I see sounds. I see them. Everything that I sonically make is a painting." (West 2016). Aside from a few anecdotal accounts, such as those mentioned above, there has to date been no scholarly research conducted into how synaesthesia can affect musicians' composition processes and outputs.

There has been a breadth of research conducted into both the *potential causes* of synaesthesia (see Meier and Rothen 2015 for a review of the most prevalent theories on this) and the *nature* of auditory-visual synaesthetic experiences (see, for example, Chiou et al. 2013, Eagleman and Goodale 2009, Mills et al. 2003, Orlandatou 2015, Ward et al. 2006, and Curwen 2018 for a review of literature on characteristics of musically-induced auditory-visual synaesthesia). However, as noted by van Campen (2010), research into auditory-visual synaesthesia has mostly focussed on the perception of musical notes as colours. This subtype of auditory-visual synaesthesia is often called 'chromesthesia' – a name I do not use in this thesis, due to it defining synaesthetic experiences in which colour is the primary focus. Although my photisms are coloured, it is their shapes and textures that are the most vivid aspects of my synaesthetic experiences. This thesis therefore contributes knowledge to the underresearched topic of musically-induced shape and texture in auditory-visual synaesthesia.

While there have been several retrospective discussions on synaesthetic artists' work (see, for example, Bernard 1986, Harrison and Baron-Cohen 1994, van Campen 1999, and van Campen 2010), some first-person accounts of the impact synaesthesia has on individuals' perceptions of music (including Day 2013, Rudenko and de Córdoba Serrano 2017, and Vanhalen 2020) and a small number of academic first-person accounts by synaesthetic artists on how their experiences influence and affect their creative practice (including Lee 2018, Püschel 2017), my thesis is the first autoethnographic account of the phenomenon's role in the composition of (electronic) music. By providing an insight into how my synaesthetic experiences affect my composition processes and outputs, I am making an original contribution to knowledge in a previously unexplored intersection between music composition practice, synaesthesia, and autoethnography.

This research will also inform non-synaesthetic readers and composers who may wish to investigate or develop alternative approaches to music composition. My auditory-visual correspondences play a major role in my co-opting and adapting of visual stimuli to inform and inspire new music compositions, and are discussed throughout this document. This research might contribute to the development of new approaches to audiovisual composition and the reverse-engineering of synaesthesia for creative purposes.

1.5. Aims and Objectives

This research is exploratory in nature and, as such, I entered into it with one question I hoped to answer: "In what ways, if any, does my auditory-visual synaesthesia impact on my music composition processes and outputs?". I believed that, if I were to explore the correlations between musical parameters and synaesthetic visual characteristics (e.g., timbre and shape of photism, panning and horizontal position of photism), I may be able to ascertain whether my synaesthesia did indeed affect my creative processes.

My synaesthetic experiences tend to resemble abstract artworks and, since I prefer some abstract artworks over others, it stands to reason that I must also prefer my synaesthetic visualisations of certain music works over others. I hoped that, by

analysing my autoethnographic data for themes (e.g., that I enjoyed the visual experience of, say, red angular photisms more than blue rounded photisms), I could find links between my synaesthetic preferences and my musical-decision making. I sought to achieve this by composing a significant amount of music (that I later developed into my album *Photisms*) and concurrently interrogating my creative processes and synaesthetic perceptions of the works themselves.

As my research progressed, I identified the following areas of investigation that I wished to explore further:

1. How timbre affects my visualisations of shape and colour.
2. How timbre affects my perceptions of texture, state of matter, and weight.
3. The spatiality and temporality of my synaesthetic experiences.
4. How my auditory-visual synaesthesia can be reverse-engineered in order to translate visual images into musical ideas.

Through exploration of the first three areas of investigation, I intended to learn more about the appearance and spatial/temporal nature of my photisms. I then intended to use this newfound knowledge about my photisms to inform my approach to the fourth area of investigation.

To clarify, the aim of this thesis is *not* to investigate the causes of my (or anyone else's) auditory-visual synaesthesia. Owing to the fact that we all "experience the world […] in fundamentally singular ways" (Cavallaro 2013, p33), I do not intend to make any sweeping generalisations and erroneously suggest that my findings apply to all other auditory-visual synaesthetes or synaesthetic composers. Every auditory-visual synaesthete's experiences are different; a sound might induce the visual sensation of a blue rubber ball for one synaesthete and a red metallic prism for another. This thesis will therefore focus solely on my own synaesthetic experiences and how these have inspired and affected the creation of several new compositions. I do, however, hope that my research into my auditory-visual synaesthesia's impact on my creative practice will encourage other synaesthetic musicians to explore how their own unique perceptual experiences can inspire and influence the creation of new works.

1.6. Methodology

1.6.1. Artistic Research

My thesis is a hybrid of artistic research and autoethnography. The knowledge I am interested in attaining is practical knowledge; “learning through doing”, or “know how” (Nelson 2013, p42). Nelson (ibid., p9) describes this type of knowledge as that “which might primarily be demonstrated in practice – that is, knowledge which is a matter of doing rather than abstractly conceived and thus able to be articulated by way of a traditional thesis in words alone”. My practice is in itself a research method and, through this research, I seek to understand how my thinking affects my doing (ibid.); how my synaesthetic perceptions affect my creative practice.

According to Noë (2015, p101), “Works of art put our making practices and our tendency to rely on what we make, and so also our practices of thinking and talking and making pictures, on display”. I believe that, through gaining a better understanding of my creative processes, and synaesthesia’s role in it, I can refine my existing creative practice methods and potentially also establish new ones. I hope that this will, in turn, improve my compositions and help me to discover my own artistic voice. This is something that I value deeply: I want my compositions to sound unique and identifiably created by me. While I hope that others will enjoy my music and be intrigued by (and potentially even inspired by) my synaesthetic accounts, the music I am creating is primarily for my own enjoyment.

At the centre of this research, is an interpretivist philosophy: a research paradigm or “a lens through which we view the world” (Collins 2010, p38). According to Collins, interpretivism is concerned with meaning-making, “reject[s] the objectivist view that meaning resides within the world independently of consciousness” (ibid., p38), and attests that meaning resides “between a conscious, meaning-making subject and the objects that present themselves to our perception” (ibid., p39). I intend to make (musical) meaning from my synaesthetic experiences: my own unique perceptions of the world around me. I acknowledge my subjective viewpoint as both researcher and subject, but consider the adoption of both roles an unavoidable inevitability due to my unique perceptions of the world; no two synaesthetes’ experiences are identical and so any attempt to generalise my findings would be misguided.

Collins (2010) identifies several interpretivist research approaches including arts-based methods, autobiography, and ethnography. In this PhD research, I utilise an arts-based method and a combination of autobiography and ethnography: autoethnography.

The artistic component of my thesis is practice-based in nature, since "the creative artefact is the *basis* of the contribution to knowledge" (Skains 2018, p86). The practice-based method, according to Skains (ibid., p86) "is applied to original investigations seeking new knowledge through practice and its outcomes". Nelson (2013) suggests that creative practice can itself be a form of research in its own right: that the development of technique or process and the findings that may arise from such practice are valid forms of knowledge-creation. I believe this is true of my own composition practice.

Through the composition of original music, I have developed new approaches to music composition and have made several compelling discoveries about my creative processes. The musical works I have composed are evidence of this and are, in themselves, contributions to knowledge. Nelson defines this form of investigation as practice *as* research, comparing it with practice-based research, which he describes as "research which draws from, or is about, practice but which is articulated in traditional word-based forms" (ibid., p10). However, I would argue that my work constitutes both practice-*as* and practice-*based* research, due to the equal importance of the music and this textual document. In Skains' (ibid., p86) definition of practice-based research, "The creative artefact is accompanied by a critical discussion of the significance and context of the claims, and a full understanding can only be achieved through the cohesive presentation of the creative artefact and the critical exegesis". In my case, both components of the thesis – the music and this textual document – must be considered in order to fully understand my thesis's contribution to knowledge.

1.6.2. Autoethnography

The introspective nature of my research also required me to employ a method that offered "nuanced, complex, and specific knowledge about particular lives,

experiences and relationships rather than general information about large groups of people" (Adams at al. 2014, p21). I decided that an autoethnographic method would suit my research aims well, due to its focus on self-reflection which, according to Chang (2008), "can lead to self-transformation through self-understanding" – precisely what I hoped to achieve with regards to my compositional processes. Adams et al. (2014, p23) claim that, by "using narrative and storytelling to research and represent experience, autoethnographers […] attend to *how* narratives and stories are constructed and told. […] this means studying and practicing the methods and means for conducting *research*, as well as studying and practicing the mechanisms and means for making *art*." Since my research is into my own compositional processes and outputs, I decided to take this a step further, by "studying and practicing the methods and means for conducting research" *into* my "mechanisms and means for making" music (ibid., p23). Skains (2018) advocates "the employment of a self-directed form of ethnomethodology during the composition of the texts, in the form of a research log (noting insights, process, difficulties), and draft materials and revision notes (which can later be analysed as *in situ* utterances)" (p87). She suggests the use of autoethnography, "as creative research questions are often inseparable from artist identity, experiences, and culture" (ibid., p88). Throughout the composition process and retrospectively, I utilised the occurrence recording method proposed by Chang (2008). The method will be discussed in greater depth in each of the respective chapters.

1.6.3. Artistic Research *as* Autoethnography

It is worth noting that the practice-based component of my thesis could also be described as a form of autoethnography in and of itself. Adams et al. (2014, p83) propose that "[b]ecause autoethnography is the study of culture through the lens of the self, separating the content of the text from the form of its representation is not desirable or possible", while Ellis and Bartleet (2009) suggest that the 'doing' of autoethnography as a research method can legitimately extend beyond the writing and analysis of text to explore "the auditory world of musical sounds and relationships" (p6). This reframing of musical composition as a form of *autoethnography itself* elevates it beyond the status of a mere lens through which my

synaesthetic experiences can be analysed and explored in an autoethnographic text at a later date.

In considering musical composition a form of autoethnography in its own right, I intend for my own compositions to play as important a role in the story I aim to tell as the accompanying textual document that seeks to make sense of the intentions behind, processes involved in the creation of, and reflections on these musical works. This document should be considered of equal importance as my portfolio of compositions. It is only through the combination of both portfolio and commentary that my autoethnography is complete.

1.6.4. Digital Autoethnography

While my synaesthetic experiences are unique to myself, and therefore my findings cannot be arbitrarily applied to other synaesthetes, my research should not and cannot be considered in complete isolation from the wider cultures of which I am a member. According to Chang (2008), culture is “a web of self and others” (p15). The culture that I seek to learn more about is my own; the “web” that I find myself wrapped up in, consisting of musicians (especially electronic music composers and producers), listeners, friends, family, and crucially other synaesthetes. Chang argues that “[t]he notion of “individual culture” does not, and should not, imply that culture is about the psychological workings of an isolated individual; rather, it refers to individual versions of group cultures that are formed, shared, retained, altered, and sometimes shed through human interactions” (p17). Referencing Gajjala’s (2004) cyberethnographic work, Chang (2008) points out that these interactions can occur in the digital realm. This strikes me as especially relevant to my own research, since much of it took place during the 2020 and 2021 COVID-19 lockdowns in Scotland, where face-to-face human interaction was severely restricted and virtual socialisation became the norm for many.

For many months, my own experiences of social interaction were mostly limited to online discussion forums, video conferencing software, and other virtual platforms. I immersed myself in the thriving online culture of synaesthetes and networked with and asked questions of like-minded individuals in social media groups and email

forums. I also used file-sharing sites to share my music with peers for feedback. Furthermore, technology has also facilitated my recording and analysing of my autoethnographic data; I used the word-processing software Pages (Apple 2021a) to record my autoethnographic notes throughout the composition process. This is not without precedent: Neil (2017) made use of “Digital tools such as a digital voice recorder, Go-Pro headcam, and private and public digital platform” (p47) to observe her practice in an autoethnographic study of her creative processes in the making of visual arts. Technology is therefore as embedded in my autoethnographic methods as it is in the practice-based methods.

1.6.5. Musicking with Technology

Digital technologies not only played a crucial role in my (virtual) interactions with others in my culture “web” and autoethnographic methods, but also in my musicking. Small (1998, p9) defines musicking as “to take part, in any capacity, in a musical performance, whether by performing, by listening, by rehearsing or practicing, by providing material for performance (what is called composing), or by dancing”. Regardless of whether I am listening to, audiating, or composing music, I am always visualising synaesthetic photisms: my mind perceives (sound) and creates (photisms) simultaneously. In other words, my synaesthetic experiences are an integral part of my musicking. Noë (2015, p97) points out that: “The world acts on us and changes our brains. But we act right back on the world, and so we change what there is changing us. We do so just by moving, not to mention by making, doing, taking hold.” In my case, music listening is not a passive experience. Upon listening to another artist’s composition, I may be inspired by the sounds and synaesthetic visuals I perceive and, as such, decide to borrow sonic and visual ideas to utilise in my own work.

Listening, of course, also has an important role to play in my composition process. This process tends to consist of a cycle of the following three stages: audiation, production, and listening. A sound or musical idea is audiated (Gordon 1999): conceived in my mind’s ear (and its corresponding synaesthetic photism in my mind’s eye). This sound or musical idea is then produced in my DAW. Listening back

to the sound or musical idea induces a synaesthetic photism. I will then audiate changes I wish to make, make these changes in the DAW, and listen back to these changes. The cycle repeats until I am content with the result. In this thesis, I therefore treat music listening as equally as valid a musical activity as composing, and therefore equally as worthy of interrogation.

I am only able to enjoy the auditory and synaesthetic visual experiences of listening to my own and other artists' music due to the affordances of digital technologies. I regularly listen to and discover music using the digital streaming service Spotify (2022), while my compositions are produced using the Logic Pro (Apple 2021b) Digital Audio Workstation on my MacBook laptop. Tuuri and Koskela (2020) argue that our use of digital streaming services have transformed the ways in which we engage with music – how we partake in musicking – while Steinert (2016) points out that we often perceive the world through the tools we use and that, the more one uses these tools, the more transparent they become; they "extend our sense perception" (p65).

According to Nijs et al. (2013), and drawing upon extension theories of technology including the *embodiment relationship* theory proposed by Ihde (1990), the musical instrument – the "tool" of the musician – functions as "a natural extension of the musician" (p6). My instrument is, of course, the laptop (running a Digital Audio Workstation loaded with virtual synthesisers and samplers) which I would argue has become a cognitive extension of myself, due to the transparency my familiarity with the instrument has afforded me, and an integral part of my creative processes. Magnusson (2009, p168) describes digital musical instruments as *epistemic tools*: "a designed tool with such a high degree of symbolic pertinence that it becomes a system of knowledge and thinking in its own terms". This is a view shared by Strachan (2017, p7) who notes that "the computer environment should not be understood as a neutral way of recording, capturing and presenting sound but as highly influential to the creative process in its design, construction and capability which in turn have a central influence on the sounds and eventual recordings that are produced". Many of my compositional processes are at least partially a result of techniques I have developed and habits I have picked up working in Logic Pro for several years, including my use of sidechain compression and gating, filter sweeps,

and grid-based sequencing and editing. I therefore acknowledge that my musicking is shaped as much by the tools I use as it is by my synaesthesia and artistic influences.

1.6.6. Summary of Methodology

To summarise, my methodological position could be defined as the following: Through an investigative process involving autoethnography and practice-based/-as research, I am interested in learning how my synaesthetic experiences impact on my musicking – that is, the audiation of, composition of, and listening to music, mediated by music technology which I view as a cognitive extension of the self – in order to refine my artistic methods and develop my own unique and identifiable artistic voice.

1.7. Methods

1.7.1. Data Recording Methods

Throughout the composition of new works of music for my portfolio, and shortly after their completion, systematic self-observational data on my synaesthetic experiences and composition processes were gathered using autoethnographic recording, analysis, and interpretation methods proposed by Chang (2008). The nature of the data I intended to work with (synaesthetic experiences during, and my opinions of, the music I was creating) necessitated the collection of data on *oneself* from the *present* (as opposed to drawing upon memories of past experiences). I chose to record this type of data since it "[gives access] to covert, elusive, and/or personal experiences like cognitive processes" (Rodriguez & Ryave 2002, p3), which was precisely what I intended to analyse. To record this data, I chose to use Chang's (2008) occurrence recording method, which warranted the recording of my synaesthetic experiences and the creative decisions I made during the composition process, *whenever they occurred*. I made use of both the on-site and retrospective recording variations of this method. Chang (ibid.) points out the limitations of on-site recording, arguing that, while thoughts and experiences can be recorded

immediately, therefore retaining their vividness and accuracy, there is a risk of disruption to the flow of thought. Conversely, retrospective recording maintains this natural flow, whilst potentially sacrificing a degree of accuracy. To make up for these shortcomings, I opted to use both variations, recording my thoughts both during the composition process and shortly afterwards. By using this method, which I found to be easily understandable, I was able to accurately and succinctly record descriptions of the photisms experienced while listening to my work, and the creative decisions I made during the composition process.

1.7.2. Data Analysis and Interpretation Methods

Chang differentiates between data analysis and interpretation, defining the former as the identification of relationships between data, and the latter as the formulation of meaning “in the researcher’s mind” (2008, p127). While analysing and interpreting data, Chang (ibid.) also notes the importance of “shifting [one’s] attention back and forth between self and others, the personal and the social context” (p125). Chang (ibid., pp131-137) suggests ten data analysis and interpretation strategies, of which I utilised four:

1. I *searched* for recurring themes, topics, and patterns in my autoethnographic data. I identified any mentions of photism shape/form, texture, state of matter, colour, brightness, size, weight, location, and pulsation, and found patterns between these and my accounts of the composition/production techniques I had utilised. I interpreted these patterns as my synaesthetic visualisations influencing the creative decisions I had made.
2. I *compared* my descriptions of my own visualisations of sound with those experienced by other synaesthetes, my use of composition/production techniques with those utilised by other musicians, and my translating between sonic and visual media with similar processes utilised by other synaesthetic artists.
3. I *contextualised* my findings by interpreting the data I had gathered through the lens of the various cultures I belong to (those of electronic music

producers and auditory-visual synaesthetes) and by acknowledging the influence and impact of external factors on my work and my experiences.

4. I *framed* my findings within existing theories, where appropriate.

In the discussion of my findings in the four chapters that follow, I utilise a combination of descriptive-realistic and analytical-interpretive writing styles. The descriptive-realistic writing style proposed by Chang (2008) was chosen due to its ability to "depict […] events as "accurately" as possible" (p143). Since my findings were predicated on my synaesthetic experiences and their role in the creative process while composing music, I felt it important that these experiences and decisions were described as accurately as possible. However, due to my need to extrapolate key findings from this raw data, I opted to intersperse my descriptive-realistic writing with analytical-interpretive writing. According to Chang (ibid., p146), with this form of writing, "essential features transcending particular details are highlighted and relationships among data fragments are explained." To avoid simply describing my synaesthetic experiences and creative decision-making, I therefore decided to write in an analytical-interpretive style in order to establish, contextualise, and interrogate the key findings from the studies.

1.8. Summary of Findings

I will now outline my key findings from this research project. I composed several works of music, analysed the autoethnographic notes I made during and shortly after the composition process, and identified four key themes from the data that I was keen to explore further: photism colour and shape; photism texture, state of matter, and weight; the spatiality and temporality of my photisms; and photism reverse-engineering. I composed works of music that explored all of these themes and continued collecting autoethnographic data. Having analysed and interpreted this data in full, I have uncovered the following findings.

The use of timbral transformation techniques including timbral mutation, transmutation, fusion, and fission (terms proposed by Roads (2015)) resulted in significant alterations to the shape and colour of my photisms. I find the results of these techniques to be enjoyable, from both a sonic and synaesthetic visual

perspective. Several compositions explore timbre and its effect on my perceptions of shape and colour.

I realised that I could also understand my photisms from a visual-tactile perspective. By visually-perceiving in my mind's eye my auditorily-induced photisms, I can understand what my photisms would *feel* like if they could be touched or held. In other words, each photism has a discernible surface texture, weight, and state of matter. Processing sounds to alter a sound's timbre changes these synaesthetic properties and so I composed several works to explore the tactilely-understood elements of my synaesthetic photisms.

I also learned how my photisms functioned in time and (mental) space. I found that I was able to map my photisms across three dimensions, using the Cartesian coordinate system, with each photism's location dependent on the inducing sound's panning, pitch, volume, and reverb level. The passing of time is not represented in my synaesthetic experiences as left-to-right movement, as is the case with many other synaesthetes. Instead, my photisms materialise, evolve, and dematerialise in real time and in perfect synchronisation with the inducing sounds. I created several compositions that explore the spatiality and temporality of my synaesthesia.

Bringing together the above findings, and with a better grasp of my auditory-visual correspondences, I subsequently learned to reverse-engineer my synaesthesia in order to translate visual images into sonic ideas to develop into full compositions, through a process of audiation (Gordon 1999).

1.9. Structure of the Thesis

As previously mentioned, this thesis consists of two equally-important parts: my portfolio of music and this textual document. The portfolio of music comprises the 11 works composed for my 85-minute album *Photisms* which, at the time of writing, has not yet been released publicly. I have provided audio tracks of the 11 compositions, which should be listened to in the following order:

1. Mindscape
2. Glue
3. Infinity Pyramids
4. Intersect
5. Shiraga
6. Balloons
7. Expansion
8. Everest
9. A XXI
10. Rust
11. Fluorescent

I have also included one audio file of a continuous mix of the album, which preserves, contextualises, and makes explicit the transitions between tracks. The portfolio also includes 18 minutes of early drafts and alternative versions of compositions, and unfinished animations referred to in the document.

The document is structured into the following sections:

1. Introduction
2. The Impact of Timbre on Visualisations of Shape and Colour
3. The Impact of Timbre on Visualisations of Texture, State of Matter, and Weight
4. Spatiality and Temporality
5. Translating and Reverse-Engineering
6. Conclusion

The Introduction chapter provides background and artistic and scholarly context to my research, establishes a gap in the literature and explains why this thesis is an original contribution to knowledge. It outlines my aims, objectives, and methodology, and summarises the key findings from, and structure of, the thesis.

The second chapter (The Impact of Timbre on Visualisations of Shape and Colour) investigates the role shape and colour play in my synaesthetic visualisations of music. Ward (2017, p307) notes that “colour is one common feature of the [auditory-visual synaesthetic] experience, but the sounds are almost always accompanied by

visual shape". There is a breadth of research on coloured synaesthesias but far less that explores synaesthetic visualisations of three-dimensional shapes. This chapter ascertains that timbre is the primary factor that determines the shape and colour of my photisms. In this chapter, I explore how timbre affects the shape and colour of my photisms, by analysing the timbral parameters that dictate the visual appearance of my photisms, and comparing my own experiences with those of other synaesthetes. I discuss the timbral transformation techniques utilised in many of my compositions and how these impact on my synaesthetic visualisations of shape and colour. I also hypothesise that many of the timbral transformation techniques I frequently utilise have come to characterise much of the music I make, and that my frequent use of these may be explained by my enjoyment of the resulting synaesthetic experience.

The third chapter (The Impact of Timbre on Visualisations of Texture, State of Matter, and Weight) explores additional properties of my photisms beyond their shape and colour. While usually tactilely understood, I am able to establish the perceived texture, state of matter, and weight of my photisms through visualisations alone. We are able to ascertain the tactile properties of an object through visual observation (Sun et al. 2016, Gallivan et al. 2014). It therefore stands to reason that, due to the visual detail of my photisms, I am able to 'just know' what they would feel like, what state of matter they would be made of, and how heavy they would weigh if they could somehow be interacted with. This chapter discusses how the texture, state of matter, and weight of my photisms have impacted on my composition processes and outputs.

The fourth chapter (Spatiality and Temporality) explores the mental space in which my photisms appear, and how I synaesthetically perceive the passing of time. As an associator synaesthete, my photisms are visualised internally in the mental space often referred to as the 'mind's eye' (Smilek et al. 2001, Dixon et al. 2004, Mohr 2013). The position of my photisms in my mind's eye can be explained using the three-dimensional Cartesian coordinate system. A photism's position on the X axis (left to right) is determined by the inducing sound's placement in the stereo field, its position on the Y axis (up and down) is determined by the inducing sound's pitch, and its position on the Z axis (front to back) is determined by the inducing sound's volume and reverb levels. The fourth dimension, time, is perceived as motion and

dynamic changes to the photism that occur in synchronisation with the music. This chapter discusses several works of music that explore the spatiality and temporality of my synaesthetic visualisations.

The fifth chapter (Translating and Reverse-Engineering) discusses three studies into my translating of sounds into visual images, and vice-versa, the latter two of which involve the reverse-engineering of my synaesthetic experiences – a technique which has only previously been explored by artist and synaesthete James Wannerton (Wannerton 2020, 2015; Nowness 2013). The “descriptive” study investigated whether it was possible to show others what I visualised when listening to music, by creating animations that represented my visualisations of two of my compositions. The “analytic” study which followed explored whether it was possible to translate in reverse (i.e., visual to auditory rather than auditory to visual) and convert an entire visual image into a music composition. Finally, the “aesthetic” study involved the translation of only specific aspects of visual stimuli into musical ideas, which allowed for more interpretation and creative freedom compared to the first two studies.

The Conclusion chapter summarises the overall findings from the project, evaluates the contribution of the research, and identifies limitations of the research and suggestions for future study.

2. The Impact of Timbre on Visualisations of Shape and Colour

2.1. Introduction

This and the following chapter focus on timbre, as the primary sonic characteristic that determines the shape/form, colour, texture, and state of matter of my photisms. By timbre, I mean the defining characteristic of a sound: what makes it unique and identifiable from other sounds. A piano's timbre, for example, is entirely different to that of a guitar; its timbre is what gives it its sonic identity. According to Roads (2015, p289), "timbre can be articulated by variations in waveforms, spectra, filters, modulations, MPEG-7 timbral descriptors, etc., all operating simultaneously".

Smalley (1986) and Wishart (1994) suggest that 'timbre' is an inadequate term to epitomise the multifaceted nature of a sound's spectral structure. Smalley (1986) posits that all sounds exist on a noise-note continuum. According to Smalley, a note (i.e., a sound with one or more discernible pitches) can be split into its 'note proper' (fundamental pitch), 'harmonic spectra' (overtones harmonically related to the fundamental) and 'inharmonic spectra' (overtones not harmonically related to the fundamental), noting the importance of morphology (the temporal dynamic profile of the note: e.g., its attack and decay) and motion (changes and patterns in spectral and dynamic shaping over time) in how we perceive and understand the sound. Wishart (1994), meanwhile, identifies several aspects of sound spectra including harmonicity, formant structure, and noisiness: all of which can be modified in both the frequency and time domains. For me, the harmonicity of a sound (how clear a specific pitch is) synaesthetically corresponds to how many colours and/or shades of a colour are present in a photism; formant structure corresponds to the compression and expansion of the shape of a photism (see Section 2.4.3); and noisiness corresponds to the roughness of the surface texture of the photism. A strong understanding of these sound spectra characteristics would undoubtedly be invaluable if I were to attempt to compose electroacoustic music in future. However, my own conceptual understanding of timbre comes mainly from my experience with subtractive synthesis: in particular, creating patches on my Juno-106 synthesiser (Roland 1984). This form of synthesis involves generating and blending sounds of

different waveforms (which induce photisms of different shapes), using filters to remove frequencies (which affects the lightness, sharpness, and size of the shape of the photism: see Section 3.3.3), and adjusting ADSR envelopes to affect how the sound evolves over time (which affects the perceived weight of the photism: see Section 3.3.3).

Regardless, it is evident that 'timbre' is almost impossible to classify and categorise and cannot be placed on a linear scale, like pitch can. For example, electronic music composer Brian Eno (cited in Scoates 2013) compares the unmappability of timbre with his futile attempt at classifying smells. For me, even minute changes in timbre can result in photisms changing shape, colour, surface texture, weight, and state of matter – often in unpredictable ways. As a result, my synaesthetic visualisations of musical works where timbre, and not melody, is the main focal point (e.g., Autechre's 'Gantz Graf' (2002), Terence Fixmer's 'When the Sun' (2012), Dot Major's 'Bear' (2023), Scuba's 'Gekko' (2012), Jon Hopkins' 'Open Eye Signal' (2013b), Max Cooper's 'Resynthesis' (2017), and Four Tet's remix of Bicep's 'Opal' (2018)) can be harder to predict and therefore tend to be more enjoyable to 'watch' than those of melodically driven compositions with static and predictable timbres (e.g., those of familiar, acoustic instruments such as the piano and guitar, played conventionally). The manipulation of timbre is therefore a prevalent feature of my own compositions, since I choose to create music that I find to be enjoyable both to listen to and 'watch'.

As pointed out by Ward (2017, p307), "colour is one common feature of the [auditory-visual synaesthetic] experience, but the sounds are almost always accompanied by visual shape, movement and/or texture perceived in some spatial location (often extending in three dimensions)." As explained in the Introduction, timbre is the sonic factor that has the most significant bearing on the appearance of my photisms. These two chapters will therefore concentrate on the impact of timbre on my synaesthetic visualisations. The most prominent features of these photisms are their shape, colour, surface texture, state of matter, and weight. Since an object's shape and colour are primarily perceived visually, while surface texture, state of matter, and weight tend to be understood tactilely (though can also be ascertained through visual observation (Sun et al. 2016)), this chapter will focus specifically on the visual appearance of my synaesthetic photisms, while the following chapter will

address the visually inferred perception of the photisms' surface texture, state of matter, and weight. This chapter will analyse the impact of musical timbre on the shape and colour of my photisms, and how the shape and colour of the synaesthetic photism of a sound can inform the composition of new works of music. The following chapter will then discuss how the perceived surface texture, state of matter, and weight of my synaesthetic photisms have inspired the creation of several compositions.

In this chapter, I will first give an overview of the role shape and colour play in my synaesthetic visualisations of music, comparing my own experiences with those discussed in literature. I will then in turn analyse how the transformation of timbre in my own composition practice has come to characterise much of the music I make, and impacts on the shape and colour of the corresponding synaesthetic photisms.

2.2. Synaesthetic Perception of Shape and Colour

According to Cytowic (2018), 40% of synaesthetes experience auditory-visual synaesthesia (also referred to as chromesthesia, sound-colour synaesthesia, and coloured-hearing), where sounds induce the perception of moving, coloured shapes. The visual perception of shape in auditory-visual synaesthesia is often associated with the aural perception of timbre; Ward (2017) notes the strong connection between timbre and shape in auditory-visual synaesthesia, while a study by Mills et al. (2003) found that the shape of the photisms perceived by auditory-visual synaesthete GS was primarily determined by a sound's timbre, and that the size of each shape was determined by the sound's pitch. Furthermore, both synaesthetic and non-synaesthetic participants in a study by Adeli et al. (2014) were also found to associate the aural perception of timbre with the visual perception of shape.

The colour of the forms perceived by auditory-visual synaesthetes is often influenced by timbre, instrument, and musical key, while the brightness of these colours tends to be determined by pitch, with lower and higher tones inducing darker and lighter colours, respectively (Mudge 1920; Menouti et al. 2015). This is absolutely true of my own synaesthetic visualisations of sound. In respect of timbre-induced colours, shades of red, orange, and yellow tend to be triggered by distorted and 'analogue'-

sounding electronic sounds, while cleaner and more 'digital'-sounding electronic timbres usually induce blues, greens, and purples.

When composing and listening to music, I frequently find myself being drawn to electronically produced timbres. Similar to how, with my grapheme-colour synaesthesia (another form of synaesthesia I experience, where numbers and letters induce the perception of colours), the names of monochromatic objects tend to suspend the standard colours I usually associate with letters and words[1], I can't help but associate the sounds of each instrument to their most prominent colour[2]. For this reason, I find that the resulting visual experience of sounds produced by acoustic musical instruments tend to be predictable and uninspiring. On the other hand, the colours of the corresponding photisms of electronically synthesised or heavily processed sounds are far less predictable, since these sounds are not determined by the physical form of an instrument or the material it is made from. A Digital Audio Workstation equipped with synthesis and effect plugins, for example, enables the user to produce, mould and arrange an infinite number of new sounds which induce an extensive mix of colours in my mind's eye.

I do also associate musical key and individual notes with colour; however, I suspect that these associations are not triggered by the aural perception of different keys and notes, but instead by my conceptual understanding of musical key/note. For example, if I was told that the work of music that I was listening to was in the key of D major, or that the note I was hearing was a D, I would visualise the colour orange, since I associate the letter D with this colour. My synaesthetic photisms of the music would be tinted orange regardless of whether the music really was in the key of D, or whether the note really was a D – it would only matter that I *understood* the music to be in the key of D or the note to be a D. A study by Ward et al. (2006) found that the association of musical notes with colour may be a by-product of grapheme-colour synaesthetic correspondences. This is likely to be true in my case, since the colours I associate with each musical note and key are the same as those that I associate with the corresponding alphabetical letter (e.g., A = red, B = blue, C = creamy beige,

[1] For example, I usually associated words beginning with the letter 'b' with the colour blue (e.g. brain, bell, bingo, best). 'Banana', however, is coloured yellow in my mind since bananas are yellow.

[2] Sounds produced by brass instruments, for example, tend to be coloured a yellowish gold.

D = yellowish orange, E = grey/silver, F = light brown, G = green), suggesting a conceptual association of musical note/key with colour, and not a perceptual one. In instances where I am aware of the key or note that I am hearing, my photisms are often tinted with the key/note's corresponding colour, however the dominant factor that determines the fundamental colour of each individual shape is timbre. When the key or note is unknown to me, the colours of my photisms are exclusively determined by timbre.

Associations between musical note and colour have formed the basis of several coloured music notation systems. Kuo and Chuang's (2013) proposed coloured music notation system, to aid beginner musicians in the development of their music-reading abilities, is based on auditory-visual synaesthetes' associations of musical notes with colours. Breaden (2020) surmises that this system could be uncomfortable for synaesthetes if the colours used in the notation did not match their own note-colour associations. I would go further and maintain that such a system would pose a significant challenge for any synaesthetic beginner-musician with their own note-colour associations. Figurenotes is a similar colour- and shape-based music notation system developed by Kaarlo Uusitalo and Markku Kaikkonen, which has since been adopted by Drake Music Scotland and developed into resources to help beginners learn music (Figurenotes n.d.). I recall a music performance class in which I was required to read and perform a work of music written using the Figurenotes system. This proved to be extremely challenging for me, since (with the exception of the grey-coloured E) all of the colours assigned to notes in the Figurenotes system were different to my own (see Figure 2.1).

The colours I associate with each musical note:	The colours that represent each note in the *Figurenotes* system (Figurenotes n.d.):
A (red)	**A (yellow)**
B (blue)	**B (green)**
C (cream)	**C (red)**
D (yellowish orange)	**D (brown)**
E (grey/silver)	**E (grey)**
F (light brown)	**F (blue)**
G (green)	**G (black)**

Figure 2.1.

My note-colour associations and the colours of notes in the Figurenotes system.

Seeing musical notes written in the "wrong" colour resulted in the Stroop effect (see Stroop 1935), which is often tested for to ascertain whether an individual has synaesthesia (Nikolić et al. 2007). Throughout the lesson, I frequently found myself playing the wrong notes. To make matters even more confusing for me, a range of shapes (crosses, squares, circles, and triangles) were used to signify the octave of the note (Figurenotes 2020), whereas I associate shapes with timbre. Contrary to the assertion "With Figurenotes, everyone can play" (ibid.), from personal experience, I would assert that colour- and shape-based music notation systems like Figurenotes have the potential to induce the Stroop effect in auditory-visual synaesthetes and, as a result, disadvantage musicians who experience the phenomenon.

I have so far ascertained that, in my auditory-visual synaesthetic visualisations of music, I associate shape with timbre, and colour with both timbre and musical key/note. Since the timbre of a sound determines both its corresponding photism's shape *and* colour, and since these coloured shape perceptions are consistent, certain shape and colour combinations frequently arise. Distorted and "raw" sounding timbres tend to induce the perception of angular shapes and warm colours (e.g., reds, oranges, yellows), while clean and soft sounding timbres tend to induce rounder shapes and cooler colours (e.g., blues, greens, purples). It is therefore unusual, although not unprecedented, for me to visualise a blue-coloured prism, or a red sphere, for example, when listening to music.

Having confirmed that the shape and colour of my synaesthetic photisms are primarily determined by timbre, I will now discuss how timbre in my musical compositions affects my synaesthetic perceptions of shape and colour and, conversely, how these perceptions influence my decision-making in the composition process.

2.3. Methods

2.3.1. Creative Methodology in Album Sequencing

Before focussing on the composition of individual tracks, I will first briefly outline the methods I used in selecting and sequencing tracks for my *Photisms* album. Several factors were considered during the album sequencing process. All compositions that were completed over the course of the research project were included in the album. I believed that to exclude any finished composition from the album would have made it feel incomplete, akin to omitting key-findings from this accompanying textual document. In deciding how to arrange the tracks within the album, so that it could be listened to and experienced as one cohesive creative work, the following factors were considered.

Firstly, I wanted to maintain a flow and logical continuation of musical and synaesthetic visual ideas. By having some tracks segue into each other, the photisms induced by the sounds in the first track appeared to endure and evolve into the next. Some tracks that induced photisms of similar shapes and colours were therefore placed next to each other; others were adjoined due to their shared or similar musical key or tempo, to convey a seamless musical transition. Any silent gaps between tracks were kept brief and timed to last multiples or divisions of a bar of the preceding track's tempo. This continuation of musical and synaesthetic visual ideas helped me to consider the album as one complete work by sonically and visually tying the compositions together in my mind.

Secondly, I also considered how the album would be experienced by other listeners when deciding how to sequence the album. Marketing-related decisions played a role in my decision to frontload the album with tracks that I believed to be more

commercial sounding. Considering many listeners only listen to the first few tracks on an album (Trust 2012), ‘Mindscape’, ‘Glue’, ‘Infinity Pyramids’, ‘Intersect’, and ‘Shiraga’, the tracks that I perceived as more danceable with clear and repetitive melodies and simple structures, were awarded the first five places on the track list. I placed ‘Balloons’, a slightly more restrained composition, directly after these high-energy tracks to act as a palette-cleanser. Aware that many listeners might not venture further than this point, I opted to hold back ‘Expansion’, ‘Everest’, and ‘A XXI’, the tracks that I considered to be slightly more challenging listens, for the second half of the album. I chose to have ‘Rust’ and ‘Fluorescent’ bring the album to a close due to the rousing finality I felt they conveyed.

2.3.2. Data Analysis and Interpretation Methods

During and shortly after the composition of each work of music, experiential autoethnographic data on my synaesthetic experiences and my creative practice was recorded. To discover how my perceptions of timbre impacted on my visualisations of shape and colour, I analysed the data by searching for mentions of photism shape/form and colour and timbre-related composition/production techniques I had utilised. I interpreted any patterns that I found as links between my synaesthetic visualisations of shape and colour and the creative decisions I had made during the composition process. I compared my descriptions of my own visualisations of shape and colour with those experienced by other synaesthetes, and my use of timbre-related composition/production techniques with those utilised by other musicians. I contextualised my findings by interpreting the data I had gathered through the lens of the various cultures I belong to and by acknowledging the influence and impact of external factors on my work and my experiences. I also framed my findings within existing timbral manipulation theories proposed by Roads (2015).

The following themes emerged from the data and will now be discussed in the order in which they are listed:

- Timbral mutations and transmutations
- Timbral fusion and fission

- Timbral sampling and repurposing
- Photism multiplication and emergence
- Connotative photisms and their impact on the composition process

For a full review of the data recording, analysis, and interpretation methods I utilised, please refer to the Methods section in the Introduction chapter (1.7.).

2.4. Findings and Discussion

2.4.1. Timbral Mutations and Transmutations

In my compositional practice, timbral transformation is achieved by employing techniques such as: reversing recordings; filtering frequencies; changing the speed and pitch of recordings; modifying the ADSR (attack, decay, sustain, release) envelope of sounds; granulating sounds; distorting sounds; applying TCE (time compression/expansion) to sounds; processing sounds through audio effects such as reverb, delay, flangers, phasers, and gating; and the sequencing and combining of multiple copies of sound recordings, each of which have been processed in a particular way through a unique effect chain.

Roads (2015) separates timbral transformations into two types: mutations and transmutations. He writes:

> "We call a mild transformation, in which the sound is altered but the perceived source identity signature of the sound is retained, a *mutation*. In a mutation, we can tell by listening that a second sound is derived from an initial sound. […] In contrast, radical transformations obliterate the source identity of the sound being transformed. We call such radical transformations *transmutations*. This range of effects is the *identity continuum*: identity—mutation—transmutation" (pp116-117).

Roads' terminology provides apt definitions for both my aural and synaesthetic visual perceptions of minute and substantial timbral transformations. With my own synaesthesia, subtle transformations in timbre result in minimal changes to both shape and colour of the corresponding photism, while more significant timbral transformations result in extensive changes to the photism's shape and colour. I will therefore use the terms "mutation" and "transmutation" when describing minute and

substantial transformations, respectively, in both timbre and any corresponding photisms.

Timbral mutation can be achieved through audio effects processing, which can have a significant impact on the resulting synaesthetic photism, due to some effects' capabilities to significantly alter the timbre of a sound. For example, during the composition of 'Glue', I ran a synthesised sound through a tape delay effect (from 00:58 to 01:20), which added saturation (subtle analogue-sounding harmonic distortion) and flutter (fluctuation in speed) to it. Due to the resulting alterations to the attack of the amplitude envelope and the spectral characteristics of the sound, I noted that the resulting photism appeared to change both shape and colour – from an "orange blob" to a "khaki smudge". This suggests that my synaesthetic perception of colour and shape is indeed affected by audio effects processing. Since these alterations retain "the perceived source identity signature of the sound" (Roads 2015, p116) and, additionally for me, the corresponding photism, they could be described as timbral and photism mutations.

I have discovered that, when composing music, I frequently make several copies of short musical passages produced during the initial sound design stage of my typical composition process. I mutate each of these copies in a slightly different way by applying a different combination of audio effects, in order to maximise the various possible timbres (and, therefore, photisms) available for me to build a composition with. This finding has helped me to refine my typical composition process, by encouraging me to split up my composition process into 'stages' and to spread the production of a track across several DAW projects. The timbral variations created during the initial sound design stage are often imported into a new Logic project, to allow me to focus on the structuring and arranging of musical ideas separately from the designing of timbres. Through analysis of my compositions, I have found that this arrangement stage often centres around the sequencing of timbral variations on a theme. This is achieved by running the same passage of music through different combinations of audio effects, to create several distinct 'takes', then cutting up and arranging sections of each 'take' into a sequence.

It is evident that the division of my composition process into stages (and separate DAW projects) made for a more efficient workflow, as I was better able to focus on

each aspect of my composition process in isolation from the others. An example of this approach to composition can be found in the making of ‘Infinity Pyramids’. I began this composition by designing timbres inspired by sketches I had drawn, as is evidenced by this extract from my autoethnographic data:

> “I initially created this ‘Infinity Pyramids’ sound design piece as an experiment to explore the phenomenon of multiple photisms being generated by a single sound. I started with a basic sound that ‘looked’ like an infinity symbol. Having sketched this idea out on paper, I embellished this drawing and modified my synth patch to mirror these changes. I made further modifications to the sound and sketched these out in my notepad. Having then made another set of changes to the drawing, I went on to represent these in the music. This process proved to be useful in providing inspiration from a sound design perspective, though I am not convinced that its usefulness extends beyond helping me to produce timbres that I otherwise might not have come up with. I will now attempt to compose an original piece of music using the sounds I have created as a starting point” (autoethnographic notes, 19 February 2020).

Having produced several sounds that I believed had potential, composed short passages with them, and ran each passage through several different combinations of audio effects, I bounced each of these and imported them into a new Logic project. In my notes, I likened my photisms of the mutated variants of the original timbres to variations on a visual theme, comparing them to the diverse series of colourful circles featured in Kandinsky’s *Farbstudie Quadrate* (1913). Depending on the combination of effects each timbre had been processed with, the colour or shape of the corresponding photism was altered slightly. Through the use of the DAW’s multitrack editing functionality, several short excerpts from each variation of the vocal part, bassline, and main synth part were extracted, stitched together, sequenced, and layered during the arranging of ‘Infinity Pyramids’, which formed the main structure of the composition. Since each section of the composition features different mutated variations of a small number of timbres, I visualise ‘Infinity Pyramids’ as a small group of shapes and colours that subtly mutate over time. I have since brought this approach to effects processing and arrangement into the composition of ‘Shiraga’ and ‘Rust’, treating the arranging of both works as the sequencing and layering of variations on a (synaesthetic) visual theme.

While moderate processing of sounds can result in timbral (and photism) mutation, intensive processing and alteration of sounds has the potential to transmutate

timbres (and photisms) to the point that they no longer resemble their original forms. In analysing the autoethnographic data that I had collected while composing and listening back to many of my compositions, I realised that I thoroughly enjoy the synaesthetic visual experience of timbres in a state of transformation. It is especially satisfying when photisms transmutate, and eventually become so unstable that they appear to 'self-destruct' and fall apart completely. For example, towards the end of my composition 'Infinity Pyramids', from 03:19 onwards, the corresponding photism for the chopped-up vocal sample transforms from an 'orange and green jelly snake' into a 'barbed blue wire strip', as the vocal sample is pitched up and distorted. The photisms of the other instruments in the arrangement also become thinner and more jagged in appearance. This was intentional; I intended for the final section of the composition to contrast both sonically and visually (in a synaesthetic sense) with the prior sections. As the composition nears its end, the sounds decay further as the kick drum recording is stretched at 03:51, resulting in audio artifacts visually resembling oily bubbles. Furthermore, the vocal sample is further distorted at 04:07, resulting in the photism becoming increasingly serrated and amorphous. I have found that stretching and distorting the audio can, respectively, reveal additional visual details that were not previously visible and drastically change the appearance of the photism. Like with 'Infinity Pyramids', the ending of 'Intersect' (from 04:20 onwards) similarly constitutes the apparent destruction of the corresponding photisms, as they dissolve, collapse, and transform into unrecognisable forms. This synaesthetic visual effect is achieved by decreasing the resolution and increasing the noise and overdrive controls on the synthesiser parts: effectively degrading the sounds and intensifying the ambiguity of their fundamental pitches. A similar synaesthetic visual effect is also achieved after the first 'drop' section, when the bass begins sweeping out of control (from 02:48 to 03:03). This portion of experiential data was recorded after listening back to the composition for the first time in full:

> "I've noticed that I like the synaesthetic visual experience that results when I push sounds beyond all recognisability (e.g., applying overdrive and bitcrushing, turning up LFOs, detuning pitch/formant) – which results in shapes that appear to be expanding out of control, as if they're about to burst – and then reigning them in just before all sense of melody/rhythm is lost" (autoethnographic notes, 27 July 2020).

This timbral tension-release results in the corresponding photisms gradually destabilising before suddenly reverting to their original form. This makes for a particularly satisfying aural and synaesthetic visual experience, which explains why I have made use of this compositional technique so frequently in my music.

2.4.2. Timbral Fusion and Fission

Through analysis of my autoethnographic data on the composing of ‘Glue’, ‘Rust’, and ‘Everest’, I found that the combining of sounds to create composite sounds results in the perception of composite photisms, i.e., photisms with attributes from multiple source photisms. Simply layering sounds is not enough to induce composite photisms. The sounds must be rhythmically synchronised; in other words, they must be heard at the same time. The sounds must have similar timbres for them to induce photisms similar in both shape and colour. Photisms that are visually dissimilar will not give off the impression that they have fused together. Sounds must also be of roughly the same pitch and position in the stereo field, in order for them to occupy the same space in my mind’s eye and therefore appear to overlap. If the sounds’ pitches are too far apart, or if they appear at different points in the stereo field, they will not overlap in my mind’s eye. If these conditions are all met, the photisms will appear to be fused together, resulting in the perception of a composite photism. Roads (2015, p371) calls this process ‘fusion’, explaining that “[f]usion melds several sounds into a Gestalt—a composite whole. In contrast, fission comingles sounds while keeping them perceptually distinct. […] In electronic music, fission and fusion take the form of transitional processes such as morphing or mutating sounds (one sound becoming another in a continuous fashion), splitting apart fused sounds, or the opposite of splitting: the convergence of disparate strands into a fused block.” I find these processes of timbral fusion and fission to be very (synaesthetically) visually appealing, which is why I use these frequently in my work.

Several examples of fusion can be found in my composition ‘Rust’. At points, the melodies performed by the chopped vocal and the lead synthesiser become mirrored (e.g., at 02:46), resulting in the perception of their corresponding photisms fusing together to induce composite photisms. Furthermore, in the breakdown section at

04:59, several sounds are processed through the same sidechained noise gate effect, causing the sounds and their corresponding photisms to become synchronised. This also gives the impression of sonic (and photism) fusion.

In the case of ‘Everest’, I sampled a small portion of audio from one of my earliest compositions. This appears both as sudden bursts of sound (e.g., at 01:23) and as a recurring loop (e.g., at 02:55) at several points in the composition. The sample of audio was taken from the full mix of my early composition (as opposed to a single isolated track) and thus consists of all the sounds present. These sounds span the entire range of human hearing, resulting in a ‘wall of sound’ effect. Furthermore, the sample is too short in length for me to be able to distinguish forms representing each individual instrument within its corresponding photism. As a result, this short sample of such a large composite sound induces a composite photism resembling a flash of greyish-white light that extends across my entire (mental) field of vision.

An example of fission, meanwhile, occurs in my composition ‘Intersect’ when a duplicate of the main vocal sample heard throughout the work is re-pitched to create a harmony. Due to the altering of the duplicate recording’s pitch, the corresponding photism appears to split in half at the moment the harmony line is first heard (at 02:33). Further fission occurs when the harmony vocal is distorted, while the formants of the lead vocal are gradually lowered (from 04:05 to 04:36). The divergent processing applied to each part results in disparate transmutations to the parts’ corresponding photisms.

2.4.3. Timbral Sampling and Repurposing

This is not the only time that I have sampled previous compositions in my work; I used samples of timbres from earlier works to help me find direction in the following compositions: ‘Expansion’, ‘Glue’, ‘Infinity Pyramids’, ‘Intersect’, ‘Everest’, ‘Rust’, and ‘Fluorescent’. In the majority of these cases, the samples I used were of vocal recordings from previous works that I chopped up and reassembled (and often also repitched and/or reversed) to create new melodies. This technique was used partly for sake of ease; I do not consider myself to be skilled at lyric-wring nor do I find it to be particularly enjoyable. Use of the technique enabled the creation of an original

vocal melody without the need for new lyrics to be written. I also enjoy the unique sound of these ‘vocal chops’ and the resulting synaesthetic photisms the effect induces. The chopped nature of the recordings and the lack of natural glide between notes causes the photisms’ forms to exist in a state of constant mutation. I have found that the shape of the photism rapidly changes depending on the vowel or consonant being sung. For instance, I described the vocal part in ‘Fluorescent’ as “a light golden-pink gelatinous substance that changed shape according to the vocalist’s mouth movements” (autoethnographic notes, 8 February 2022). Similarly, I wrote that the vocal part in ‘Infinity Pyramids’ “elastically takes the form of every vowel and consonant heard – growing then shrinking, stretching then compressing” (autoethnographic notes, 13 April 2020). The photism shape of vocal sounds appears to resemble the shape the human mouth makes when singing these vowels and consonants. For example, the photism induced by a vocalist singing the word ‘today’, would morph into the following shapes in very short progression (see Figure 2.2).

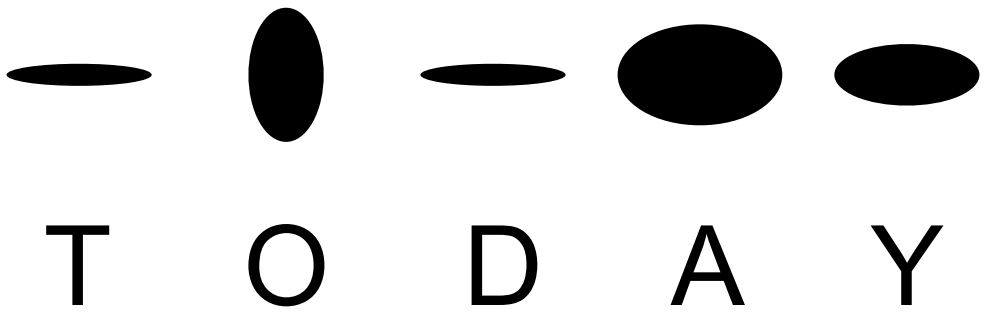

Figure 2.2.
The shapes that I visualise in quick succession when hearing a vocalist sing the word ‘today’.

This fluctuation in form also occurs in other sounds when the formants are varied, through a process of vocoding for example (Wishart 1994).

By cutting up and then re-splicing together vocal recordings, the corresponding photisms appear to abruptly snap to new shapes, rather than smoothly transition between shapes. This ‘vocal chop’ effect is present in compositions by Four Tet (e.g., ‘Baby’ (2020b)) and Skrillex (e.g., ‘Scary Monsters and Nice Sprites’ (2010), ‘First of the Year’ (2011a) and ‘Summit’ (2011b)) that undoubtedly have had an influence on my own compositional processes and style. I thoroughly appreciate

compositional techniques that induce such erratic photism transformations and so have recently adopted this ‘vocal chop’ technique into my own compositional practice, by repurposing old vocal recordings for use in new works. Furthermore, my frequent use of samples of old vocal recordings also reflects the COVID-19 lockdown situation in place at the time of the creation of the majority of these compositions, which resulted in me being unable to enter the recording studio and produce new recordings with vocalists.

In all of these cases, I chose to reuse specific samples that both sonically *and* (synaesthetically) visually complimented what I had so far created for the new composition, and referred back to previous works of mine. By revisiting previous musical works and studying the synaesthetic photisms they induce, I can see how my compositions have *visually* evolved over time. Firstly, the colour and shape of the photisms that I experience while listening back to the recordings of my earliest compositions generally remain static, compared to those of my latest compositions which evolve visually over time. This staticity can likely be explained by the lack of automated parameters in the compositions’ DAW projects. When I began composing and producing my own music as a teenager, the only DAW available to me at the time was the free audio-recording/editing software Audacity, which lacks the ability to apply and modify audio effects in real time, and does not support virtual instruments, the recording and editing of MIDI data, or track automation. The fact that I could not automate parameters when producing my compositions meant that the timbre of each sound was unchanging: fixed in place. I now use Logic Pro which supports track automation, allowing me to incorporate time-varying sound transformations (Roads 2015) into my work. Secondly, when listening back to my early work, the resulting synaesthetic shapes and colours that I visualise are lacking in definition and separation. Aurally, I struggle to differentiate between the different sounds in each composition due to my limited audio mixing skills at the time. With my auditory-visual synaesthesia, each sound is visually represented by a different coloured shape. If I cannot aurally distinguish one sound from another, the resulting synaesthetic visual experience tends to resemble a blur of indistinct shapes and colours that blend together. Having since spent 12 years honing my music production and mixing skills, the sounds in my latest compositions are generally much more identifiable, with their own place in the mix.

An exception to this is my composition ‘Everest’, where I attempted to create a work of music that induced a synaesthetic experience resembling, to an extent, an indistinct blend of shapes and colours: not dissimilar to those induced by my early compositions. To help achieve this, I incorporated a sample from one of my earliest works. I only made use of short segments of this sample (e.g., at 01:23), as the sound and resulting synaesthetic experience were both very overpowering. This is an extract from my data on the composition of ‘Everest’:

> “I brought in flashes of bright white light that took on the appearance of a mesh of barbed wire. This was a sample from a very early composition of mine consisting of several sounds that had been layered, compressed, and distorted to the limit. I enjoyed the visual juxtaposition between the small, curvy, subdued, golden-brown circle being ‘drawn’ by the cello and the bright, violent flashes of the distorted composite sound, which I felt added an element of surprise/shock to the music and synaesthetic visuals” (autoethnographic notes, 21 August 2020).

Here, I acknowledge that the flashes of indiscernible shapes and colours provide a satisfying contrast to the simple imagery induced by the other instrumentation. This sonic call-back to my earlier work helped to recreate the indistinct, opaque synaesthetic experiences akin to those triggered by my first compositions.

This idea of reusing and adapting previous material into new works is not without precedent. Roads (2015, p129) discusses how he granulated a single ‘click’ sound into a sound object, which then formed the basis for his composition *Volt Air, Pt. 3* (Roads 2003b). By granulating *Volt Air, Pt.3*, he was able to create the composition *Now* (Roads 2003a). By granulating *Now*, he was able to create the composition *Never* (Roads 2010). And, by granulating *Never*, he was able to create the composition *Always* (Roads 2013). Although the process of granulation is different to those that I have used, this basic idea of reusing small samples formed the basis of ‘Expansion’, where each section of the composition was based on a repurposed sample of the previous section. ‘Expansion’ was initially conceptualised as an audiovisual work that would involve the audience’s aural and mental-visual perspective ‘zooming out’ as the piece progressed. I intended for each section of the work to be split into ‘levels’ with the musical and visual elements of the previous level forming the basis of the subsequent level. To achieve this, the instrumentation comprising each level includes a sample of the previous level. Although ‘Expansion’

ultimately ended up as an entirely sonic work with no visual element, the use of this compositional technique resulted in the perception of new shapes and colours as my (synaesthetic) visual perspective appears to zoom out, revealing each new level.

The instrumentation evolves as the work moves from level to level and so the palette of timbres is refreshed with each section. Level 1 (00:00 to 00:59), for example, consists entirely of 808 kick drum pulses which get increasingly faster. This is perceived as a rubber black ball which eventually morphs into a flashing grey prism. Contrastingly, Level 2 (01:00 to 02:09) features increasingly brighter reddish-orange sparks circling a pulsating wave of grey coarse metal. As the composition progresses, new shapes and colours are revealed with each level. As a result, listening back to the composition gives the impression of a gradual zooming out: starting with a microscopic focus on the most minute of sonic/synaesthetic visual ideas and slowly pulling out to reveal increasingly larger and more complex sounds and coloured shapes, which evolve over time. This perceived widening of my visual perspective to reveal and bring in to focus new photisms is visually very satisfying.

2.4.4. Photism Multiplication and Emergence

Equally as satisfying is when the mutation of sounds results in the perception of multiple photisms, henceforth designated ‘photism multiplication’, or the perceptions of photisms emerging from within other photisms, henceforth designated ‘photism emergence’. These are terms that I have coined to define these phenomena, which have not previously been investigated. I believe that the discovery of these phenomena is important, as this is an original contribution to knowledge on auditory-visual synaesthesia. In addition, in defining these phenomena, I have since been able to make better sense of my own synaesthetic experiences.

Photism multiplication was experienced when listening back to my composition ‘Glue’ during my attempts to represent my synaesthetic visualisations of the work in the form of computer animation. I found that it was possible for single timbres to induce the perception of multiple photisms, when mutated in certain ways. By increasing the resonance of a synthesised sound, I noted that “even though it is part of the same sound, I ‘see’ the resonance as separate from the main tone – at first.

But as the cut-off is decreased, the resonance ‘merges’ with the main tone” (autoethnographic notes, 24 October 2019). Here, it is apparent that the whistle produced by increasing the resonance on a synthesiser induces the sensation of an additional photism above the core photism induced by the fundamental frequency of the sound. As the cut-off frequency control is turned down, the resonant whistle’s pitch is lowered and the resulting photism appears to envelope the core sound’s photism (see 00:53 to 00:57 and 01:13 to 01:19 of the ‘Glue Animation (Unfinished Draft)’ in the Appendices).

The phenomenon of photism multiplication was further explored when synthesising timbres that would go on to form the basis of ‘Infinity Pyramids’. By increasing the glide between notes, I noted that ‘wings’ appeared to protrude from the sound’s corresponding photism. By increasing the FM intensity and number of overtones, additional duplicate photisms were synaesthetically induced above the original photism. And by turning up the LFO control on the synthesiser and increasing the modulation applied to FM intensity, I was able to separate the carrier and modulator waves into two distinct photisms.

Meanwhile, I frequently detected the theme of photism emergence in the notes I had made during the composing of ‘Balloons’. When reflecting on the middle section of the composition (05:46 to 09:36), I mention that balloons appear to be “coming free, revealing darker balloons (black/green/orange) below” (autoethnographic notes, 29 September 2020). By gradually increasing the volume and opening low-pass filters, the sounds and their corresponding photisms that had, until then, been buried in the mix and therefore obscured from my mind’s eye slowly became more audible and (synaesthetically) visible. However, it was only when other sounds had been stripped away, that these previously unnoticed sounds and their corresponding photisms became truly perceptible. The resulting visual experience was of new photisms appearing to emerge from within other photisms – much like flowers sprouting from plants.

A similar effect was observed at the end of ‘Rust’. As the drums are gradually filtered and vocoded (from 09:42 onwards), the corresponding visual experience is that of layers slowly peeling off a large, heavily rusted, dark grey mesh of metal, revealing underneath a photism resembling a glowing, slightly scratched, light blue, fluorescent

bulb. I mention in my notes how pleasing this evolving photism was to observe, adding: “it is a very light blue in colour, however, which is very different to the colour palette of the other sounds in the composition. I’m wondering if this might be a good segue into a different composition…” (autoethnographic notes, 13 April 2021). Because this photism, which emerged right at the end of ‘Rust’, diverged so drastically from the visual palette of the rest of the composition, I chose to use this sound as the catalyst for a new composition, ‘Fluorescent’.

2.4.5. Connotative Photisms and their Impact on the Composition Process

The timbre which emerged at the very end of my composition ‘Rust’ induced a photism that did not resemble the rest of the work, but instead suggested a different musical direction. I found that the sound’s photism resembled an old (slightly weathered), flickering, light blue, fluorescent light tube. I expanded upon this visual idea by imagining a long corridor filled with decaying fluorescent lights. This is an excerpt from my data on the creation of ‘Fluorescent’:

> “I imagined that the perspective of the listener/viewer was from below; lying down and looking up at fluorescent lights on the ceiling (of, say, a hospital), as they are wheeled through corridors in slow motion, with blurred, dazzling lights above appearing to shoot past in slow motion” (autoethnographic notes, 8 February 2022).

I sought to recreate this scene by adding long reverb tails and a reverse reverb to the sound, in order to evoke the image of the gas inside the light tube, noting that this “appeared to create a breathing in/out effect, where the gas seemed to come and go in waves” (autoethnographic notes, 8 February 2022). I panned each consecutive appearance of the ‘light tube’ left and right, and used volume fades to give the impression of motion, as if the listener/viewer was moving through a corridor, facing upwards and seeing lights on alternating sides of the ceiling.

The name ‘Fluorescent’ also brought to mind connotations of bright glowing lights of a variety of colours. I was therefore keen to introduce sounds that induced photisms with various shape and colour configurations as the music progressed, in keeping with this theme. As with several of my other compositions (e.g., ‘Shiraga’ and ‘Rust’), synthesised and processed found sounds (a creative approach to sound design for

music composition advocated by Moir (2020)) were blended to achieve a sonic landscape comprising a variety of timbres. The mixing of sounds from my everyday environment with synthesised timbres places this composition firmly at the intersection between the familiar and the unfamiliar: a common theme in my work. The result was a composition that gradually built up to a climatic final section, and which succeeded in inducing a synaesthetic experience resembling an array of multicoloured fluorescent lights. This case is especially interesting, as it established that the transformation of a timbre, if transmutated beyond recognition, can induce a photism so unlike that of the original timbre that it can itself inspire the synthesis and processing of new sounds based on its visual connotations, for use in a new composition.

On several other occasions, it was apparent that the visual appearance of the synaesthetic photism of a sound's timbre, along with its connotations, informed how I chose to develop the composition. For example, the idea to automate the overall playback speed of 'Balloons' was informed by the way in which the synaesthetic photism of the lead synthesiser part's timbre strongly resembled a bunch of balloons. I decided to convey in the music the imagery of balloons rising, and then falling, by gradually increasing and then decreasing the playback speed. At a slower speed (and therefore also at a lower pitch), the balloon photisms appeared larger, deeper in colour, and fixed at the bottom of my mind's eye. By gradually increasing the playback speed, the 'balloons' appeared to float upwards to the top of my mind's eye and gradually appear smaller and lighter in colour. This decision wouldn't have been made if the photism of the main timbre present in the composition didn't resemble a bunch of balloons.

Strachan (2017) points out that DAW-based composers (such as myself) often make creative decisions based on "the affordances and affective qualities of a particular sound" (p90). In the case of 'Shiraga', the way I visualised the timbre of the 'beeping' found sound that ultimately formed the basis of the composition led to the discovery of the painting *Sorin* (Shiraga 1970), which influenced the creation of other sounds to use in the arrangement. The photism of this timbre resembled a metallic red disk. For inspiration on ways to expand and develop this sound into a full composition, I searched online for paintings that resembled red metallic disks. Kazuo Shiraga's

Sorin appeared to portray such an image and so I chose to interpret the other forms present in the painting sonically, to expand the timbral palette I would go on to use to construct the composition. In order to represent the fluid, chaotic nature of the painting, I synthesised timbres that induced photisms resembling smeared reds, oranges and yellows to create a sense of large, violent movements in my own composition. This was achieved by audiating timbres that generated photisms resembling Shiraga's work and then using audio synthesis, editing techniques (e.g., reversing, TCE), and audio effects (e.g., filtering, equalisation, compression, reverb, and delay) to produce these audiated timbres in my DAW. It can therefore be summarised that the synaesthetic visual appearance of timbre can influence how I choose to develop a composition.

2.5. Conclusions

Through analysis of the compositions created to explore my auditory-visual synaesthesia, I have ascertained that timbre has a major impact on my visualisations of shape and colour, and that these visualisations can, in turn, affect my creative decision-making during the composition process. The key findings that have been uncovered from this analysis are, as follows:

- Timbral mutation (a moderate timbral transformation) results in a moderate change in the corresponding photism, while still retaining some resemblance to its original form. This can be achieved through, for example, light audio effects processing, modification of playback speed or pitch, or editing and resequencing of audio.
    - Timbral mutation can result in photism multiplication (the perception of multiple photisms corresponding to a single timbre).
    - Timbral mutation and transmutation can result in photism emergence (the perception of photisms appearing to emerge from within other photisms).
    - The editing and resequencing of vocal samples can result in the perception of photisms in a state of constant mutation.

- Timbral transmutation (a drastic timbral transformation) results in a complete change in the corresponding photism, to the point that it no longer resembles its original form, often going so far as to result in the original photism appearing to dissolve, collapse, or be destroyed altogether. This can be achieved through, for example, heavy effects processing, or significant changes to a synthesiser's parameters.
- Timbral fusion (where similar sounds are layered together and synchronised) results in the aural perception of composite sounds and the synaesthetic visual perception of composite photisms.
- Timbral fission (where the component sounds that make up composite sounds are separated through desynchronisation, timbral transmutation, and/or pitch alteration) results in the synaesthetic visual perception of composite photisms splitting apart.
- I often sample and repurpose timbres created for earlier compositions in new works, if I find that they sonically complement the new composition and visually complement its corresponding photisms. This provides a satisfying sonic and synaesthetic visual call-back to earlier works and allows these timbres to be heard, and their corresponding photisms to be seen, in a new context.
- I often design and transform timbres in keeping with the visual connotations of another timbre's corresponding photism.
- I have begun separating my composition/production process into several stages, each associated with a separate Logic project. The initial stage is focussed exclusively on timbral design, to come up with a sound palette to be used in the composition. The second stage is focussed on the arrangement of mutated variations of these timbres into a coherent musical composition, the structure of which is visualised as variations on a visual theme.

These compositional techniques and approaches to composition have been utilised in the creation of most of my latest works and, therefore, it could be argued that these are definable components of my compositional style. I have found that the use of the timbral manipulation techniques mentioned above is not only aurally pleasing but also synaesthetically visually appealing, hence why I have been using them so frequently in the creation of my own compositions. I believe that the use of these

techniques has helped to define my own identifiable sound. I do not doubt that my musical style has been influenced by the music that I tend to listen to: for example, the works of Jon Hopkins (2009, 2013, 2018a), Nathan Fake (2017, 2020, 2023), Rival Consoles (2018, 2022), Bicep (2017a, 2021), Burial (2007, 2022), Four Tet (2017, 2020a), George FitzGerald (2022), Boards of Canada (2013), and Max Cooper (2019). There are certainly some sonic (and synaesthetic visual) similarities between my latest compositions and some of these artists' works. However, I would argue that my frequent use of the techniques outlined above has helped to establish a unique and identifiable sonic signature and synaesthetic visual identity for my compositions.

3. The Impact of Timbre on Visualisations of Texture, State of Matter, and Weight

3.1. Introduction

The synaesthetic photisms I experience while listening to music have additional properties beyond their shape and colour; from synaesthetic visual observation, I also 'know' what each photism would *feel* like if it could somehow be touched or held. In analysing the autoethnographic notes describing my synaesthetic experiences while composing music for my album *Photisms*, I realised that I was characterising my synaesthetic experiences in terms of texture, weight, and state of matter. Chiou et al. (2013) describe such multidimensional visualisations as 'synaesthetic objects', which may more accurately express the numerous properties of my own experiences than the more commonly used term 'photism', which might not fully depict the multifaceted nature of my synaesthetic experiences. Cytowic (2018, p249) defines a photism as "[a] visual sensation involving light, color, and form". However, the visual objects that are induced in my mind's eye by different musical sounds have additional properties beyond their lightness, colour hue, and shape or form. Hochel and Milán (2008, p93) offer an even more limited definition of photisms as "mental percepts of colour", which omits any mention of light or form. This focus on colour appears to be symptomatic of an obsession in music synaesthesia research with 'coloured hearing', often at the expense of other attributes of auditory-visual synaesthetes' experiences.

From correspondence over email and social media with synaesthesia researchers Professor Jamie Ward (2022) and Dr Romke Rouw (2022), I learned that there has been little research into the auditory-visual synaesthetic perception of textured objects and none into the perception of these objects' state of matter or weight. This was confirmed by my own investigations of the literature. As Eagleman and Goodale (2009) point out, synaesthetic experiences often involve far more than just the perception of colour and so, if the term 'photism' is to be used to describe my visualisations, it must encapsulate more than just colour sensations. Colman (2008) defines 'photism' more generally as "[a] form of synaesthesia in which a visual

sensation accompanies stimulation of another sensory modality". I use the term 'photism' in this broader sense to describe the multifaceted synaesthetic objects induced by my perception of musical sounds.

Like with shape and colour, the texture, state of matter, and weight of a photism are also determined, primarily, by a sound's timbre. Although these additional perceptual properties are perceived visually, a tactile sensation is also *inferred*, since texture, weight, and state of matter can also be understood tactilely. In other words, it is possible to imagine what each sound's corresponding synaesthetic object would feel like, how heavy it would weigh, and how dense or malleable it would be, if it could somehow be touched, held, or squeezed. For one auditory-visual synaesthete interviewed by Ward (2017, p317), "the synaesthetic shapes of music typically are not just two-dimensional but have solidity and texture that lends them an almost tactile quality". This account bears a strong resemblance to my own experiences. My synaesthetic photisms also have solidity and texture and can be imagined as if having tactile qualities. Ward suggests that this is "probably not providing a true auditory-tactile synaesthesia, but rather there is a sense of what the visualizations would feel like if touched" (ibid.). My case is also probably not an example of auditory-tactile synaesthesia, since the perception of sound does not actually induce a tactile sensation. However, it is certainly possible to ascertain, from their visual appearance, what my photisms would feel like if they could somehow be touched. Sun et al. (2016, p353) point out that "[w]hen we look at objects, we are able to predict how they will feel once we come into contact with them". Although my photisms are not physically observed, these visualisations always appear to have texture and could be described as metallic, rubbery, gelatinous, furry, rusty, etc.. In my case, a photism's texture is determined by its corresponding sound's timbre. Furthermore, Gallivan et al. (2014, p1866) note that we can also "predict the weights of viewed objects based on learned associations linking object weight to object visual appearance". It is perhaps not unsurprising that, in my case, larger photisms (which tend to be induced by louder or lower-pitched sounds) are perceived as being 'heavier', while smaller photisms (which tend to be induced by quieter or higher-pitched sounds) are perceived as being 'lighter' in weight. The perceived state of matter of a photism can also have an impact on its perceived weight, with 'solid' photisms appearing somewhat 'heavier' than 'liquid' photisms, and significantly more

so than ‘gaseous’ photisms. However, to date, there has been no research into the perceived weight or state of matter of sound-induced photisms.

Since each composition in the *Photisms* album – the practice-based component of this thesis – consists of a distinct set of timbres, the perceived mix of textures and range of weights and states of matter are different for each composition. When mixing sounds, I aim to achieve a visual landscape of complementary textures, and a wide range of variously weighted photisms of different states of matter. In several cases, the perceived surface texture, state of matter, and weight of individual sounds consciously influenced the direction I took the composition in. In this chapter, I will, in turn, analyse how the texture, state of matter, and weight of my photisms have impacted on my composition processes and outputs, comparing my own experiences with those discussed in literature.

3.2. Methods

To discover how my perceptions of timbre impacted on the visual-tactile nature of my photisms, I analysed autoethnographic data gathered during and shortly after the composition process by searching for mentions of photism properties that are normally tactilely perceived, and timbre-related composition/production techniques I had utilised. I interpreted any patterns that I found as links between my synaesthetic visualisations of tactilely-perceived properties, and the creative decisions I had made during the composition process. I compared my descriptions of my visualisations of these properties with those experienced by other synaesthetes. I contextualised my findings by interpreting the data I had gathered through the lens of the various cultures I belong to and by acknowledging the influence and impact of external factors on my work and my experiences.

The following themes emerged from the data and will now be discussed in the order in which they are listed:

- Photism texture
- Photism state of matter
- Photism weight

For a full review of the methods I utilised, please refer to the Methods section in the Introduction chapter (1.7.).

3.3. Findings and Discussion

3.3.1. Photism Texture

The synaesthetic experiences of a 22-year-old music composition student, who perceived coloured and textured shapes induced by music (amongst other stimuli), were said by Mills et al. (2003, p1360) to be "unique compared to any other cases reported in the literature". However, Eagleman and Goodale (2009) found that many synaesthetes' accounts of their experiences involved descriptions of texture: for instance, composer Michael Torke describes the sound of a flute as "cottony" and compares the sound of a clarinet with "a panther's fur" (Duffy 2001, p99). Eagleman and Goodale (2009) conclude that the sensing of texture can play a significant role in synaesthetic experiences and suggest that further research into the synaesthetic perception of texture is needed. Djonov and Leeuwen (2011, p542) point out that "[d]espite texture's increasing importance in a range of semiotic practices, it has not received much scholarly attention", while Moos et al. (2013, p2) confirm that "no systematic investigation of visual texture perceptions in synesthesia has yet been conducted". I will aim to contribute to knowledge on how this somewhat unexplored aspect of synaesthesia can impact on music composition processes and outputs, through examination of the role texture plays in my own synaesthetic experiences of music. For the avoidance of doubt, I will not explore the synaesthetic visualisation of musical texture here (see, for example, Rudenko and Serrano 2017); but rather how musical sounds induce the synaesthetic visual perception of surface texture.

In composing the music for my album *Photisms*, I have become aware that hearing and audiating music (and sound, more generally) induces the visual sensation of texture. Specifically, a sound's timbre appears to be the primary factor that determines the texture of the sound's corresponding photism. In my notes on my composition 'Infinity Pyramids', I remark that the bass at 00:32 is "rubbery with a black matt finish" (autoethnographic notes, 13 April 2020), while the chopped vocal is described as "jellylike in texture […] elastically [taking] the form of every vowel and

consonant heard – growing then shrinking, stretching then compressing" (ibid.). Changes in pitch, dynamics, and positioning in the stereo field have little to no impact on photism texture.

Timbral changes however (which are a common staple of my work, as noted in the previous chapter) can significantly alter the perceived texture of a sound: for example, I note that distorting the timbre of the synthesiser playing the chords in 'Infinity Pyramids' (at 01:02) gives it a "texture like gravel" (autoethnographic notes, 13 April 2020). Furthermore, when describing the visual effect of the low-pass filter added to the drums at 05:08 in 'Mindscape', I note that the corresponding photism's texture has been softened: that it is "less solid and smoother" (autoethnographic notes, 1 May 2022).

Distorting a timbre or increasing a low-pass filter's cutoff frequency applied to a sound makes the texture of the corresponding photism appear more course, rough, or jagged, while decreasing a low-pass filter's cutoff frequency results in a smoother and softer texture. Increasing the noise control on a synthesiser gives the corresponding photism a hairy or furry texture, while a vinyl crackle can make a texture appear dirty and grainy. Increasing the filter resonance or adding a flanger effect (which slightly delays a copy of the audio signal and shifts it in and out of phase with the original) can give a its photism a wet, gel-like texture. Processing a sound through a chorus effect (which involves more noticeably delaying and varying the pitch of one or more copies of the original signal) results in a shiny, shimmering texture. As with flanging, this type of processing occurs within the temporal domain, as it affects the timing of the sound. By running a sound through a bitcrusher (a form of digital distortion that involves reducing the bit depth of a recording), its photism's texture will appear sharp like a blade or barbed wire. This type of processing occurs within the spectral domain, as it affects the frequencies that make up the sound. These production techniques are all regularly used in my work, resulting in the surfaces of my photisms frequently vacillating between different textures.

Although the perception of texture is visual, in that it is perceived in the mind's eye, a tactile sensation is also inferred. Just as one can look upon a physical object that they have not previously seen and ascertain, from visual observation alone, how the object would feel if it were touched, so too can I know how my synaesthetic photisms

would feel if they could somehow be held in my hands. For example, while describing the impact running a sound through a reverse-delay effect has on the corresponding photism in ‘Balloons’ (e.g., at 01:31), I note that the “rubbery” photism takes on “an elastic, stretchy texture” (autoethnographic notes, 30 September 2020). The lead synthesiser part in ‘Glue’ is visualised as having a “sticky” texture (hence the title), while the bass part in ‘Fluorescent’ resembles “a pulsating perforated ball of black mesh with white fuzzy edges” (autoethnographic notes, 8 February 2022). The visualised texture of the vocal part in ‘Infinity Pyramids’, meanwhile, changes throughout the composition. It is initially described as a “jelly snake” at 00:15 and 00:47 (autoethnographic notes, 16 April 2020) but later, when the vocal is heavily distorted at 03:35, the texture is recounted as being “incredibly rough, jagged even, with many sharp edges” (ibid.). I can easily imagine holding these photisms in my hands, squeezing and compressing them, and running my hands along their surfaces to physically substantiate their textures. All the textures that I have described in my autoethnographic notes exist in the real world; no doubt in my life I will have touched many objects with “rubbery”, “sticky”, “fuzzy”, or “jagged” textures. Evidently, I do not synaesthetically visualise textures that I have not previously encountered. All my synaesthetic experiences are therefore clearly influenced by prior (real) experiences, since no auditory stimulus is capable of inducing a photism with properties that I have not previously experienced in real life.

Although I perceive sounds as having textures synonymous with those of real-world objects (such as balloons), I do not believe that my synaesthetic perception of texture is true auditory-tactile synaesthesia, as the perception of sound does not induce a physical tactile sensation. This is somewhat like the inverse of Nikolić’s theory of ideaesthesia (2009), which argues that the inducer is semantic and only the concurrent is truly sensory. In this case of my sound-to-texture synaesthesia, it is the concurrent that is semantic: it is an *idea* of texture, rather than a *sensation* of texture that I experience; an association between timbre and texture. However, it is also worth noting that, in my case, the inducer (sound) can be either sensory or semantic, as the Translating and Reverse-Engineering chapter will discuss.

Understanding my timbral-textural associations enabled me to take inspiration from textures when designing timbres for use in my own compositions. During the

composition of ‘Intersect’, I noted that “I wanted to ensure that some sections resulted in more muted colours with smaller and smoother shapes, while other sections induced brighter colours with larger and rougher shapes” (autoethnographic notes, 21 July 2020). This contrast between ‘smooth’ and ‘rough’ textures was achieved by automating parameters that affected the timbre of the sounds used in the composition, such as sound resolution, noise level, low-pass filter cutoff frequency, and distortion amount. In constructing the sounds for ‘Shiraga’, I tried to design timbres that induced the texture of ‘smeared paint’, in keeping with the visual appearance of the artwork the composition was based on. This was achieved by processing sounds with long release settings through reverse-delay, reverb, and flanger effects.

It is also possible to use the perceived texture of a specific timbre as the catalyst for a new composition, in the sound design stage (by creating other sounds that synaesthetically induce matching textures to use as the palette of sounds) or to influence the development of a composition in the arrangement stage. In the cases of both ‘Rust’ and ‘Fluorescent’, the majority of sounds that make up the composition were designed to induce the same texture as the catalyst sound that the composition originated from.

‘Rust’ was inspired by the corresponding synaesthetic photism of the sound made by my oven. This photism was described as “jagged and uneven” in shape, “a mixture of black, white, dirty silver and reddish brown” in colour, and “with a surface texture of rough, uneven, dirty, rusted metal”. I went on to write that “I could imagine running my fingers across the surface of this photism; it certainly ‘felt’ like rust. I therefore titled the composition ‘Rust’, which I decided would be based around the noise coming from my oven, the synaesthetic photism of which ‘looked’ like rusted metal” (autoethnographic notes, 18 March 2021). I was keen for other sounds in the composition to take on a similar rusted appearance, in keeping with the oven sound that formed the basis of the work. Sounds were passed through reverb and flanger effects with very short reflections and high feedback levels, which resulted in the corresponding photisms taking on a metallic appearance. Saturation was then applied by pushing the sounds through overdriven compressors, giving the corresponding photisms a crispy, rusted look.

‘Rust’ ends with a sound that does not look particularly rusted, having had further processing applied in the final section of the composition; I described this sound as “an old (slightly weathered), flickering, light blue, fluorescent light tube” (autoethnographic notes, 8 February 2022). I recalled the scratched, degraded plastic texture of the ‘light tube’ as being particularly distinct. This sound went on to form the basis of another composition: ‘Fluorescent’. To build on the theme of imperfect, somewhat degraded textures, the other sounds present in the composition were mostly found sounds that had been sliced up, stretched, filtered, and slightly distorted, resulting in photisms with textures similar to that of the composition’s base sound.

While the texture of my photisms influenced the *sound design stage* of the composition process for ‘Rust’ and ‘Fluorescent’, the texture of the photisms induced by some of the sounds in both ‘Glue’ and ‘Balloons’ influenced the directions I took each composition in during the *arrangement stage*.

My perception of the lead synthesiser in ‘Glue’ as a sticky, viscous substance (like glue: hence the title) gave me the visual idea of photisms appearing to stick together. This visual image was achieved by making use of sidechain-gating. The lead synthesiser was sidechained to the drums. The synthesiser was therefore triggered by each drum hit, which resulted in the perception of the sticky fluid representing the lead synthesiser enveloping the solid brick-like objects representing the drums. To further emphasise this visual theme of agglutination, I sidechain-gated all further sounds introduced in the arrangement to each other. This resulted in all timbres sounding together in perfect synchronisation and induced a composite photism, with the individual constituent parts appearing to be glued together.

The rubbery texture of the photism of the main synthesiser part in ‘Balloons’ informed my idea to automate the global playback speed. This texture appeared to me to be similar to that of a bunch of balloons and prompted the visual idea of photisms rising up from the base of my mind’s eye to the very top, like balloons floating upwards. This synaesthetic visual effect was achieved by having the playback speed of the entire track increase gradually over the course of the composition, and then decrease fairly abruptly at the end, as if the balloons had been burst and were falling back down to earth.

I have found that certain textures are often accompanied with the perception of specific states of matter. For example, photisms with hard, soft, metallic, wooden, and rubbery textures are often perceived as solid objects, while photisms with sticky, gooey, oily, and watery textures tend to be perceived as liquids. I will now discuss the impact timbre has on my visualisations of state of matter.

3.3.2. Photism State of Matter

As previously ascertained, I visualise sounds as synaesthetic photisms, which appear as objects in the mind's eye. These objects have definitive states of matter, in that they appear as either solids, liquids, gases, or plasmas (e.g., lightning). Although the perceived state of matter of synaesthetic photisms has not previously been studied in academic literature, other synaesthetes have alluded to this phenomenon. A participant in a study into synaesthetic percepts by Zigler (1930) described the surfaces of their synaesthetic photisms using terms such as 'hard' and 'soft'; the participant also explained that some of their photisms appeared to have "a superficial layer of hard crystalline material which represents a crust or covering of an inner mass of soft jelly-like substance" (p278). I can certainly relate to this account, as I too often find that certain sounds' photisms appear to have a hard outer shell with a soft, liquid, or gaseous interior.

Day (2013), a projector synaesthete, perceives musical sounds as translucent objects, which he describes as "see-through, similar to tinted glass or cellophane" (p908), while flavours and odours induce solid objects that he cannot see past. As an associator synaesthete, sounds are visualised in my mind's eye, not seen in front of me; unlike Day, my 'solid' photisms therefore do not block my field of vision. Day goes on to describe some of the photisms induced by specific musical sounds, including "a floating sphere […] of red plasma" (p919) induced by an electric guitar, and a ball of "glass tubings [filled with] neon gas" (ibid.). Musician Elisabeth Sulser, meanwhile, visualises materials of various states of matter whenever she hears human voices. These materials could be categorised into solids ("glass", "silver threads", "cotton wool", "steel", "mercury", "sand", "gravel", and "steel wool"), liquids ("water", "honey", "wine", and "oil"), and gases ("steam" and "air") (Sulser 2009,

p183). Both of these accounts bear a great deal of similarity to my autoethnographic notes on my own synaesthetic visualisations of each composition. Having analysed these autoethnographic notes, by searching for verbs that describe a photism's state of matter and determining its corresponding sound's key timbral features, I now have a clearer understanding of the factors that determine which state of matter a sound's corresponding photism is visualised as.

Timbres with transients, and fast attack and release settings are often visualised as solid objects. It is for this reason that drums and other percussion generally induce the perception of solid photisms. Photisms with liquid and gaseous appearances tend to be induced by timbres with longer attack and release settings. Increasing filter resonance will often induce the perception of liquid, by giving the photism a wet appearance: for example, the sticky liquid-like appearance of the lead synthesiser in 'Glue' is achieved by increasing the resonance on the low-pass filter (e.g., at 02:52). Adding a flanger effect to a sound can also liquefy its photism. During Level 3 of 'Expansion', all tracks are briefly processed through a flanger effect (at 03:04). This results in the corresponding photisms to appear wet and swell like a liquid. Applying reverberation to a sound, on the other hand, will cause its photism to appear to exude gas. A gaseous cloud appears to envelope the balloon-like photisms induced by the primary synthesiser in 'Balloons', due to the reverb effect applied to the sound. Removing the dry unprocessed signal completely, leaving only the reverberated sound, results in a photism evaporating entirely into a plume of gas: for example, the heavily reverberated sound first heard at the start of 'Fluorescent' takes on the appearance of a light blue cloud of fluorescent gas. Excessively distorting a sound, meanwhile, causes its photism to transform into an erratically fluctuating ball of brightly coloured electrical energy, what could be described as an example of the fourth state of matter: plasma. For instance, at the very end of 'Intersect', the bass synthesiser is so heavily distorted that it appears to collapse into an unstable mesh of pure electrical energy, rhythmically pulsing in time with each filter sweep.

'Mindscape' was composed with the intention to explore my perception of various states of matter when listening to music, and how certain parameter changes can affect this. The first minute of 'Mindscape' consists of stretched vocal samples, heavily processed through reverb effects, and perceived as a morphing cloud of

silver mist. As the vocals are gradually filtered through a gate sequencer with fast attack and release settings (from 00:55 onwards), their corresponding photisms become slightly more solid, taking on the appearance of paper prisms filled with gas, rhythmically scattering left and right across my mind's eye. The synthesisers are visualised as viscoelastic gelatinous materials with varying levels of solidity throughout the composition, depending on the filter settings. The transient peaks of the drums and cymbals results in me visualising them as solid, hard objects.

I realised that the instrumentation that comprises the arrangement of 'Mindscape' – drums (visualised as solid objects), synthesisers (usually visualised as gelatinous liquids), and reverb-soaked vocals (visualised as gaseous clouds) – is typical of many of my compositions. Accordingly, my visualisations of most of my compositions are comprised of a mix of solid, liquid, and gaseous photisms. If my synaesthetic visualisation of a composition was to lack any of these states of matter, the composition would appear to me to be incomplete, which may explain why most of my compositions consist of drums, synthesisers, and vocals.

Although some of my compositions also incorporate sounds that induce plasma-like photisms, 'Mindscape' does not. An early draft of the composition (see 'Mindscape (Original Idea)' in the Appendices) did include a section (at 03:40) that induced photisms resembling balls of lightning. However, I struggled to find a way to transform photisms from their solid, liquid, and gaseous states into the plasma state that made musical (and synaesthetic visual) sense. I was able to transform the gaseous vocals into liquid photisms through sequenced high-resonance filters, and then add distortion to liquid-like synthesisers in order to induce a plasma photism. However, the amount of distortion required to induce plasma photisms resulted in harsh sounds that I did not find pleasant to listen to, and that visually diverged too drastically from the photisms induced by the 'gaseous' sounds earlier in the composition. I felt that this original draft sounded and 'looked' too disjointed. I was keen to compose a work that was more musically and visually cohesive, so removed the 'plasma' section and reworked the opening build-up so that it led into a composition that I visualised as solid and liquid objects. However, I did feel that some of the ideas present in the original draft nonetheless had potential and could, in future, be repurposed in a separate composition in future.

Many sounds' photisms appear in the grey area between solid and liquid states of matter. As discussed in the previous chapter, the photisms of vocal recordings (in particular, those of vocal 'chops') change shape depending on the vowels and consonants sung by the vocalist. Additionally, the frequent fluctuation between different vocal sounds can also result in varying degrees of solidity being perceived in rapid succession. For example, when describing my synaesthetic visual perception of the vocal part in 'Fluorescent' (from 03:56 onwards), I wrote that "the different consonants heard in the vocal loop changed the perceived level of solidity of the corresponding photism" (autoethnographic notes, 8 February 2022). Furthermore, pitched synthesised timbres often induce viscoelastic photisms: photisms with a jelly- or plasticene-like appearance that frequently contort and forge themselves into new shapes. These viscoelastic photisms appear less solid and hard than those induced by percussive sounds, but not as liquid-like as those induced by timbres with high filter resonance or sounds processed through flanger effects.

Co-founder of the German Synaesthesia Association Jasmin Sinha also references the solidity, or firmness, of her photisms, describing a bass vocal as being "not very firm: it would be easy to squeeze in the hand and it would immediately return to its original size" (Sinha 2009, p202). For me, the solidity and malleability of a photism (how hard or soft, and how flexible or rigid it appears to be) is affected by several factors. Dialling down the cutoff frequency on a low-pass filter softens solid photisms, increasing their perceived malleability: for example, in the breakdown section of 'Rust', all sounds are processed through a low-pass filter, which is gradually removed; this appears to soften their photisms' rusted textures, reduce their solidity, and increase their malleability; and as the filter is removed, the rusted texture returns. The bass synthesiser in 'Mindscape' and those that perform a countermelody in the latter part of the composition (e.g., at 05:15) appear slightly softer and more liquid-like than the other synthesisers, due to their high filter resonance and portamento. The bass synthesiser's photism hardens as the cutoff frequency is increased. Conversely, in the breakdown section (from 04:16 to 05:11), the main synthesiser playing the chords is initially processed through a low-pass filter, which softens its corresponding photism.

Diffusing or slightly saturating a sound through a tape-emulation effect can also have a softening effect on its perceived photism. This occurs when listening back to the section starting at 00:58 in ‘Glue’. The photism induced by the lead synthesiser sound, which normally resembles a viscous glue-like fluid with a thin and somewhat crispy layer (like dried glue), appears to soften, becoming runnier and losing its crispy coating, when processed through a tape-emulation effect. Furthermore, increasing glide between notes, or portamento, decreases photism rigidness; their forms become more elastic and changeable. Portamento is partly what gives the photism of the lead synthesiser in ‘Glue’ its viscous form.

3.3.3. Photism Weight

There is a strong link between my photisms’ perceived states of matter and weight. I generally observe solid photisms as heavier objects than liquid photisms, while gaseous photisms tend to be perceived as being much lighter still. For example, the gaseous synaesthetic photisms induced by the ending of ‘Shiraga’, in which all sounds are soaked in reverb, are much lighter in weight than the solid and liquid photisms induced by the main body of the composition, which revolves around drums and synthesisers. Since a photism’s weight is partly influenced by its state of matter, which is itself determined by the inducing sound’s timbre, it can therefore be concluded that, for me, sound timbre significantly affects its photism’s weight. By manipulating timbre through use of filters and ADSR envelopes, I can alter the weight of my photisms.

Filtering a sound can drastically change its photism’s shape and size, which impacts on my perception of its weight. Low-pass filters smoothen sharp edges, but leave the bulk of the photism and its weight intact, while high-pass filters remove the bulk and leave the sharp edges intact, reducing the overall size and therefore weight of the photism significantly. The bulky, dense appearance of a low-passed sound’s photism suggests to me a heavier weight, while the thin, acute appearance of a high-passed sound implies a lighter weight. As a common production feature found in electronic music, I often gradually reduce the volume of the bass part or roll off its low

frequencies in the build-up to a particularly loud section of the music, to increase the perceived energy of the bass ‘drop’.

This technique is utilised in ‘Mindscape’ (02:13 to 02:26), ‘Glue’ (02:04 to 02:13), ‘Infinity Pyramids’ (03:16 to 03:19), ‘Intersect’ (02:02 to 02:17), ‘Shiraga’ (05:18 to 05:43), ‘Everest’ (03:20 to 03:27), ‘Rust’ (07:43 to 07:59), and ‘Fluorescent’ (05:24 to 05:54), to take some of the weight out of the ‘heaviest’ sounds in the lead-up to the drop, in order to heighten its impact a few bars later when the bass-induced heavier photisms return. The reverse of this technique is featured in several places in ‘Everest’, where a ‘light’ sound is introduced and gradually made ‘heavier’, by slowly opening a high-pass filter, enabling more bass frequencies to be heard (e.g., from 04:48 to 05:15). The resulting synaesthetic experience is of photisms appearing to come closer, as they become larger in size and heavier in weight.

The ADSR settings on a synthesiser can also be adjusted to modify a photism’s perceived weight. Longer notes and timbres with larger decay, sustain, and release settings remain in my mental field of vision for longer and therefore appear heavier. Shorter notes and timbres with smaller decay, sustain, and release settings disappear from my mind’s eye much faster and therefore appear lighter in weight. As an example of this, at 03:55 in ‘Expansion’, the synthesiser plays short staccato notes that induce small photisms that appear very light in weight. As the decay and release settings are increased over the next few bars, the photisms appear to grow and gain weight.

The perceived weight of my synaesthetic photisms is not only influenced by sound timbre, but also by pitch. Walker and Smith (1985) point out that humans naturally associate pitch with size (lower pitch = larger object) and size with weight (larger object = heavier object). It is therefore very likely that I am not alone in perceiving lower pitches as heavier photisms and higher pitches as lighter photisms. In my composition ‘Balloons’, the speed of the track is increased as the composition progresses. As the pitch slowly rises, the balloon-like photisms induced by the lead synthesiser appear to float from the base of my mind’s eye to the top, giving the impression that their weight is gradually reducing. The increase in tempo also has a significant impact on the photisms’ perceived weight. Higher tempos result in photisms moving at a faster speed, and quicker movement gives the impression of

the photisms being lighter in weight. Conversely, slower moving photisms suggest that they are heavier in weight. As the tempo of ‘Balloons’ increases, the photisms movements quicken, further suggesting a decrease in their weight. The same phenomenon is experienced at the start of ‘Expansion’. As the kick drum plays faster, the weight of its corresponding photism appears to lighten.

Dynamics can also affect my photisms’ perceived weight. Louder sounds appear larger and therefore heavier, while quieter sounds appear smaller and therefore lighter. For example, I visualise the loud noises that appear in the opening section of ‘Everest’ (e.g., at 01:23) as large boulders that I know to be heavy, in contrast to the looped cello sample, which I visualise as small mounds of soil that I know to be very light in weight. The timbres in ‘Everest’ were designed to synaesthetically resemble stones, rocks, and boulders of various sizes (all objects one would find on a journey up a mountain). In the opening section, I varied the dynamics of the sounds heard, so that my synaesthetic visualisation was that of different sized and therefore differently weighted rocks.

3.4. Conclusions

Through analysis of the compositions created to explore my auditory-visual synaesthesia, I have ascertained that timbre has a major impact on my visualisations of texture, state of matter, and weight, and that these visualisations can, in turn, affect my creative decision-making during the composition process. The key findings that have been uncovered from this analysis are, as follows:

- In composing the music for my album *Photisms*, I have become aware of the fact that hearing music (and sound more generally) not only induces a visual sensation but also *infers* a tactile sensation. My photisms have surface textures, can be grouped into distinct states of matter (solid, liquid, gas, plasma), and are weighted differently.
- All my synaesthetic experiences are influenced by prior (real) experiences. No stimulus can induce a photism that has properties beyond any that I have experienced in real life.

- The perceived texture of my photisms is determined by timbre. Distorting, filtering, and processing sounds through audio effects can significantly alter a photism's perceived texture.
- It is possible to use the synaesthetic texture of a specific sound as the catalyst for a new composition, by creating other sounds that have the same synaesthetic texture to use as the palette of sounds. For example, the sound that instigated my composition 'Rust' induces a rusted texture. To complement this sound, I synthesised other timbres that also induced rusted looking photisms.
- It is also possible for the connotations of the synaesthetic texture of a sound to influence how a composition is arranged. For example, the lead synthesiser in 'Balloons' induces a rubbery texture, like balloons, which have connotations of flying. This led me to gradually increase the speed of the track, to cause my synaesthetic photisms to appear to float upwards.
- The perceived state of matter of my photisms is determined by timbre. Distorting, filtering, adding portamento, adjusting the ADSR envelope, and processing sounds through audio effects can significantly alter a photism's perceived state of matter.
- All my compositions consist of 'solid', 'liquid', and 'gaseous' sounds, and several also contain 'plasma-like' sounds. Percussive sounds tend to be perceived as 'solids', harmonic/melodic sounds tend to be perceived as 'liquids', reverberated sounds and sounds with long attack and release settings tend to be perceived as 'gases', and heavily distorted sounds tend to be perceived as 'plasmas'.
- Different consonants induce the sensation of different states of matter. Chopping up and rearranging or glitching vocal recordings therefore results in a quick succession of states of matter, which is visually very pleasing and may, to some extent, explain why I frequently incorporate this production technique into my work.
- Sounds that induce 'solid' photisms are generally perceived as heavier than sounds that induce 'liquid' or 'gaseous' sounds.

- The perceived weight of my photisms is primarily determined by timbre, but also by pitch, tempo, and dynamics. Adjusting the ADSR envelope and filtering sounds can significantly alter a photism's perceived weight.

These findings come as revelations to me. While I was fully aware that my synaesthetic visualisations had shape and colour, I had not considered the material properties of my photisms. It was only upon analysis of the autoethnographic data, while writing the Impact of Timbre on Visualisations of Shape and Colour chapter, that I realised that my synaesthetic photisms induced by music also have properties that would normally be perceived tactilely. It is likely that I have always unconsciously considered my perceptions of texture, state of matter, and weight while composing music. For example, I have come to the realisation that my compositions tend to include sounds that I would consider to be solid, liquid, and gaseous, and that if any of these states of matter were lacking in my synaesthetic visualisation of the composition, I would likely consider the work to be incomplete. Going forward, I intend to consciously exploit this newfound understanding of my synaesthesia and experiment with different approaches to music composition that take into account my synaesthetic perceptions of texture, weight, and state of matter. This could involve composing works that induce exclusively solid, liquid, gas, or plasma photisms, or that contrast sounds that I perceive to be exceptionally heavy with those that I regard as being extremely light in weight. I have already composed a work of music that only utilises sounds that I consider to be 'rusty' in texture. I am keen to continue in this vein and compose works that explore other textures.

Having reviewed literature on auditory-visual synaesthesia and communicated with experts on the issue, it is clear that synaesthetic visualisations of texture, weight, and state of matter induced by musical sounds is a particularly under-researched area. I hope that documenting my own experiences will pave the way for more research into the multifaceted nature of auditory-visual synaesthetic experiences.

4. Spatiality and Temporality

4.1. Introduction

This purpose of this chapter is to explain how my synaesthetic photisms operate in (my mental) space and time. I will first discuss the spatiality of my synaesthetic visual experiences and explain, through analysis of works composed for my album *Photisms*, how the pitch, stereo placement, reverberation, and volume of a sound determine where in my mind's eye its corresponding photism is perceived. Alterations to these parameters are reflected in changes to the photism's spatial position, while automating them results in photism movement. I will then discuss the temporality of my auditory-visual synaesthesia, by examining how the passing of time and the utilisation of time-based music production techniques in my compositions affect my synaesthetic visual experiences. My photisms are perceived in real-time, their materialisation and dematerialisation in my mind's eye synchronised with the start and end of sounds, and their spatial movement synchronised with changes in their inducing sound's pitch, pan, volume, and reverb level. If two sounds are synchronised together, either by aligning MIDI notes or audio transients or through use of sidechaining, their corresponding photisms will also appear synchronised. If one sound is displaced temporally, its corresponding photism's movements will go out of sync with the other. Speeding up the tempo of a work of music results in its constituent sounds' photisms moving, pulsing, and fluctuating faster, while slowing down the tempo also decelerates the photisms. Since music is a time-based medium, any attempt to accurately illustrate my synaesthetic visual experiences can only be done so using a time-based visual medium, such as animation or film. Experiments involving the interpretation of my synaesthetic visual experiences in such visual media will therefore also be discussed here.

4.2. Methods

To learn more about the spatial and temporal qualities of my photisms, I analysed the autoethnographic data I had gathered by searching for mentions of photism location, motion, and evolution over time, and spatial/temporal composition/production techniques I had utilised. I interpreted any patterns that I found as links between the spatial/temporal nature of my photisms and the creative decisions I had made during the composition process. I compared my descriptions of my own photisms' relationship with time and space with the documented experiences of other synaesthetes, and my use of spatial/temporal composition/production techniques with those utilised by other musicians. I contextualised my findings by interpreting the data I had gathered through the lens of the various cultures I belong to and by acknowledging the influence and impact of external factors on my work and my experiences. I also framed my findings within an existing audio-spatial theory proposed by Gibson (2019).

The following themes emerged from the data and will now be discussed in the order in which they are listed:

- The spatiality of my synaesthetic experiences
- Photism location and motion
- The temporality of my synaesthetic experiences
- Photism synchronisation

For a full review of the methods I utilised, please refer to the Methods section in the Introduction chapter (1.7.).

4.3. Findings and Discussion

4.3.1. Spatiality

As explained in section 1.3., synaesthetes who experience photisms are often divided into two groups: associators and projectors (Smilek et al. 2001, Dixon et al. 2004, Mohr 2013). Associators' photisms are visualised internally in the mental space often referred to as the 'mind's eye', while projectors' photisms appear

externally in the space immediately in front of and around them (ibid.). Day (2013), an auditory-visual synaesthete like myself, ‘sees’ his photisms in the space around him. Waldeck, also an auditory-visual synaesthete, experiences sounds as colours and shapes “projected onto [an] internal monitor” which “surrounds [him] like a sphere” (Waldeck 2009, p213). But unlike Day (2013) and Waldeck (2009), my photisms are not projected in front of me; they are instead visualised within my mind’s eye, placing me firmly in the associator group of synaesthetes.

Simner (2012) points out that “a synaesthete who sees colours from music only ‘in the mind’s eye’ (not projected into space) can still describe the movement of colours, and their relative positions within a *mental* space” (pp8-9). This is certainly true of my own synaesthesia; I would describe my mind’s eye as a three-dimensional imagined space: a ‘mental 3D canvas’ that my photisms appear to move around in.

Cytowic (2018) argues that the distinction between projector and associator synaesthetes “no longer seems warranted” (p50), since it is not only projectors whose synaesthetic experiences are spatially afforded. This is in contrast to the view expressed by Dixon et al. (2004), whose study into the “systematic differences in the patterns of Stroop interference between projectors and associators” (p335) found that projectors’ photisms were more intense and harder to ignore than those experienced by associators. However, Cytowic (2018) posits that, since many associators can also “describe the movement and position of colors within their mental space”, it is possible that projectors may simply have a higher “capacity for vivid imagery” (p50). Cytowic also ponders the possibility that projectors’ experiences may be caused by multiple forms of synaesthesia (ibid.). For example, a synaesthete who ‘sees’ their musically induced photisms in the space around them may actually be experiencing musical-space synaesthesia, in addition to auditory-visual synaesthesia.

Musical-space synaesthesia involves the perception of spatially defined musical sounds (Linkovski at al. 2012, Akiva-Kabiri et al. 2014) and is similar to sequence-space (also known as spatial sequence) synaesthesia: another form that I experience. For sequence-space synaesthetes, sequences are “perceived to occupy spatial locations in the mind’s eye or peripersonal or extrapersonal space” (Jonas & Price 2014, p1). Examples of such sequences might include the alphabet, numbers,

days of the week, and months of the year. I perceive the alphabet as a descending sequence starting with ‘A’ at the top left of my mind’s eye, descending diagonally to ‘Z’ at the bottom right. My number sequence ascends from the bottom left to the top right of my mind’s eye, with small steps at each multiple of 10 and larger steps at each multiple of 100. I visualise the days of the week starting with Monday just above the centre of the far-left of my mind’s eye and finishing with Sunday just below the centre of the far-right, with the weekend contained within a black box. Months of the year, meanwhile, begin with January at the bottom right of my mind’s eye and ascend diagonally to December at the top right.

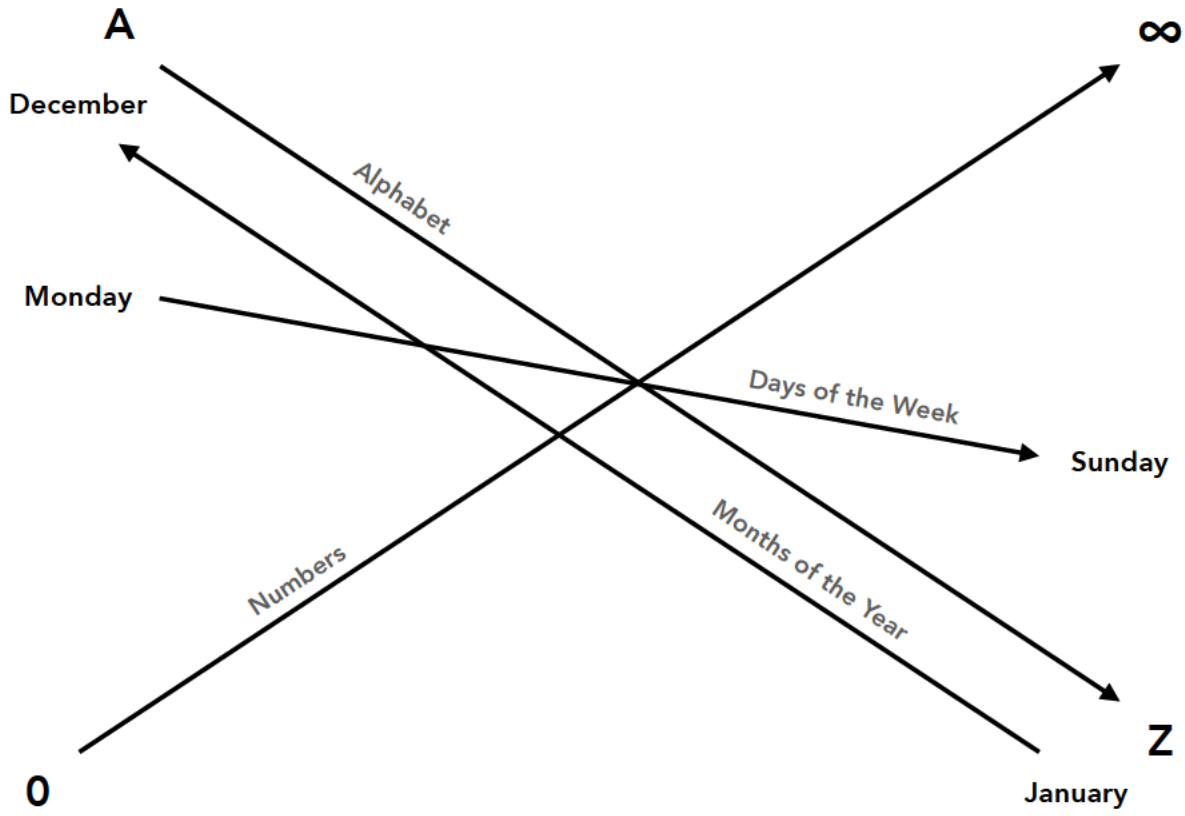

Figure 4.1.

The start and end points in my mind’s eye of my alphabet-form, number-form, week-form, and calendar-form sequences, and arrows showing their ‘direction of travel’.

When it comes to music, I visualise the sequence of musical notes as they are laid out on a piano keyboard. This is probably not synaesthesia though, merely a visualisation of my understanding of the concept of musical notes. I suspect that if guitar was my primary instrument, and not piano, I would likely picture a fretboard instead when visualising musical notes. The spatiality of my auditory-visual

synaesthesia is not sequence-based; for me, only graphemes and some conceptual arrays (months of the year, days of the week, etc.) induce the perception of spatially afforded *sequences*. However, sounds (in particular, musical ones) do induce the perception of spatially afforded *photisms*, as I will now go on to discuss.

4.3.2. Photism Location and Motion

Upon analysis of the autoethnographic data recorded during the composition of works for my album *Photisms*, it became apparent to me that the location of a photism in my mind's eye is dependent on the inducing sound's pitch (not its musical note), its placement in the stereo field, and its volume and reverberation. Sounds heard to my left are visualised at the left of my mind's eye, while sounds emanating from my right are visually perceived at the right of my mind's eye. A higher pitch induces a photism at the top of my mind's eye, while a lower pitch results in the photism being perceived at the bottom. Louder sounds with little to no reverb applied, induce photisms that appear closer to me, while quieter sounds with a large amount of reverb applied induce photisms that appear further away from me. A high volume and minimal (or no) reverb are both required for the photism to appear close, while a low volume and maximal reverb are both required for the photism to appear distant. A high volume with maximal reverb would result in a mid-range large photism with a large shadow, while a low volume with minimum (or no) reverb would result in a mid-range small photism with a small (or no) shadow.

If we were to visualise these parameters using the Cartesian coordinate system, the stereo placement of a sound would determine its photism's position on the X axis, the pitch of a sound would determine its photism's position on the Y axis, and the volume and reverberation of a sound would determine its photism's position on the Z axis, like so:

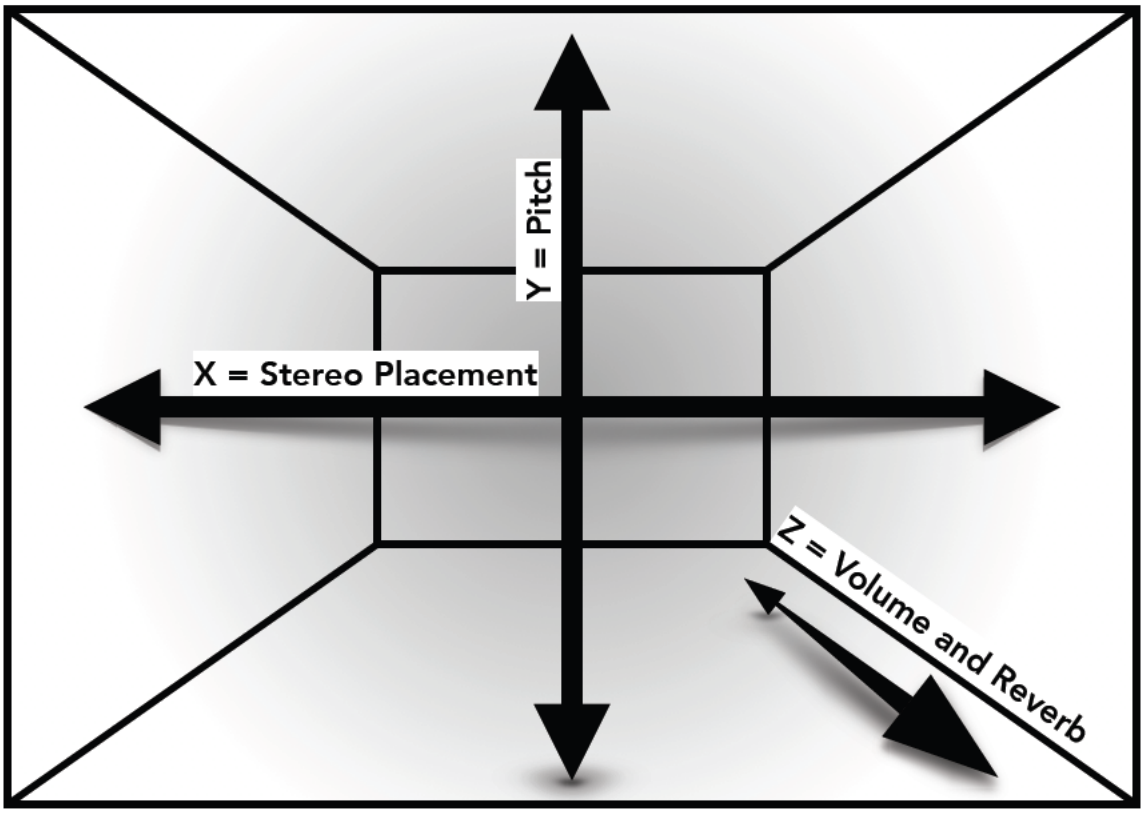

Figure 4.2.

A diagram of my mind's eye: the three-dimensional imagined space that my photisms appear in.

This visualisation system is not unique to me, or indeed to auditory-visual synaesthetes for that matter. Chiou et al. (2013) note that synaesthetes and non-synaesthetes alike correlate increases in pitch with "elevation in spatial location" (p1760). Audio engineer (and, presumably, non-synaesthete) David Gibson also associates pitch with height and advocates 'imaging' while mixing music: that is, imagining sounds as visual objects between the speakers or headphones (Gibson 2019). Gibson correlates panning (i.e., the placement of sounds in a stereo field) to the X axis (left to right), frequency (i.e., the pitch of sounds) to the Y axis (up and down), and volume to the Z axis (front to back). Gibson also notes the importance of reverberation in gauging a sound's proximity but does not include it in his three-dimensional sound imaging model. Aside from the omission of reverberation, Gibson's model is identical to the rules that dictate my photisms' position in my mind's eye.

Throughout the entire composition process, and not just at the mixing stage, I ensure that each distinct sound can be heard clearly in the mix by affirming that its

corresponding photism has its own defined space in my mind's eye. If any part of my mental three-dimensional canvas appears cluttered, photisms can be moved: up or down through equalisation or by transposing parts up or down an octave; left or right through panning; and forwards or backwards through volume and reverberation adjustments. When composing 'Everest', I was keen to learn whether it was possible to induce a synaesthetic visual experience resembling a Jackson Pollock painting (see, for example, *Number 5, 1948* (Pollock 1948)). By intentionally cluttering my mind's eye by having several sounds close in pitch, stereo placement, and volume and reverb level to each other at several points in the composition, I was successfully able to induce a landscape of indiscernible shapes, colours, and textures.

To create the perception of motion, I must move my photisms along one axis or multiple. Automating the pan control results in the photism moving left or right on the X axis. For example, I decided to automate the pan of the lead synthesiser when mixing 'Mindscape', so that its corresponding photism appeared to ricochet from side to side, giving my synaesthetic visual experience a sense of horizontal motion. Changes in pitch, meanwhile, prompt upwards or downwards motion on the Y axis. Melodies (e.g., those performed by the sampled vocal parts in 'Infinity Pyramids', 'Intersect', 'Rust', and 'Fluorescent') are therefore visualised as vertical movement.

Sigrist (2012) points out that, in perceiving a melody, "You are aware […] not just of each successive note, but also of the succession of notes *as* a succession. This is what it means to *hear* a melody, rather than just to know that one has been played" (p207). I would extend this explanation to my own synaesthetic visualisations. In order to visualise melodic movement (as vertical motion), retention of the immediate previous locations of my photisms is required.

A more general, global perception of upwards movement is induced by the constantly rising pitch of 'Balloons'. The corresponding photisms of all sounds in the composition appear to rise slowly upwards in tandem with the continuous pitch increase.

For my original attempt at interpreting Moholy-Nagy's *Composition A XXI* (1925) (see the 'Composition A XXI Animation' in the Appendices), in order to depict the diagonal

striped red and orange strip that cuts across the bottom of the canvas, I had the synth play a two chord sequence in which the second chord was higher in pitch than the first chord, and automated the pan to move from hard left to hard right.

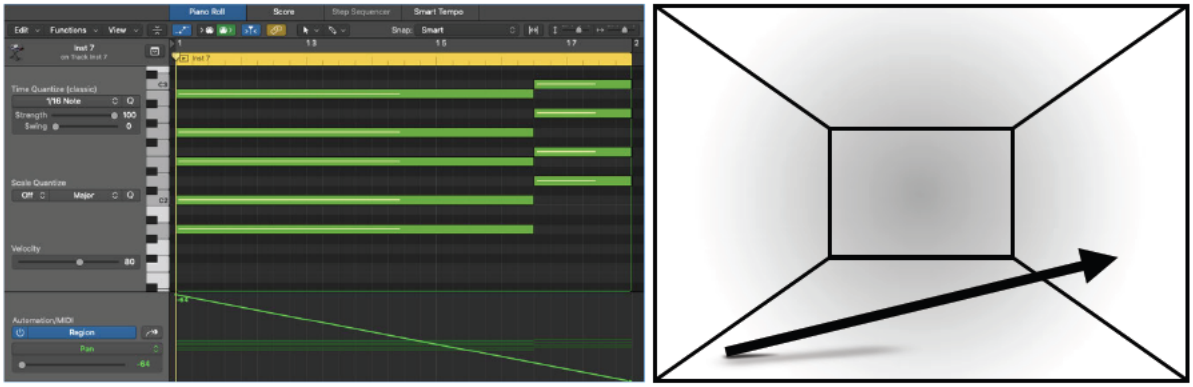

Figure 4.3.

Left: Screenshot of the looped MIDI region played by the synthesiser in Logic. In the chord sequence displayed, the second chord is pitched higher than the first chord. The automated pan is also shown. Right: The resulting northeast direction of travel of the synthesiser's corresponding photism. This is the same route I imagined the striped strip depicted in Moholy-Nagy's Composition A XXI *(1925) taking.*

By increasing the pitch and adjusting the pan simultaneously, I was able to successfully move my photism diagonally from the bottom left to the centre right of my mind's eye. Finally, automating a sound's volume and reverb level simultaneously can bring about forward or backwards movement on the Z axis. An example of this occurs at the start of 'Infinity Pyramids'. The volume levels of the vocal and synthesiser tracks are initially low, with an ample amount of reverberation applied to both. The corresponding photisms therefore appear far away from me. Volume levels are gradually increased, while reverberation is reduced, resulting in the photisms appearing to move towards me.

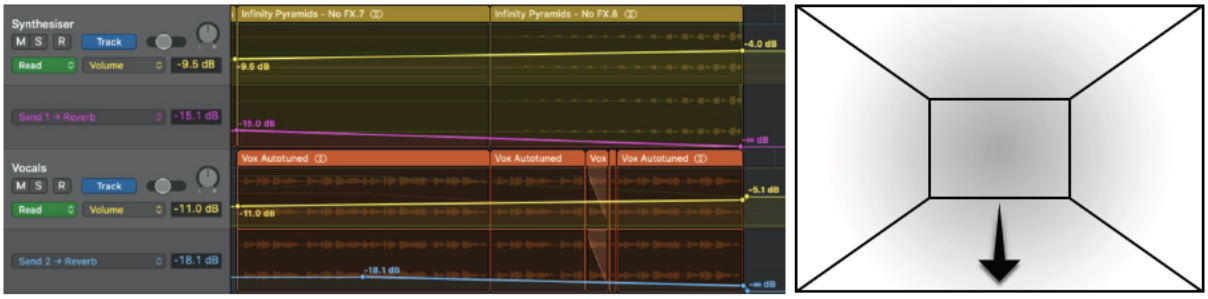

Figure 4.4.

Left: Screenshot of the vocal and synthesiser tracks, showing an increase in volume and decrease in reverb level for both tracks.

Right: The resulting forwards motion of the vocal and synthesiser's corresponding photisms, as they appear to move closer towards me.

Whether or not my perception of sound (and the motion of sound) in an imagined spatial location is actually synaesthesia is debatable. According to Pratt (1930), the perception of upwards or downwards movement when a succession of pitches is heard is almost universal. This phenomenon is coined by Rusconi et al. (2006) as the SMARC (Spatial-Musical Association of Response Codes) effect. Pratt (1930) also acknowledges "the apparent localization of high vocal tones in the head and low ones in the chest" (p279), which may explain why even non-synaesthetes associate higher and lower pitches with greater and lesser spatial height, respectively.

Furthermore, I suspect that, if non-synaesthetes were to attempt to visualise musical sounds, a majority of them would associate left- and right-panned sounds with objects positioned to their left and right, respectively, quieter and more reverberated sounds with objects positioned further away, and louder and less reverberated sounds with objects positioned much closer to them. In real life, if a sound is heard to one's left, and if it is quieter and more reverberated, whatever is producing the sound is likely positioned to one's left, far away from the receiver, so it follows that the rules of Gibson's (2019) (non-synaesthetic) sound visualisation model are almost identical to the factors that determine the spatial position of my photisms. However, Linkovski et al. (2012) did verify the existence of a distinct musical pitch-space form of synaesthesia by studying one synaesthetic musician who visualised "each musical tone of a given octave in a distinct spatial location, rising diagonally from lower left to upper right" (pS248). This confirmed the suggestion made by Rusconi et al. (2006) that some musicians experienced both a vertical *and horizontal* SMARC effect for

pitch height. The authors hypothesised that this anomaly could be a result of "musicians' familiarity with keyboards (on which low-frequency pitches are played by pressing leftward keys and high-frequency pitches are played by pressing rightward keys)" (ibid. p125), while Linkovski et al. (2012) believed that their synaesthete's diagonal organisation of pitches was induced by their "abstract concept of the musical notation" (pS250). It is likely that this synaesthete is visualising a sequence of pitches, an arrangement of musical notes in time – a musical scale, perhaps – rather than a stack of pitches played at the same time, which would explain the diagonal layout of their music-space synaesthesia. Akiva-Kabiri et al. (2014) found that non-synaesthetic musicians also associated "ascending musical pitch tones to an ascending diagonal spatial array" (p28) but acknowledged that "the spatial association could also be related to a more conceptual level of the musical tone identity or its position on the musical staff" (p26) than as a result of auditory-visual crossmodal correspondences.

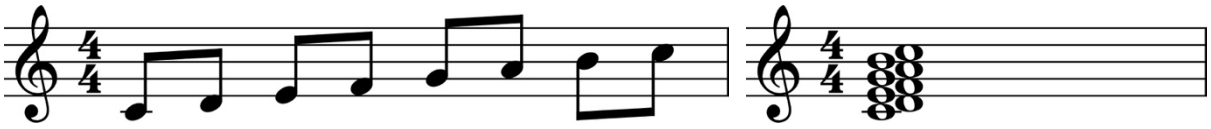

Figure 4.5.
Left: The notes of an ascending C major scale to be played in sequence appear as a diagonal arrangement.
Right: The notes of a C major scale to be played at the same time appear as a vertical arrangement. The former is more commonly encountered by musicians and so may explain why some synaesthetic musicians experience a diagonal spatial arrangement of music notes.

I rarely use music notation when composing or performing music, which would explain why my photisms are not arranged diagonally in space. However, as a keyboard player, I do often visualise musical notes, chords, scales, and keys laid out left-to-right on an imagined piano keyboard but, as mentioned before, this is unlikely to be a form of synaesthesia. Hearing pitch movement instead gives me the visual impression of vertical motion.

Regardless of whether the spatiality of my synaesthetic photisms is indeed a feature of my auditory-visual synaesthesia, it is important for me to understand my crossmodal correspondences between musical parameters, such as pitch, panning, volume, and reverberation, and the three spatial dimensions, in order to translate

visual ideas into music compositions. For example, by understanding that a high pitched, left panned sound will induce a photism located at the top left of my mind's eye, I know to interpret abstract forms located at the top left of a painting as high-pitched musical sounds that are panned hard left. And if the form appears smaller and further away, this could be interpreted as a quieter sound with a high level of reverberation applied.

4.3.3. Temporality

It is also important to understand how my synaesthetic experiences are affected by the fourth dimension: time. Music is, of course, a time-based medium, i.e., one that unfolds over time. When considering how music induces and affects my synaesthetic experiences, I must therefore consider how my photisms move and evolve over time. Duffy (2001) points out that, "[f]or many synesthetes, time *is* space. Units of time are experienced internally as places, three-dimensional landscapes with color, texture, shape, perspective" (p147). As already discussed, I do find that temporal concepts such as the months of the year and days of the week are spatially afforded; these sequences are located and arranged in space in my mind's eye. The temporal nature of my synaesthetic experiences, on the other hand, is not spatially visualised or arranged. This differs from the experiences of other auditory-visual synaesthetes.

Ward et al. (2008) found that auditory-visual synaesthetes' experiences often move in a left-to-right direction. The authors suggested that this may be a result of "the cultural tendency for left-to-right reading" (p1295). Music notation and the arrangement section of most digital audio workstations exhibit a left-to-right arrangement of notes and audio/MIDI recordings, respectively. The progression of time in the music is therefore expressed as left-to-right movement. However, temporality in my synaesthetic experiences is instead expressed as motion and transformation of my photisms. As the music unfolds over time, my photisms change their spatial location according to changes in pitch, pan, volume, and reverberation, and change their shape, colour, texture, state of matter, and weight according to timbral alterations. The passing of time is therefore expressed through photism materialisation, dematerialisation, transformation, and motion. This is similar to how

Day describes time's impact on his synaesthetic experiences: "my perceptions of music are dynamic, rather than static, moving in three dimensions as the music progresses through time" (Day 2013, p906). In her analysis of Laurie Spiegel's 'The Expanding Universe' (1980), Gottschalk (2018a) visualises the music as a journey through space instead of time. From her perspective, the music seems to have always existed; it is her, the listener's, perspective that appears to be changing. In her analysis of Toshiya Tsunoda's *O Kokos Tis Anixis* (2013), meanwhile, Gottschalk (2018b) visualises the music as loops of different meter. Depending on the perceived meter, different shapes are visualised (e.g., a triangle for 3/4, a square for 4/4). I was interested in exploring these relationships between time and perspective, and meter and shape, in my own composition.

Originally conceived as an audiovisual work, 'Expansion' was composed with the intention to explore the idea of 'changing states' over time. I intended for 'Expansion' to be split into sections – what I saw as 'zoom levels', with my mental perspective zooming out with each 'level'. To achieve this, some musical elements from the previous section formed the basis of the subsequent section. This concept is not too dissimilar to Neely's (2017) theory of musical fractals, except that each level does not self-reference; levels are instead based around multiple iterations of the previous level. When dealing with tempo, I took inspiration from the soundtrack of the film *Inception* (Zimmer 2010). Composer Hans Zimmer describes how he subdivided the tempo of Édith Piaf's *Non, je ne regrette rien* (which forms the basis of the score) to represent different levels of dreams within dreams (Itzkoff 2010), a core theme of the film. While Zimmer made use of different tempos to differentiate dream levels, I chose to utilise different time signatures to separate the levels of my composition. With 'Expansion', the music starts at Level 1 and 'zooms out' through the levels, ending on Level 10. For me, the temporal nature of 'Expansion' is perceived as a zooming out from level to level. The level count (1, 2, 3, etc.) determined the number of beats in a bar and the types of sounds used in that level. For example, Level 3 is written in 3/4 and focuses on what I consider to be 'triangular' sounds.

'Expansion' stands apart from the rest of my compositions, in that I find each section to be visually (and sonically) distinct, due to the mostly different palette of sounds used in each. As the composition progresses, I experience an ever-changing

landscape of photisms of different shapes, colours, textures, states of matter, and weights. ‘Expansion’ is atypical in this regard since, for most of my compositions, I synaesthetically perceive musical structure as variations on a visual theme, with all the sections of a composition appearing visually similar, yet somewhat distinct, to each other. My visualisations of musical structure differ from those of Sinha (2009) who sees “the form and internal structure of a piece of music on my internal screen like a chart or a three-dimensional film” (p200). Sinha’s account bears similarity to that of composer Jon Hopkins who admits to experiencing a mild form of auditory-visual synaesthesia (Telekom Electronic Beats 2013), which enables him to “see every track, not just in colours, but as a 3D structure” (THUMP 2013). While Sinha and Hopkins experience musical structure as imagined spaces, I find that the structure of a composition is defined by the unique *combination*, *position*, and *appearance* of my photisms in each section of the music. Each of these factors will now be explained in turn.

It is common for each section of my compositions to comprise a unique *combination* of sounds. Some sounds may only appear in certain sections, while other sounds will be utilised throughout the whole composition. Providing each section of the music comprises its own unique grouping of sounds, the precise combination of photisms I perceive will be unique to that section. For example, I find that each section of ‘Fluorescent’ is visually identifiable due to the sounds (and therefore photisms) that appear in each. As the composition begins, only the ‘fluorescent bulb’ photism (induced by the solitary synthesised sound) is present in my mind’s eye. As more sounds are added in each section, my mind’s eye becomes populated with an ever-increasing number of photisms. Depending on whichever photisms are being visualised at any one point, I can easily identify which section of the music I am currently listening to.

Depending on the sounds’ pitch (melodic changes obviously affects this), pan, volume, and reverberation, my photisms’ *position* may also change from section to section. For example, the pitched-up cello sample that opens ‘Everest’ is initially low in volume and immersed in reverberation, resulting in its photism being visualised at the back of my mind’s eye. In later sections, its volume is increased and reverb level decreased, bringing its photism further forwards in my mind’s eye.

Finally, depending on how the timbres of the sounds have been modified in each section, my photisms' *appearance* might also change slightly from section to section. In my notes on 'Infinity Pyramids', as stated above, I describe a green and orange "jelly snake" (the photism induced by the lead vocal). As this is processed in different ways in each section, its form changes over the course of the composition. In some sections, the shape of the photism becomes more defined with sharper edges, while in others the texture becomes "barbed wire"-like in appearance. Utilising different photism combinations and positions and by making frequent changes to their appearance in each section of a composition helps to give each section its own unique visual identity. This helps me to understand the composition's structure and provides visual variety while maintaining a consistent visual theme.

All of these techniques were employed in the making of 'Shiraga' to enforce its sense of structure. In each section of the work different arrangements of musical ideas are utilised, affecting the combination of photisms induced; sounds are processed differently, affecting their photisms' visual appearance; and sequences are played back in different octaves, affecting their photisms' vertical position in my mind's eye. By giving each section of the music its own unique visual identity, my understanding of the musical structure of a composition is therefore akin to a 'snapshot' of my synaesthetic visualisation of each section of the music. These mental snapshots are visually related to one another and, if they were to be arranged side-by-side, would look like variations on a visual theme, not unlike the series of closely-related forms conveyed in Kandinksy's *Farbstudie Quadrate* (1913). Of course, since music is a time-based medium, my mental snapshots of each section of a composition cannot accurately represent exactly how I synaesthetically visualise music.

Kandinsky (1977) himself notes that "[i]n manipulation of form music can achieve results which are beyond the reach of painting. On the other hand, painting is ahead of music in several particulars. Music, for example, has at its disposal duration of time; while painting can present to the spectator the whole content of its message at one moment" (p20). These temporal differences between the two artforms can pose problems in depicting synaesthetic visualisations of music using visual artforms. Synaesthetic painter Melissa McCracken's solution to the problem of portraying her dynamic synaesthetic visualisation of an entire song in a static painting is to layer

depictions of her photisms on top of each other on the canvas (McCracken 2016). The outputs of this technique could be considered the physical equivalent of my mental snapshots of each section of a composition, which are also assemblages of the most notable photisms induced by the music.

In my opinion, animation is a better medium for accurately depicting synaesthetic visual experiences of music than painting, due to its dynamic time-based nature. For example, Syamori's (2017) animation depicting his synaesthetic visualisation of Haywyre's 'Do You Don't You' (2016) closely resembles how I visually perceive the song. I previously attempted to portray my synaesthetic experiences in the form of animation in the creation of an audiovisual work, *Shapeshifter* (CoriAnder 2018), but struggled to accurately depict my visualisation of the music, due to the multitude and complexity of the photisms and my lack of experience with animation software. More recently, I attempted to animate 'Glue' and 'Expansion', both originally conceived as audiovisual works, but abandoned the visual elements of the works for the same reasons expressed above. Going forward, I intend to spend time familiarising myself with animation software so that I can create audiovisual works that accurately represent my synaesthetic experiences.

4.3.4. Photism Synchronisation

Materialisation and dematerialisation of my photisms are synced to the start and end of musical notes, respectively. Whenever I hear a sound, a photism is automatically visualised. When I can no longer hear the sound, the photism disappears. This behaviour of my synaesthesia is not unusual. In discussing the temporal dimension of synaesthesia, Dittmar (2009) notes that "sound-induced synaesthesia […] which appears with the sound, undergoes changes as the sound changes, and then disappears as the sound fades away" (p51). To demonstrate this temporal behaviour, the image below shows music notation of a sine wave playing on the first and third beats of a bar. It is not played on the second and fourth beats. I would therefore visualise a light pink-coloured and rubber-textured sphere (the corresponding photism of a sine wave) on the first and third beats only, with the photism vanishing on the second and fourth beats, as shown below the notation.

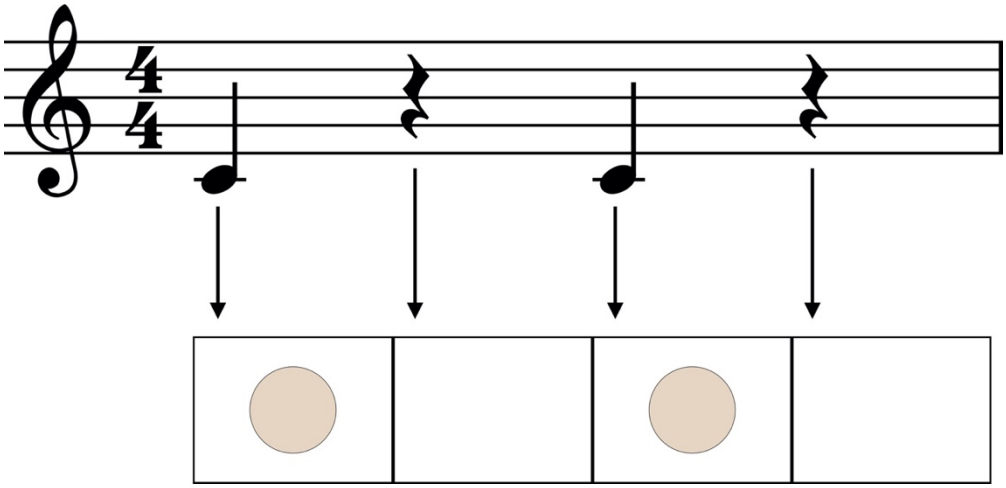

Figure 4.6.
Top: Music notation showing a bar of music to be played by a sine wave.
Bottom: My resulting synaesthetic visualisation of each beat of the bar.

A photism will appear and disappear suddenly if the attack and release of its inducing sound is set to zero (or close to zero) milliseconds. I have become aware that, when listening to very rhythmic music, I often blink in time with the rhythm of my photisms to accentuate their flashes and therefore heighten the synaesthetic experience. A longer attack or release will be perceived as the photism fading in or out, respectively, rather than appearing and disappearing suddenly. Musical rhythm itself does not constitute motion in my synaesthetic experiences; it only determines the rhythm of photism flashes. A photism will blink and pulsate in time with any rhythm performed by its inducing sound, but will remain fixed to the same location unless its pitch or pan is modified, or its volume and reverb levels change. Even if the rhythm changes, so long as the other parameters remain static, so too will the photism's position.

If two sounds are rhythmically synchronised, their corresponding photisms will appear temporally locked together, i.e., they will appear and disappear from my mind's eye at the same time as each other. Sidechain gating has been used in several of my compositions to synchronise sounds together. Sidechain gating comprises a noise gate opening on one audio signal, allowing it to be heard, whenever the volume of another audio signal exceeds a set level. This results in the first audio signal adopting the rhythm of the second audio signal. To give the visual impression of sounds having been glued together, I used sidechain gating on most of

the synthesiser and sampled vocal sounds in ‘Glue’ to synchronise their rhythms (and therefore, their photisms’ rhythms). This effect is also utilised in ‘Expansion’ in the transition from Level 3 to Level 4, in order to conform the rhythm of the sampled Level 3 audio to the rhythm of the synthesiser in Level 4.

Sidechain compression, meanwhile, is present in most of my compositions in the *Photisms* album. Sidechain compression involves compressing the dynamics of one audio signal whenever the volume of another audio signal exceeds a set level. This can be used to create a pumping effect, especially when the kick drum is set as the input signal, and is a common staple of electronic dance music production. Use of this effect results in my photisms appearing to react to each other – whenever one photism (induced by the input sound) appears, another photism (induced by the compressed sound) is squashed down. This effect is utilised in all compositions in *Photisms* but is especially prominent in ‘Intersect’, ‘Balloons’, ‘Everest’, and ‘Rust’.

Furthermore, as discussed in Chapter 2, two timbrally similar sounds that are rhythmically and melodically synchronised, either through sidechaining or by having multiple instruments perform the same part, will induce composite photisms, i.e., photisms with attributes from multiple source photisms. For example, in ‘Rust’, composite photisms are induced by the synchronised vocal and synthesiser parts.

The use of polymeters and polyrhythms in music results in photisms appearing to drift in and out of sync with each other. In ‘Intersect’, the synthesisers, kick drum, and cymbals are written in 3/8, while the other drums and vocal parts are in 4/4. Wherever the first beat of all loops intersects (every three bars written in 4/4 and every eight bars written in 3/8), photism synchronisation occurs. Wherever the first beat of a loop does not align with that of other loops, the rhythms of the photisms do not align and they therefore appear out of sync with each other.

Polymeters are also utilised in ‘Rust’ (in the breakdown section, where the drums and some synthesisers are in 3/4, while other synthesisers remain in 4/4) and in ‘Expansion’ (during the transition from Level 7 to Level 8, in which a seven-beat loop fights against an eight-beat loop). As with ‘Intersect’, my visualisations of these polymeters involve photisms drifting in and out of sync with each other. Level 6 of ‘Expansion’, meanwhile, features a 3:2 polyrhythm in places, and the bassline and

kick drum parts in ‘Shiraga’ perform a 4:3 polyrhythm in the first three beats of each bar (the composition is mostly in 9/4 but occasionally switches to 8/4). This results in my photisms only appearing in-sync with each other at the first beat of each bar and out-of-sync at all other points. I enjoy the disorienting visual effect of photisms drifting in and out of sync with each other; I find this sonic and visual sense of tension brings me a great sense of satisfaction when my photisms do occasionally lock together.

4.3.5. Speed and Tempo Manipulation

Manipulating the speed or tempo of some or all tracks in a composition can drastically alter my synaesthetic experience of the music. Increasing the overall playback speed of any musical work results in my synaesthetic visualisation unfolding more quickly and, due to the consequent pitch increase, moving further up the Y axis in my mind’s eye and becoming lighter in colour. A small change in speed (resulting in a pitch increase or decrease of no more than two semitones) will not noticeably affect my synaesthetic visualisations of the music. I often slightly adjust the speed to songs that I am very familiar with to provide me with a fresh auditory experience, without altering the resulting synaesthetic visual experience. This technique is particularly useful while mixing and mastering my music, as it allows me to hear my work with ‘fresh ears’ and make more objective decisions. Any more than the smallest increase in speed, however, does noticeably affect my synaesthetic visualisations of music.

A moderate and very obvious increase in speed is employed in the transition from Level 2 to Level 3 of ‘Expansion’. The photisms’ rhythms quicken and they rise slightly upwards from the base towards the centre of my mind’s eye. A more elongated increase in speed ensues over the course of the first nine-and-a-half minutes of ‘Balloons’, with a slightly shorter deceleration transpiring in the final two-and-a-half minutes of the composition. This manipulation of speed was intentionally performed in order to give me the synaesthetic visual impression of the balloon-like photisms rising up from the base of my mind’s eye, and later falling back down as if they had been ‘punctured’.

An increase in tempo that does not also involve an increase in pitch, on the other hand (e.g., playing back a MIDI recording at a faster tempo), will generally only result in my synaesthetic visualisation of the music unfolding more quickly, as if the 'fast forward' button has been pressed when watching a film. However, if a regular pulse is played at a considerably fast tempo, a definite pitch can be heard. I was keen to learn what my synaesthetic visualisation of this phenomenon would look like. So, inspired by composer Adam Neely's (2018) discussion on the relationships between rhythm, pitch, and colour, I designed Level 1 of 'Expansion' to investigate my synaesthetic visual perception of a pulse played at an increasingly faster tempo that it became perceived as a definite pitch. This section (or 'level') features a kick drum performing a simple beat at an ever-quickening tempo. Even as the tempo increases, the drum's stereo placement, pitch, volume, and reverb level remain constant. The photism therefore flickers 'on and off' at an increasingly faster speed but remains fixed to the same position in my mind's eye. However, once the frequency of a pulse rises beyond 20Hz, our human ears begin perceiving a pitched tone. As the tempo continues to increase, the pitch of this tone rises. At this point, since I am now hearing an increase in pitch, and no longer an increase in tempo, the photism appears to rise upwards from the base of my mind's eye. Furthermore, as the kick drum pulse has been accelerated so much that it sounds more like a sawtooth wave, the shape, colour, and texture of the corresponding photism have all been transformed, and what initially looked like a heavy solid object now resembles a lighter viscoelastic material. There is therefore undeniably a strong link between speed/tempo and the spatial location and appearance of my synaesthetic photisms.

4.4. Conclusions

In this chapter, I have established that, as an associator synaesthete, my photisms are visualised in my mind's eye: a three-dimensional mental space. The spatiality of my synaesthetic experiences is different to that of many musical pitch-space synaesthetes who perceive music notes in an ascending diagonal row. The location of my photisms can be defined using the Cartesian coordinate system, with the X, Y, and Z axes corresponding to the inducing sound's pan setting, pitch, and volume and reverb levels, respectively. Since non-synaesthetes' auditory-spatial crossmodal

correspondences closely resemble my own, it is possible that the spatiality of my sound-induced synaesthetic photisms might not itself be a synaesthetic trait. However, understanding how musical parameters affect the spatiality of my synaesthetic photisms is crucial to the translating of visual ideas into musical ones.

Unlike for some synaesthetes, my perception of the passing of time is not perceived on a left-to-right horizontal plane. My synaesthetic experiences are dynamic, with the passing of time perceived through photism materialisation, dematerialisation, transformation, and motion. Automating the pan, pitch, volume, or reverb settings of a sound induces a sense of motion in space. Musical rhythm does not induce a sense of motion but does correspond to the materialisation and dematerialisation of photisms. Fast rhythms therefore induce a flashing effect, which I often accentuate by blinking in time to the music. Since my synaesthetic experiences unfold in real-time with the inducing music, as a time-based visual medium, animation offers more potential in accurately depicting my photisms. However, my experiments with animation have, to date, been of limited success.

I have attempted interpreting musical meter as various-sided shapes and then design timbres that induce such forms. I have also structured many of my compositions by ensuring that the sections that make up the work induce variations on a consistent visual theme. I recently discovered that, for me, the structure of any composition is visually defined by each section's unique *combination* of photisms (determined by the specific blend of sounds used in that section), *position* of the photisms (determined by the pitch, panning, volume, and reverberation of sounds in that section), and unique *appearance* of the photisms (determined by the specific way in which the corresponding sounds have been altered or processed in that section). I have discovered that I enjoy the visual experience of my photisms appearing to be locked together, in synchronisation with each other, which explains my frequent usage of sidechain gating and compression. I also enjoy the synaesthetic visual experience, induced by polyrhythms and polymeters, of photisms drifting in and out of sync with each other and occasionally overlapping. Some of my recent compositions incorporate speed and tempo manipulations, which cause photisms to flash quicker and move faster, and can result in changes to their vertical position, shape, colour, texture, state of matter, and weight.

Through analysis of the autoethnographic notes on the creation of my compositions, I have learned how music affects spatial location and movement of my photisms, and how the passing of time is perceived in my synaesthetic visualisations of music. This understanding of the spatiality and temporality of my synaesthetic experiences is fundamental in the reverse-engineering of my auditory-visual synaesthesia, as the next chapter will now go on to discuss.

5. Translating and Reverse-Engineering

5.1. Introduction

For many years, synaesthetic artists and musicians have utilised their synaesthetic experiences as a source of inspiration in the creation of new works (van Campen 1999; 2010). Cavallaro (2013, p5) asserts that: “In looking at art created by actual synesthetes, it is vital to focus on the ways in which these artists translate their perception of things into artifacts”. This chapter focuses on the ways in which I translate my ‘perception of things’ into works of music, through scrutiny of my preliminary attempts at creating audiovisual music, by interpreting my synaesthetic experiences of the music as computer-generated animations, and how I later flipped this process to create music using visual stimuli as inspiration. Through a strong understanding of the auditory-visual crossmodal correspondences of my synaesthesia, I have found that it is possible to compose music inspired by a visual image (real or imagined) by audiating (hearing in my mind’s ear and giving musical meaning to (Gordon 1999)) sounds that induce synaesthetic photisms resembling the image, then producing these sounds and arranging them into a work of music in a DAW. This process involves: interpreting the shape, colour hue, texture, and apparent state of matter of forms in an image as the timbre of sounds; interpreting the brightness and vertical position of these forms as the pitch of sounds; interpreting the horizontal position of these forms as the placement of sounds in the stereo field; and interpreting the depth, size, and clarity of these forms as the volume and reverberation of sounds.

This chapter will first provide an overview of the auditory-visual crossmodal correspondences of my synaesthesia. I will then discuss other artists’ attempts at translating between sonic and visual mediums. Finally, through analysis of three compositional studies, I will explain how I came to develop and refine my unique approach to music composition, where a process of synaesthetic reverse-engineering is employed in the translation of visual images into sound palettes for new works of music.

5.2. Auditory-Visual Crossmodal Correspondences

I perceive music visually, in my mind's eye. As discussed in previous chapters, all identifiable sounds in a work of music appear as photisms in a mental three-dimensional space, their form dependent on their timbre, and their location dependent on their pitch and placement in the stereo field. Having listened to music and noted how changes in pitch, timbre, dynamics, etc., affect different aspects of these photisms, I have developed a strong understanding of my synaesthetic auditory-visual correspondences (or, in other words, the connections between sonic and visual attributes). I have since used this understanding to enable me to translate music to visual works and vice versa, as this chapter will go on to discuss. I will first describe the crossmodal correspondences present in my auditory-visual synaesthesia.

Orlandatou (2015) investigated the mappings of certain sound characteristics to attributes of the synaesthetic visual sensation in a group of sound-colour synaesthetes. It was found that, in the participants present, chroma (hue) was determined by the type of sound heard, colour plurality (number of colours present) was determined by sound simplicity/complexity (e.g., pure tones vs. complex tones), colour brightness was determined by the frequency (pitch) of the sound, and visual density (complexity and number of forms present) was determined by the sound's power density (the frequency range of the sound). Much of these findings align with my own synaesthetic experiences.

Every sound that I hear has colour. Although some synaesthetes associate colour hue with musical key or pitch, for others (myself included), the hue of a photism is dependent on timbre (Galeyev 2007). I find that bright and distorted timbres give off warmer hues like reds, oranges, and yellows, while softer, cleaner sounds induce sensations of cooler colours like blues, greens, and purples. Like with the participants in Orlandatou's study, sound frequency affects the brightness of these colours, with higher- and lower-pitched sounds inducing lighter and darker shades, respectively. The frequency of a sound also determines the size and vertical position of the corresponding photism; higher-pitched sounds appear smaller and are situated at the top of my 'mental canvas', while lower-pitched sounds appear larger and are located at the bottom. Galeyev (2007) notes that even non-synaesthetes are

inclined to associate lower pitches with larger, darker images, and higher pitches with smaller shapes of brighter shades. The location I perceive a sound to emanate from determines its photism's horizontal position on my 'mental canvas'.

It is worth pointing out that this 'mental canvas' is not two-dimensional; my photisms have depth, with quieter sounds not only appearing smaller but also further away, and louder sounds appearing both larger and closer to me. However, the predominant features of my synaesthetic visualisations are the shapes and textures of the forms induced by different timbres. It is not unheard of for sound-induced synaesthesias to be timbral-based; a study by Chiou, Stelter and Rich (2013) found that timbral changes influenced some auditory-visual synaesthetes' perceptions of shape and colour. In my synaesthetic experiences, harsh, thin, noisy, and piercing sounds induce jagged, angular shapes with rough, sharp, and uneven surface textures, while warm, mellow sounds induce rounded shapes with soft, smooth, and flat surface textures.

By understanding how my synaesthesia 'works', I was able to translate between sonic and visual mediums, inspiring the creation of new artworks. This is not without precedent, as I will now go on to discuss.

5.3. Translating in the Arts

Over the years, many artists have translated between mediums to inspire the creation of new works. Amongst these include Messiaen, whose coloured synaesthetic experiences played an important role in his compositional process (Bernard 1986). Kandinsky matched timbres with colours (Abbado 2017) while animator John Whitney "borrowed concepts of musical harmony and visually transposed them into authentic visual compositions" (ibid., p56). In his dissertation *Synesthetic Music Experience Communicator* (2006), Lewis Charles Hill II, researcher in human-computer interaction, proposed several systems that translated MIDI data into synaesthetic-like imagery to accompany musical performances. Musician Pharrell Williams claims that the lyrics he writes are partly inspired by his synaesthesia (Seaberg 2011), while synaesthetic singer-songwriter Lorde describes her composition/production process as getting the final recording to visually match

her initial ideas (Weiner 2017). In all these cases, the translation between mediums (whether synaesthetic or not) has inspired, informed, and influenced the creation of new artworks. A study by Ward et al. (2008a) found that "people with synaesthesia are more likely to be engaged in the creative arts (e.g. music, visual art) [and that] they score higher on some, but not all, measures of creativity" (p139). The authors propose that auditory-visual synaesthetes' "rich experiences (movement, textures, colour, shapes) […] may provide a source of motivation" (p35) in creating artworks. Cavallaro (2013) points out that:

> "though synesthesia usually manifests itself as a one-way phenomenon, whereby a person may see certain colors or images upon hearing certain sounds, for example, there are cases in which cross-sensory perception works bi-directionally. In such instances, the synesthete is able to *both* see certain colors or images upon hearing certain sounds *and* to hear certain sounds upon seeing certain colors or images". (p17)

My synaesthesia is not bi-directional; my synaesthesia automatically and involuntarily translates sounds into visual images but does not translate visual images into sounds. However, due to my familiarity with my synaesthetic auditory-visual correspondences, I have found that I can reverse-engineer my synaesthesia, which enables me to forcibly and with great effort translate visual ideas into sounds. This reverse-engineering process involves audiating (hearing and understanding music in my head (Gordon 1999)) and then producing the musical sounds that would induce synaesthetic experiences closely resembling certain visual stimuli. I will now discuss the compositional studies that I conducted into my ability to synaesthetically translate between mediums.

5.4. Translation Studies

This section is based on the foundation of three autoethnographic studies that I carried out to investigate how translating between sonic and visual mediums can aid in the composition of new musical works. Retrospectively, I have chosen to classify these studies as 'descriptive', 'analytic', and 'aesthetic', due to their purpose.

In my 'descriptive' study, I intended to show others what it was like to experience auditory-visual synaesthesia, by creating animations that represented my

synaesthetic visualisations of two of my compositions. The study is ‘descriptive’ since its aim was to visually *describe* my synaesthetic experiences by translating from the sonic realm to the visual.

The purpose of the ‘analytic’ study which followed was to explore whether I could work backwards (i.e., in the opposite direction from which my auditory-visual synaesthesia naturally translates) and precisely and accurately (according to my crossmodal correspondences) convert a visual image into a work of music. It is described as ‘analytic' since it aimed to *analyse* my attempts to accurately translate entire visual stimuli into musical compositions.

With my later ‘aesthetic’ study, I translated only specific aspects of visual stimuli into musical ideas, selectively choosing from these only (what I considered to be) the best ideas to form the bases of new compositions. It is described as ‘aesthetic’ since its aim was to create compositions that were *aesthetically* pleasing to me, by selecting and translating only certain elements of visual stimuli into musical ideas. The following three sections discuss the three autoethnographic studies I carried out that explored the translation of visual to sonic and vice-versa.

5.4.1. Methods

To evaluate the effectiveness of each study, I analysed my autoethnographic data by searching for mentions of translative processes I had utilised and reflective, evaluative thoughts I had recorded. I compared my descriptions of my own translative processes with those employed by other synaesthetic artists. I contextualised my findings by interpreting the data I had gathered through the lens of the various cultures I belong to and by acknowledging the influence and impact of external factors on my work and my experiences. I also framed my findings within existing theories, including the theory of audiation proposed by Gordon (1999), and the theory of ideaesthesia proposed by Nikolić (2009). For a full review of the methods I utilised, please refer to the Methods section in the Introduction chapter (1.7.). Each study will now be discussed in turn.

5.4.2. Descriptive Study

This section will discuss my initial study into my auditory-visual correspondences, by comparing two attempts at translating audio recordings of my musical compositions into video animations for descriptive purposes. My intentions with these animations were: to convey a sense of what it is like to experience auditory-visual synaesthesia while listening to music, for the benefit of those who did not experience the phenomenon; and to gain a better understanding of the crossmodal correspondences of my synaesthesia.

My first intention was informed by a study by Ward et. al (2008b), which found that animations created to accompany music by synaesthetic artists were preferred over animations by non-synaesthetes. Computer animation technologies enable synaesthetic artists like Carol Steen, David Hockney, and Marcia Smilack to share a visual representation of their synaesthetic experiences with others (Steen & Berman 2013). Abbado (2017) notes that some artists:

> "prefer to produce both music and images, sometimes simultaneously, as a full-fledged audiovisual work. Among these today are a growing number of musicians who have started creating abstract videos and animations: it is likely that the practice of composing improves the skill of organizing images in time". (p99)

By producing animations that represented my synaesthetic visualisations of music, I had hoped that I would be able to give others the opportunity to experience what it is like to have auditory-visual synaesthesia, in part for their own enjoyment and also to educate them about the phenomenon.

This second intention was informed by Chang's (2008) autoethnographic data-generation exercise:

> "Select a place of significance that helped you gain an understanding of yourself and your relationship to others. Draw the place, putting in as many details as possible. You may outline the place or do a realistic drawing. Identify objects and persons in the drawing when necessary. Expand this exercise to additional places. Describe the place and explain why this place is significant to you." (p87)

By drawing (or, in my case, animating) my synaesthetic experiences of the music, I hypothesised that I would gain a better understanding of the mappings between my

auditory and synaesthetic visual perceptions. I composed two pieces of music with the intention to translate these into video animations, which would be based on my synaesthetic experiences.

5.4.2.1. Procedure

For the first composition, called ‘Expansion’, I worked with a video artist to create an animation that would accompany the music. I sent her sketches of my synaesthetic visualisations of my composition in rough animation form (see ‘Expansion Levels 1-3 Animation (Unfinished Draft)’ in the Appendices), along with lengthy notes, which informed her animation. I recorded my thoughts on the artist’s interpretation of my synaesthetic experiences in a Word document upon receiving drafts of her animation and sent her feedback to help her refine her work.

For the second composition, called ‘Glue’, I purchased a Huion H420 graphics drawing tablet and downloaded Krita, a 2D animation program, which I would use to create my own animation (see ‘Glue Animation (Unfinished Draft)’ in the Appendices). I chose to focus on one instrument – the lead synthesiser – as I believed that it would take too long to animate each individual sound in the composition. With frame-by-frame animation, the artist selects a frame rate which determines how many static images per second are played back in sequence. I chose a frame rate of 16fps, to avoid having to draw too many frames, whilst still retaining a natural sense of flow. Each frame therefore represents a sixteenth of a second of the lead synthesiser part in the audio recording of ‘Glue’.

5.4.2.2. Findings and Discussion

I found that translating my synaesthetic experiences of music into computer-generated animations results in the experience of ‘Martian colours’ (Ramachandran & Hubbard 2001): colours that “are somehow ‘weird’ or ‘alien’ and don’t look quite the same as normal ‘real world’ colours” (p26). I would describe this experience as something similar to the uncanny valley effect (Mori 2012): a term often used to

describe the uncomfortable response in the observer upon perceiving an object (real or virtual) which closely, but not quite perfectly, resembles a human being. Reflecting back on my collaborator's first attempt at creating an animation to represent my synaesthetic visualisation of 'Expansion', I remember being disappointed that the animation did not resemble my synaesthetic experiences as closely as I had hoped. In a message I had written to her, in response to her first attempt, I explained:

> "Because my synaesthesia is literally a visual representation of the sound, what I 'see' is totally in sync with what I hear. So if I'm hearing something to the left of me, I'll visualise it to the left. I just noticed that the yellow blobs (supposed to represent the synth) and the expanding line in the middle (supposed to represent the bass note) aren't in sync with the left/right panning" (Anderson 2019).

In addition to the movement and visual rhythm of the shapes in her animation not quite matching the rhythms of the sounds in the music, the colours and surface textures of the shapes she had produced looked similar to, but not quite exactly, how I saw them in my mind's eye. This was not her fault, however – I realised that there was no way she could know exactly what I visualised when listening to the music. I had clearly failed to emphasise the importance of the synchronisation between sound and visual objects, or explain which shapes were supposed to represent each sound, or provide enough detail on the exact surface texture of each shape. I realised that the amount of detail required to adequately describe my synaesthetic experiences of just a few seconds of music was far greater than I had initially anticipated. Furthermore, the fact that each section of the music was composed of an entirely different set of sounds meant that a unique set of shapes, colours, and textures would need to be produced and animated for each section, in order for the animation to accurately describe my synaesthetic visualisations. This led me to understand the insurmountable scale of the work that was required to finish the animation for 'Expansion'. Thus, the collaboration was abandoned and the animation was never completed.

Similarly, although my attempt at animating the lead synthesiser in 'Glue' did slightly more closely resemble the synaesthetic photism that represented this part, there was something a bit 'off' about the animation. When watching back the unfinished animation for 'Glue', I experienced something akin to the uncanny valley effect. No matter how hard I tried to match my visual creation to the photism, its movement,

colour, and surface texture, while very similar to those of the synthesiser's corresponding photism, ultimately fell short of accurately portraying the synaesthetic experience I had when listening to the music. This uncanny valley effect could at least partially explain why both animations failed to adequately represent my synaesthetic visualisations.

My inability to accurately recreate my synaesthetic photisms in animation software may simply be due to my lack of skill and experience with computer animation. However, it is not uncommon for synaesthetes to report 'Martian colours' (Ramachandran & Hubbard 2001) that do not quite match 'real world' colours. Püschel (2017) experienced this effect when attempting to pick from a limited colour palette the exact colours she synaesthetically perceived when emotionally engaging with certain photographs. She writes:

> "I picked a colour from the colour range that came closest to the one I felt, but it would not quite be the right shade of my emotion. This was frustrating at times. Other synaesthetes might recognise the problem when asked to pick a colour from a limited colour range and being unable to find the exact shade. It might feel like cheating or not telling the whole truth, because the vocabulary is missing. It literally felt like I was betraying my reality by giving it an inaccurate description." (pp189-190)

This is exactly how I felt when I saw that the draft animations produced for both 'Expansion' and 'Glue' were not exactly how I visualised the music. Püschel goes on to add: "the problem of two-dimensionality made it hard at times to find an equivalent in the colour range: my emotions are not little squares in a neat row. Instead, they are really big inside of me, they float, they are more or less present in space as three-dimensional shapes" (p190). Again, this is very relatable. My synaesthetic photisms are also three-dimensional in nature, so translating them into a 'flat' two-dimensional animation feels like I am inaccurately describing them.

While creating animations for both 'Expansion' and 'Glue', I found myself asking whether there was much point in painstakingly recording my synaesthetic experiences in the form of computer-generated animation. Cavallaro (2013, p96) postulates that "just as no two synesthesias are ever quite identical despite possible similarities in their manifestations, so no two intuitions of the dynamic properties of sound will ever be likely to yield identical visualizations. This is clearly borne out by

the impressive diversity found in visual works by synesthetic artists inclined to give shape to sound." If synaesthetic visualisations are so personal and individual, who am I to dictate what others should 'see' when listening to my music? I, for one, have found animations created by synaesthetes to accompany other artists' music to be jarring, since their interpretations of the music do not resemble my own. I would therefore imagine that other people (synaesthetic or not) may find any animations created or directed by me to diverge from their own ideas of what the music should 'look' like.

Furthermore, in trying to be as accurate as possible in my translating from music to visuals, and 'stay true' to my synaesthetic experiences, the pleasure I normally feel while musicking (i.e., when composing, producing, and listening to music) was absent. I found that there was little 'creation' in what I was doing. Abbado (2017, p136) suggests that "specific correspondences [between auditory and visual mediums] can also act as a form of cage, providing constraints that are sometimes uninspiring. These limitations can be experienced as a challenge by the artist who deliberately decides to compose within well-defined boundaries, but just as frequently they can amount to a forced restriction." In creating these animations, it felt like I was artlessly and clinically translating my compositions from one medium to another. I concluded that now was not the time to start learning how to animate and to instead focus on finding a way to use my synaesthetic experiences as inspiration for new musical compositions. I am, after all, a composer of music not an animator. I was keen to discover whether I could exploit my synaesthetic experiences to inspire the creation of new music.

5.4.3. Analytic Study

I will now examine my 'analytic' study, in which I attempted to discover whether I could translate a painting into sounds that induced a synaesthetic experience closely resembling the artwork. By translating in the opposite direction from visual to sonic (rather than sonic to visual, as was the case with my descriptive study) I had to 'reverse-engineer' my auditory-visual synaesthetic experiences. This was achieved by deconstructing the painting into identifiable shapes, then audiating sounds that

induced photisms resembling these shapes, before producing and recording these sounds in my DAW. I will then compare this study with my 'descriptive' study.

As previously mentioned, my auditory-visual synaesthesia causes me to experience different timbres as separate shapes, each with a unique colour and surface texture. Softer sounds are visualised as rounder shapes of cooler colours with smoother surface textures, while harsher sounds are experienced as angular shapes of warmer colours with coarse and rough textures. (See section 1.1. for a full description of my auditory-visual correspondences.)

Many of my crossmodal mappings are consistent with those reported by other auditory-visual synaesthetes (Chiou, Stelter & Rich 2013; Day 2013; Adeli, Rouat & Molotchnikoff 2014). Most synaesthetes experience synaesthesia in a single direction (Teichmann et al. 2017; Steen & Berman 2013). For example, auditory-visual synaesthetes perceive sound (and, by extension, music) visually, but are unlikely to also perceive shapes, colours and textures as sounds. However, a small number of synaesthetes have visually-induced auditory synaesthesia, where the reverse is true; they perceive shapes and colours as sound (Saenz & Koch 2008). The form of synaesthesia I experience is the former, not the latter.

I automatically and involuntarily visualise music as a landscape of various shapes with colour and texture, but cannot hear music when looking at a painting. However, over the years, I have come across many visual artworks that resemble my auditory-visual synaesthetic experiences and have recently inspired the composing of new works of music, such as *Composition A XXI* by László Moholy-Nagy (1925). It is this style of abstract, geometric art that I tend to be drawn to, due to its similarities to the scenes that I 'see' in my mind's eye whenever I listen to, compose, and perform music. I may not be able to accurately translate my synaesthetic experiences into visual artworks but observing these artworks which exist in the 'real world', unlike my synaesthetic visualisations, somehow seems to validate my experiences, confirming that they are not merely a figment of my imagination.

Following on from my attempts to translate music to visual artforms, I wanted to see if it was possible to work in the opposite direction and translate visual artworks that resembled my synaesthetic experiences into new music compositions, for the

purpose of better understanding my synaesthesia and the role crossmodal translation has in my compositional processes.

5.4.3.1. Procedure

I listed all of the auditory-visual mappings in my synaesthesia (e.g., timbre = shape, colour, texture, and state of matter of photism, pitch = size, brightness, and location of photism on Y axis, panning = location of photism on X axis). Using this as a translation guide, I attempted to convert László Moholy-Nagy's painting *Composition A XXI* (1925) into music, due to its strong resemblance to the synaesthetic experiences I have while listening to music. I began by mentally separating the painting into identifiable visual objects (shapes). For each visual object, I audiated (heard with my mind's ear and gave musical meaning to (Gordon 1999)) a range of sounds until I discovered one which induced a synaesthetic photism resembling the visual object. Using my synthesisers and DAW, I then produced and recorded the sound. The pitch of the sound was determined by the approximate vertical position of the shape on the canvas, while the sound's placement in the stereo field was determined by the shape's approximate horizontal position. In order to translate the still image into music (a time-based medium), I injected motion into my perception of the painting by imagining the different shapes moving in a sequenced loop around the canvas. Steen and Berman (2013) discuss how synesthetic artists who translate moving photisms (such as those induced by listening to music) to static visual artworks (such as paintings) make use of a variety of methods to convey a sense of movement in their work. These include morphing, sequencing and layering shapes. While these artists face the challenge of translating a fluid, moving medium into a fixed, static one, I wanted to do the opposite: translate a still image into an evolving work of music. Since I was keen to ensure that the resulting synaesthetic experience of the music I had composed closely resembled the painting I was translating into music, any movement that I added was intentionally minimal and repetitive through use of looping. I created an animation that demonstrated this movement and later synchronised the music I had composed to it (see the 'Composition A XXI Animation' in the Appendices folder).

5.4.3.2. Findings and Discussion

The music I composed was intended to be a fairly precise translation of the *Composition A XXI* (Moholy-Nagy 1925) painting into music. Listening back to the music causes me to visualise all the shapes present in the artwork, and so I would argue that the study was, by this measurement, successful to a great extent. The main difference between my synaesthetic visualisation of the music I composed and the painting is that the photisms move in loops around the canvas, while the shapes in the painting are fixed in place. However, the insertion of perceived motion into the painting was the only time I felt I had engaged in any sort of creative decision-making during the compositional process. Interpreting colourful shapes on the canvas as timbres with pitch and stereo position felt procedural, akin to translating a sentence from one language to another. Furthermore, the resulting music composition was extremely repetitive due to the limited movement I had allowed myself to introduce to my audiations.

Although I was displeased with the music I had produced and the lack of creativity involved in the composition process due to the limits I had set myself, I did, however, discover that it was possible to 'reverse-engineer' (to borrow a term from the engineering discipline meaning to disassemble in order to analyse) my synaesthetic experiences through a process of audiation. According to Gordon (1999, p42), "[a]udiation takes place when we hear and understand in our minds music that we have just heard performed or have heard performed sometime in the past. […] We also audiate when we hear and understand in our minds music that we may or may not have heard but are reading in notation or are composing or improvising." Hubbard (2010) opines that Beethoven – who, at this point, had become deaf – likely made use of auditory and musical imagery and notational audiation while composing his Ninth Symphony, "to create or simulate auditory qualities" of the music (p316). I would argue that audiation is crucial to the process of reverse-engineering my synaesthesia. When attempting to translate a visual image into sound, I ask myself 'what sound would induce a synaesthetic photism that resembles this shape?', then audiate a range of sounds until I find one that synaesthetically induces a photism resembling the shape. In my mind's ear, again through a process of audiation, I then

‘fine-tune’ this sound, so that its photism more closely matches the shape. I can then produce this sound and record it in a DAW.

What is especially interesting to note here is that an audiated sound still induces a synaesthetic photism, even if it is not physically heard. This suggests that it is the idea, or understanding, of the sound that triggers my synaesthesia – not merely the auditory perception of the sound. This finding supports Nikolić’s (2009) theory of ideaesthesia. Nikolić proposes that the term ‘ideaesthesia’ (meaning ‘sensing concepts’) may be a better name for what we call ‘synaesthesia’ (meaning ‘unity of the senses’), since the inducer and concurrent (e.g., in my case, sound and visuals) evidently do not both operate “at the sensory level of representation” (p1): only the concurrent arguably does (and even then, as an associator synaesthete, I do not actually see my photisms in space around me; they are instead visualised in my mind’s eye). Nikolić argues that:

> “The inducer, in contrast, contributes from the semantic level of representations—a processing stage at which the meaning of the stimulus is extracted and represented. Therefore, synaesthesia can be understood as an unusual type of a “semantic” association whereby, in addition to wiring up different concepts, synaesthesia wires concepts to sensory activations” (ibid., p1).

In another article, Nikolić (2016) also states that several artists have acknowledged and endorsed the concept of ideaesthesia when discussing their work: “When talking to some of those artists, I learned that they overwhelmingly felt that ideaesthesia somehow described the very process by which they created art” (p43). Curwen (2018) notes that this theory is supported by a study (De Thornley Head, cited in Curwen 2018) which found that a tone-colour synaesthete reported the same colours for each note on a synthesiser, both before and after it was transposed. Curwen suggests that the colours the synaesthete was reported to have experienced were determined by the notes they thought they were hearing, not the actual pitch. The fact that I synaesthetically visualise the audiations of music and sound as automatically and involuntarily as I do ‘real’ music and sound (i.e., music or sound that is physically heard) suggests that the inducer of my synaesthesia must operate at the semantic, not the sensory, level of representation (Nikolić 2009) and further supports the theory of ideaesthesia.

To summarise, my synaesthesia (or, perhaps, ideaesthesia) gives me the ability to visualise audiations of music. With a specific visual image in mind (e.g., a painting), I can therefore audiate a range of sounds and select one whose corresponding synaesthetic photism resembles the visual image. This enables me to 'reverse-engineer' my auditory-visual synaesthesia, allowing me to translate a visual image into a musical idea, which can then be produced using a musical instrument such as a synthesiser and recorded in DAW.

There is a significant lack of research into synaesthetic reverse-engineering for artistic purposes. Following a virtual presentation on my attempts at synaesthetic reverse-engineering at the 2020 Bloomsbury Festival's Online Synaesthesia Meet Up, I received an email from James Wannerton, President of the UK Synaesthesia Association, which reads: "As for reverse engineering, it caught my attention because I've been reverse engineering myself for many years – as a way of clarifying my experiences, and this was the very first time I'd heard the phrase used outside my own circle. As far as I'm aware, there's been no specific research carried out in this area" (Wannerton 2020).

On one occasion, Wannerton, who has lexical-gustatory synaesthesia (he tastes flavours upon reading or hearing words), reverse-engineered his experiences in order to translate the flavours of ingredients for various meals into objects to be photographed for food journal *The Gourmand* (Nowness 2013). Photographer Dominic Davies explains that "The project is the first time Wannerton has had to reverse-think—for example, he is used to meeting people and thinking, 'Ok he tastes like carrot cake,' but we asked him to answer questions such as: 'What gives you the taste of pork? Of roast potatoes? Of apple sauce?' The photos represent his answers." (Davies, cited in Nowness 2013). Wannerton explains that "[c]reating images of tastes is quite difficult because it requires a bit of reverse engineering and that for me is the clever part. As my synaesthesia, like most others, runs one way only, in order to create an accurate image I have to eat a particular food (the subject of the image) and read pages of text until a corresponding word "pops up" that produces a taste and texture that matches the food I'm eating" (Wannerton 2015, p30). My attempts at reverse-engineering are similar to James', in that I work

backwards from the concurrent to the inducer, asking myself questions like: ‘What sound looks like a red circle?’.

5.4.4. Aesthetic Study

I will now analyse my attempts at translating only *specific aspects* of visual stimuli into musical ideas to be used as the bases of new compositions. This was achieved by audiating a range of sounds that synaesthetically induced photisms resembling the visual stimuli, but only recording/producing those that I believed had musical potential, based on my aesthetic preferences. I will then compare this work, and the process of creating it, with my ‘analytic’ and ‘descriptive’ studies.

With the compositional studies I have so far discussed in this chapter, my intention was to, as accurately as possible, translate an entire creative work from the medium of music into visual art, or vice versa. Since the creative work had already been produced, translating it from one medium to another felt to me like nothing more than a procedural exercise. I felt little joy in the translation process and was not particularly proud of the creative outputs I produced, due to the limited role my artistic input played in the process. According to Steen and Berman (2013), “the synesthetic artist must filter [their] experiences to generate the final artistic product” (p673). They go on to argue that the synaesthetic artist “must make informed decisions about the usage or portrayal of [their] visions, and this requires a type of self-observation” (p673). When creating the following compositions this section discusses, I chose to filter my synaesthetic experiences, only translating specific aspects of visual images into musical ideas, to allow for more artistic input and creative freedom in the composition process.

5.4.4.1. Procedure

The composition process for ‘A XXI’, ‘Shiraga’, ‘Intersect’, ‘Infinity Pyramids’, ‘Balloons’, and ‘Everest’ involved the use of selective translation, based on my aesthetic preferences, most prominently in the initial sound design stage. To help

craft sound palettes and inform the musical direction I would take each composition in, visual images were translated into musical ideas through a process of synaesthetic reverse-engineering involving audiation (as explained in the previous section). These musical ideas formed the basis of each composition and are discussed below.

5.4.4.2 Findings and Discussion

Dissatisfied with my initial attempt at translating *Composition A XXI* (Moholy Nagy 1925) (as can be seen/heard in the Appendices) into music, I experimented with rearranging and remixing some of the sounds from this early draft into a coherent composition that more closely aligned with my own musical tastes and compositional style. I was much more satisfied with this composition, which I named 'A XXI'. This led me to the realisation that it did not ultimately matter whether my synaesthetic visualisation of the finished music work resembles the visual artwork that inspired it. I realised that, by choosing only certain elements of a visual stimulus to translate into a sonic palette for use in a musical work, the resulting freedom afforded me more creative input in the compositional process. With my previous attempt at translating a visual artwork into a work of music – my 'analytic' audiovisual interpretation of *Composition A XXI* (Moholy Nagy 1925) – I had made an effort to translate *all aspects* of the painting into musical ideas, limiting the artistic freedom I had in the compositional process. The only creative decisions that I can identify in the production of this work were the injection of motion into my audiations and the temporary muting of various parts in the mix. Otherwise, the work of music I produced was, for me, an accurate synaesthetic translation of the entire painting into music.

On the other hand, only *some* of the musical ideas present in 'A XXI', 'Shiraga', 'Intersect', 'Infinity Pyramids', 'Balloons', and 'Everest' were translated from visual stimuli. These compositions were not intended to be precise translations of an entire visual stimulus. They were instead created for aesthetic purposes, with translation between visual and aural only coming *at the start* of the compositional process as a means to generate initial musical ideas to be further developed into full works of

music. The underpinning musical ideas that formed the bases of these compositions were translated from specific aspects of visual stimuli, by audiating sounds that synaesthetically induced photisms resembling the visual stimuli and producing and recording those that I believed had the most musical potential.

An example of this approach can be found in the creation of ‘Shiraga’. This composition stemmed from a ‘found sound’ recording of a beeping electronic door lock. This sound induced a synaesthetic photism resembling a metallic red disk. I searched for artworks resembling a metallic red disk and discovered Kazuo Shiraga’s *Sorin* (1970). Captivated by the forms, colours and textures used in the artwork, I searched for further examples of Shiraga’s work. I found several other paintings that interested me and used these and *Sorin* (Shiraga 1970) as inspiration for the palette of sounds I would use in my composition. I reverse-engineered my auditory-visual synaesthesia and worked backwards, audiating the sounds that would generate photisms similar to some of the forms in the three paintings. I then produced and recorded these sounds in my DAW and composed short loops with them. To produce a synaesthetic visual experience that resembled the ‘smeared paint’ appearance of Shiraga’s work, I ran each loop through various combinations of distortion, reverb, delay and flanger effects (usually with the feedback turned up high). This provided me with the sound palette that I then used to construct this composition. In this instance, the forms, colours, and textures in the paintings were translated into several timbres that were then used to construct this ‘Shiraga’ composition.

My synaesthetic perception of the completed composition resembles, to a certain extent, the Shiraga paintings it was inspired by. The ‘beeping’ found sound – the focal point of my composition – induces a photism similar to a metallic red disk, much like the centrepiece of Shiraga’s *Sorin* (1970). The synthesisers that complement the found sound bring to mind red, orange, and yellow splodges, with a texture of smeared paint, much like the colourful streaks in the painting. The percussive elements in the composition (the electronic drums and cymbals) are the exception, as the photisms they induce (brown wooden blocks and silver wire blades) do not resemble any aspect of the painting. I do not think that it matters that my synaesthetic experience of the finished composition does not ultimately look

exactly the same as the Shiraga artworks I initially intended to base the composition on. My decision to add electronic drums and percussive elements, the synaesthetic photisms of which diverge drastically from the appearance of the paintings, was likely due to my own musical biases towards rhythmically-driven electronic music. As a producer and fan of electronic dance music, I must not ignore, dismiss or be ashamed of the undeniable influence of my own production and listening preferences. Indeed, there are many similarities between my latest compositions and music by Jon Hopkins (e.g., *Singularity* (2018a)), Nathan Fake (e.g., *Blizzards* (2020)), Rival Consoles (e.g., *Persona* (2018)), and Bicep (e.g., *Isles* (2021)) that I have undoubtedly been inspired by, and I believe that it is important to acknowledge these external influences.

Like ‘Shiraga’, ‘Intersect’ is another composition that was created purely for aesthetic purposes and was not intended to be a precise translation of an entire visual stimulus. This work was based on the idea of intersecting, overlapping patterns that occasionally ‘lock in’ with each other. This idea was informed by the tiles in my bathroom, the patterns of which intersect at regular intervals. By reverse-engineering my auditory-visual synaesthesia, I was able to translate these patterns into a polymetric rhythm, which formed the basis of my composition ‘Intersect’. While constructing the composition, I was very aware of the geometric synaesthetic patterns that appeared in my mind’s eye. These closely resembled the interlocking nature of the patterns formed by my bathroom tiles. By having the rhythmic loops overlap and intersect at different points, the resulting synaesthetic photisms appeared to drift in and out of sync from each other, locking together to create composite photisms every time the rhythms aligned.

My intention was to confuse and challenge the listener; I wanted the feel of the piece to be subjective – for the strong beats to be perceived differently from listener to listener – and disorientating. I also intended to make use of a cooler colour scheme when designing the timbres: to contrast with the red, orange, and yellow timbres used in ‘Shiraga’ and to instead make use of greens, blues, and purples. In doing so, I considered the music I listened to that typically induced such colours (e.g., ‘Kites’ by Bicep (2017b), ‘Baby’ by Four Tet (2020b), and ‘Resynthesis’ by Max Cooper (2017)) and noticed that I visualised much of these artists’ music as being coloured

blue and green. I hypothesised that this was due to their fairly ‘digital’, cleaner sound. This contrasted with the reds, oranges, and yellows I often experience when listening to Jon Hopkins who makes use of more ‘analogue’, raw and distorted sounds (e.g., in ‘Open Eye Signal’ (2013b), ‘Collider’ (2013c), and ‘Everything Connected’ (2018b)). I therefore chose to use sounds akin to those heard in the music of Bicep, Four Tet, and Max Cooper to provide me with the cooler colour palette I sought.

With this composition, the visual patterns I observed in my bathroom tiles were translated into intersecting polymetric rhythm loops, and the intended colour palette of blues, greens, and purples was translated into clean, ‘digital’-sounding synthesised sounds. Listening back to the composition certainly induces sensations of blue, green, and purple shades. The timbres I utilised in this composition were designed to evoke cooler colours than those perceived in ‘Shiraga’. In addition, ‘Intersect’ boasts more angular shapes and geometric patterns than ‘Shiraga’, which contrastingly features smeared, undefined forms that blend together.

In other cases, I found that it was possible to translate in both directions, from visual to aural *and* aural to visual, to provide further inspiration in the composition process. For my composition ‘Infinity Pyramids’, I was interested in composing a piece of music using an original visual stimulus as inspiration (as opposed to translating elements of a pre-existing visual stimulus). I found an infinity symbol (∞) I had recently sketched in a notepad and decided to translate this into a sound to be used in a new composition. I followed my typical visual-to-audio translation process by audiating a sound that synaesthetically induced a photism resembling the sketch, before synthesising this sound in my DAW. Not quite content with the sound this translated into, I made some modifications to the synthesiser patch and reflected these changes in my notepad by amending the sketch. Keen to explore this back-and-forth approach further, I made further alterations to the sketch and mirrored these changes in the synthesiser patch. This process continued until I was happy with the synth sound (as can be heard in ‘Infinity Pyramids (Original Idea)’ in the Appendices) that became the catalyst for my composition ‘Infinity Pyramids’.

From this point onwards in the composition process, I paid less attention to my synaesthetic experiences, focussing primarily on building a composition around this

sound. I initially tried taking this sound in two disparate directions – the audio file labelled ‘Infinity Pyramids (Alternative Version)’ in the Appendices and the released album version, respectively – and decided to pursue the latter version, as I felt it had more musical potential. The synaesthetic visualisations I now experience when listening back to the finished composition differ drastically from the synaesthetic experiences that influenced the initial sound design stage. The addition of many more instruments has led to my synaesthetic visualisation of the finished composition featuring a wide variety of shapes, colours, and textures, in addition to the infinity-shaped photisms that I visualised during the initial sound design stage.

Just like how the full composition (comprising multiple parts/instruments) is, in my opinion, much more enjoyable to listen to than the audio produced in the initial sound design stage (consisting of just one part/instrument), my synaesthetic visualisations of the full composition (comprising many shapes, colours, and textures) is, in my opinion, much more enjoyable to experience than my synaesthetic visualisations of the initial sound design stage (consisting of only a small number of variations on the one form). Interestingly, it is not only the case that more shapes have been added into the mix; the original photism representing the audio produced in the initial sound design process has been altered.

During the initial sound design stage, I described this sound as taking on the appearance of an infinity symbol. I looped these sounds and automated the pitch to rise in fifths, resulting in the overall ‘assemblage photism’ (a snapshot of how my synaesthetic visualisation unfolds over time) to resemble a series of infinity symbols stacked atop each other in the shape of a pyramid. In sampling individual instances of this sound for the full composition, the pitch no longer rises in fifths and therefore the infinity-shaped synaesthetic photisms no longer stack up in the shape of a pyramid. Furthermore, due to the processing that has been applied to the sound at various points in the composition, the colour and form of the infinity-shape fluctuates throughout the piece. Individual nuances added in the sound design stage (e.g., increasing FM intensity and overtones on the synthesiser resulting in the creation of additional smaller visual objects emanating from the main shape, and adding glide between notes resulting in ‘wings’ protruding from the main shape) are still present in the full composition but go mostly unnoticed, due to the abundance of other shapes

and sounds present at any one time. However, it did not matter to me that the finished composition deviated so drastically (both sonically and visually) from the original idea, as I was very satisfied with the final product. It is unlikely that I would have been able to compose this work of music if I had not employed the back-and-forth translative approach which spawned the original idea.

While this approach was only used in the initial sound design stage while composing ‘Infinity Pyramids’, a similar approach was employed throughout the entire compositional process in the creation of ‘Balloons’. I began with a simple sound I had designed in Logic which, when used to play chords, took on the appearance of a set of marbles. Running this sound through a reverse-delay effect gave the photism an elastic, rubbery texture, so much so that it no longer looked like marbles and instead resembled balloons bouncing off each other. The balloon-like appearance of the photism informed the direction I took the composition in. Inspired by the idea of balloons floating upwards, I automated the playback speed of the DAW so that the composition began at a lower key and BPM and gradually rose in both pitch and tempo as more ‘balloons’ were added to the arrangement, causing the photisms to appear to slowly rise upwards in my mind’s eye. Towards the end of the composition, as the ‘balloons’ appear to ‘pop’ and dissipate, the pitch and tempo gradually return to their starting positions, giving the impression of the photisms falling back to earth.

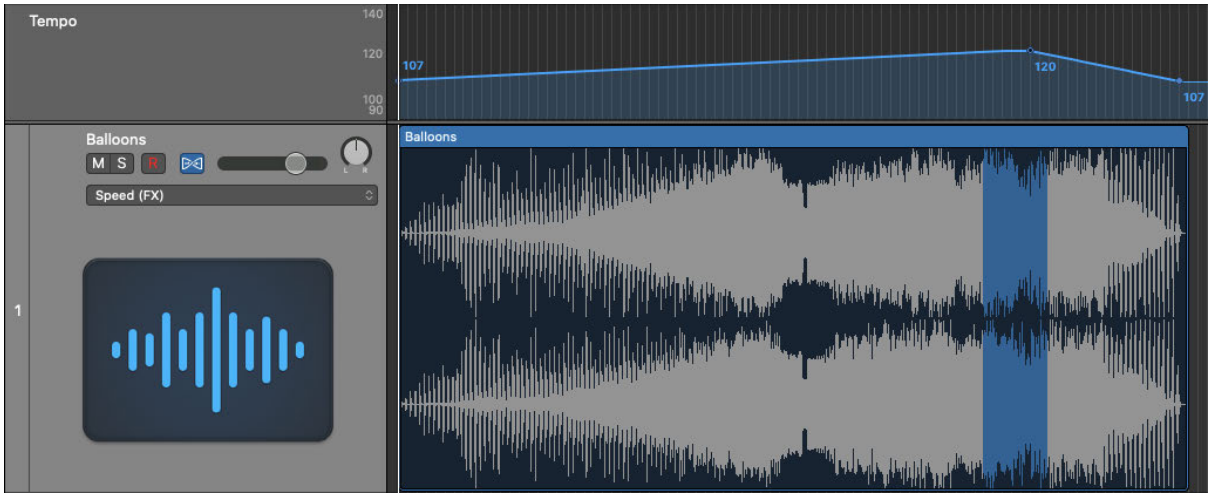

Figure 5.1.

A screenshot from the Logic project of ‘Balloons’, showing the audio of the full composition (below) conforming to the tempo map (above) which begins at 107 BPM, rises to 120 BPM, then returns to 107 BPM.

The decision to manipulate the pitch and tempo of the composition was entirely informed by my synaesthetic perception of the primary sounds in the composition as ‘balloons’. The connotative mental imagery of balloons floating upwards was subsequently translated into a rise in both pitch and tempo, while their descent back to earth was conveyed by a fall in pitch and tempo.

On another occasion, I attempted to discover if it was possible to translate an imagined scene of jumbled shapes and indistinguishable textures into a musical composition. In the creation of ‘Everest’, I had in mind a general idea that resembled the ‘all-over’ Jackson Pollock-esque stye of painting. I considered this imagined scene of indiscernible jagged shapes of clashing colours to be ugly and messy in appearance. I translated this mental image of cluttered forms into a thick musical texture of indistinct, distorted sounds. The overall impression I have of this composition is not particularly bright or colourful; I perceive lots of blacks, whites, greys and a muddy khaki colour when the many sounds present in this work are squashed together. My synaesthetic perception of this ‘wall of sound’ technique is what induces the sensation of this khaki colour. I have never been particularly fond of this production technique; I dislike the fact that I cannot discern individual shapes, colours or textures from the chaotic khaki-coloured clutter that is synaesthetically induced by such a huge composite sound. With this composition, I wanted to explore my synaesthetic perceptions of multiple timbres fused together, curious as to what such a composite sound would look like. The resulting composition not only looked rather ugly (in my mind’s eye), but it also *sounded* ugly and disjointed, in my opinion. The resulting synaesthetic visualisation of this composition was that of a cold, harsh, uneven, colourless terrain; hence the name ‘Everest’. While my first mix of the composition induced a visual experience more closely resembling a Jackson Pollock painting, as per my original intention, the final ‘tidied up’ mix is, in my opinion, more enjoyable to listen to and induces a slightly cleaner synaesthetic visual experience for me.

Reflecting on the creation of all the compositions discussed above, it is clear that my synaesthetic experiences play a key role primarily in the initial sound design stage of the composition process, the purpose of which is to provide me with a palette of sounds to work with in the arrangement stage that follows. This is because, with the

compositions discussed above, I made the conscious decision to tap into my synaesthesia and translate images to sounds and vice versa to inspire the creation of new sounds. However, it is difficult to determine whether my synaesthetic visualisations of the music affect the decisions I make when arranging the sounds and musical ideas I have produced into a coherent structure, in the arrangement stage that follows. Attempting to interrogate my creative process interrupts my state of flow and so it is difficult to gather data on whether my synaesthetic experiences influence my decision-making during the arrangement stage of the composition process. I would suggest that, in this arrangement stage, my musical decision-making is at least partly informed by which combinations and configurations of shapes, colours, and textures 'look' the most appealing, *in addition to* which combinations and configurations of timbres, rhythms, and melodies I perceive to be the most enjoyable to listen to. However, I should note that I do not consciously separate the aural and (synaesthetic) visual experiences of the music into two separate sensory streams when making these creative decisions. The music is instead perceived as one auditory-visual 'whole' – a gestalt – and it is this overall experience that informs my decision-making in both the arrangement stage and the stages that follow in the composition process.

5.5. Conclusions

The key finding from the 'descriptive' study is that attempting to recreate my synaesthetic experiences in the form of computer-generated animations results in an uncanny valley-like effect. I can conclude that these experiments were flawed in the following ways:

1. It appears to be impossible to accurately represent my synaesthetic experiences in the form of computer-generated animation, due to the 'Martian colour' effect (Ramachandran & Hubbard 2001).
2. Any animations produced or directed by me that describe my synaesthetic visualisations of accompanying music may clash with viewers' own visual interpretations of the music.

3. I believe that it is counterintuitive to spend time attempting to translate my synaesthetic perceptions of my music into animations, since my interests lie in composing and producing music – not creating animations.

It therefore became apparent that, if I were to use my synaesthesia to translate between sonic and visual mediums as inspiration for new creative works, these works should be musical in nature.

The key findings from the 'analytic' study are as follows:

1. A process of audiation must be used in order to reverse-engineer my auditory-visual synaesthetic experiences, when translating a visual image into a musical work.
2. An audiated sound still induces a synaesthetic photism, even if it is not physical heard, supporting Nikolić's (2009) theory of ideaesthesia.
3. Discernible forms in the visual image must be interpreted as being in motion, in order for a visual stimulus to be translated into a musical work. (Otherwise, any audiations will only be of sounds with fixed timbre and pitch and lacking in rhythm and musical progression/development.)
4. Accurately and precisely translating (i.e., translating all aspects of) a visual image into music results in an unimaginative composition process, lacking in creativity and artistic input.

I hypothesised that the fourth point could be remedied by choosing only certain aspects of a visual image to translate into musical ideas that could then form the basis of a new composition. I suspected that doing so would allow for a more creative approach to music-making.

The key findings from the 'aesthetic' study are as follows:

1. Choosing only certain elements of a visual stimulus to translate into a sonic palette for use in a musical work allows me more artistic control and creative input in the composition process than translating an entire pre-existing visual stimulus into a musical composition.

2. A back-and-forth translative approach between visuals and sound can be employed to provide further inspiration in the sound design stage of the composition process.
3. Translating a visual stimulus that features no discernible forms into a musical work results in a composition that sounds, and (synaesthetically) looks, messy.
4. When in the arrangement stage of the composition process (i.e., when working on the structure and texture of the composition), the chosen combination and sequence of musical ideas is at least partially determined by the extent of my appreciation for the resulting synaesthetic experience.

By tapping into my synaesthetic experiences in order to translate between sonic and visual mediums, I feel that I have developed an approach to music composition that is both uniquely personal and fruitfully inspiring. I enjoyed refining and utilising this process in the composing of new works and am proud of the finished compositions that were composed for my 'aesthetic' study. These were primarily created for my own enjoyment, however it brings me great pleasure that they are also appreciated by members of various circles and cultures that I consider myself to be a part of. The positive feedback I received from friends and family was particularly encouraging, especially throughout the 2020 and 2021 COVID-19 lockdowns in Scotland. Since most of these compositions were created in isolation during these lockdowns, I had to wait an unusually long period of time before being able to share my work with my friends and family in person. In the meantime, I shared my compositions over online file-sharing sites, while feedback was communicated over online messaging services.

Throughout the lockdowns, I took advantage of online networking opportunities to meet and share experiences and creative processes/outputs with other synaesthetes and multimedia artists. I attended the virtual seminars *Music Consciousness: what synaesthesia tells us about emotions and visualisation of senses* (Rudenko et al. 2021), *'Living Art' – Giulia Carisi's Sound-Color Synesthesia Paintings Unpacked* (Carisi et al. 2021) and *Tonia Ko: Cultivating a Personal Interdisciplinary Practice* (Ko 2020). It was especially heartening to hear that other creatives utilised similar multisensory approaches in their artistic practices. Attending these events gave me a

sense of belonging to a social group that I hadn't felt in some time, due to the sense of isolation brought about by PhD study (Velho 2020) and exacerbated by the COVID-19 lockdowns. I also took the opportunity to present a selection of my compositions, and explain how I had employed synaesthetic reverse-engineering in order to create them, to an audience of fellow synaesthetes at the 2020 Bloomsbury Festival's Online Synaesthesia Meet Up and the IASAS' 2022 'Synaesthesia and the Student' online conference. These were invaluable opportunities to meet with other like-minded individuals and receive feedback on my work. It was fascinating to hear how other synaesthetes' experiences of my work differed so drastically from my own. My presentation at the Bloomsbury Festival also led to a thought-provoking discussion with James Wannerton, President of the UK Synaesthesia Association, where I learned that there had been little research conducted into synaesthetic reverse-engineering for artistic purposes.

This chapter has considered how, through a strong understanding of my auditory-visual crossmodal correspondences, I have translated between sonic and visual mediums for:

- descriptive purposes, by representing my synaesthetic experiences of my music compositions in the form of computer-generated animations, to show others what it is like to experience synaesthesia
- analytic purposes, by interpreting entire pre-existing works of art musically, to learn more about my own synaesthetic experiences and to discover whether it was possible to 'reverse-engineer' my synaesthesia
- aesthetic purposes, by interpreting specific elements of visual stimuli musically, to inspire the creation of new compositions primarily for my own enjoyment.

To summarise, early on in my research, I concluded that it was counterintuitive spending time trying to translate my synaesthetic perceptions of my music into animations, since my interests lie in composing and producing music, not in creating animations, and because attempting to describe my synaesthetic experiences in this way resulted in the 'Martian colour' effect (Ramachandran & Hubbard 2001). In the compositional studies that followed, I attempted to translate in the opposite direction in order to analyse my synaesthetic experiences and to learn whether it was possible

to ‘reverse-engineer’ my synaesthesia. I discovered that audiation was crucial to this synaesthetic ‘reverse-engineering’ and that even audiated sounds can induce synaesthetic experiences, supporting Nikolić’s (2009) theory of ideaesthesia. When translating visuals to sound, discernible forms must be interpreted as being in motion for the musical idea to progress and develop over time.

Crucially, I learned that translating all aspects of a visual image into a musical work results in an unimaginative composition process, lacking in creativity and artistic input. To remedy this, in my later compositional studies I chose to only translate certain elements of a visual stimuli into sonic palettes for use in musical works, composed purely for aesthetic purposes. I found that this allowed me more artistic control and creative input in the composition process. I discovered that translating back-and-forth between visual and sonic mediums can help to inspire the creation of, and help to refine, these sonic palettes. I learned that I prefer to work from visual stimuli made up of easily distinguishable geometric forms, since visual stimuli with no discernible forms translate into compositions with indistinct timbres, dense textures, and chaotic structures. I also hypothesised that my decisions in the arrangement stage of the composition process are influenced by whether, and to what extent, I enjoy the synaesthetic visualisations my attempts at layering and sequencing musical ideas induce.

Overall, while my ‘descriptive’ and ‘analytic’ studies did not initially prove to be fruitful, the ‘aesthetic’ study that followed led to the development of a crossmodal translation-based approach to composition that I intend to carry forward into future work, and the creation of several compositions of which I am particularly proud.

6. Conclusion

6.1. Summary

This PhD research has explored how my auditory-visual synaesthetic experiences affect my composing. I started this research project seeking to answer the question: 'In what ways, if any, does my auditory-visual synaesthesia impact on my music composition processes and outputs?'. Through the creation of a portfolio of original music compositions and by carrying out autoethnographic research into my own composition practice and synaesthetic experiences using methods proposed by Chang (2008), I have, firstly, ascertained that my auditory-visual synaesthesia *does* impact on my music composition processes and outputs. Secondly, I have determined *the ways* in which my synaesthesia impacts on these. I will now briefly summarise these findings.

6.2. Overall Findings

6.2.1. The Impact of Timbre on Visualisations of Shape and Colour

Timbre is the primary factor that determines my photisms' shape and colour. I identified several composition techniques that I frequently utilised in my work due, in part, to the enjoyable visual effect that they had on my photisms. I learned that timbral mutations and transmutations (terms coined by Roads (2015) to denote minor and major timbral transformations, respectively) resulted in moderate and substantial changes to the shape and colour of my photisms, while timbral fusion and fission (also terminology of Roads (ibid.) to mean layering and separating of timbres) resulted in the perception of composite and divided photisms, respectively. I recognised that my frequent repurposing of samples of earlier compositions of mine were chosen and timbrally processed in ways so that their corresponding photisms complemented the other sounds present in the composition. Similarly, when synthesising new sounds, I programmed their timbres to ensure the shape and colour of their photisms' matched the visual theme of my synaesthetic experience of

the rest of the composition. I made changes to my typical production process so that I could focus on the designing of timbres independently from the arranging and mixing of sounds. In order to improve timbral coherence (and visual consistency of the resulting synaesthetic photisms) in each composition, I separated the sound design and arrangement phases of my typical composition/production process into two distinct stages, each taking place within a unique Logic project. This allowed me to focus on designing timbres that sonically (and synaesthetically-visually) complemented each other in a targeted sound design stage, before composing melodies and chord progressions with these and arranging them into a coherent structure in the arrangement stage that followed.

6.2.2. The Impact of Timbre on Visualisations of Texture, State of Matter, and Weight

I came to the realisation that I also perceived my photisms as having texture and weight and existing in a specific state of matter (solid, liquid, gas, or plasma). While these properties are perceived visually in my mind's eye, a tactile sensation is also inferred. I realised that my photisms could not have properties beyond that which I had previously encountered in real life. I discovered that photism texture was determined entirely by a sound's timbre. Following this discovery, on several occasions, I decided to use the perceived texture of a sound's timbre and its connotations to guide my synthesising and arranging of other sounds in the composition. The perceived state of matter of my photisms is also determined primarily by timbre but also by portamento; glide between notes. I found that I tend to perceive percussive and unpitched sounds as solid photisms, sounds with a definite pitch as liquid photisms, reverberated sounds as gaseous photisms, and distorted sounds as plasma photisms. I hypothesised that my frequent deconstructing and reassembling of vocal samples, and use of audio glitching, is likely explained by my enjoyment of the fluctuation in photism states of matter induced by these production techniques. I found that the perceived weight of my photisms was also primarily determined by timbre, but also by pitch, tempo, and dynamics, and that generally sounds that induced solid photisms seem heavier, while sounds that induced liquid or gaseous photisms seem lighter in weight. I determined that any composition that

did not include sounds that induced photisms of a wide range of states of matter and weights would seem incomplete, therefore acknowledging the importance these perceptions play in my composition process.

6.2.3. Spatiality and Temporality

I also identified spatiality and temporality as two prevalent themes that frequently emerged from the autoethnographic data I had collected during the composing of *Photisms*. I determined that a photism's position in my mind's eye could be defined using the Cartesian coordinate system. I found that the panning, pitch, and volume and reverb levels of a sound corresponded to its photism's position on the X, Y, and Z axes, respectively. I realised that, unlike many other synaesthetes' perceptions of the passing of time as left-to-right movement, my photisms evolved, materialised and dematerialised in real time, like an unfolding animation. I considered that my frequent use of sidechain compression and gating may be explained by how much I enjoy the resulting synchronised patterns of the photisms induced by these production techniques. Alterations to tempo and meter are also visualised and often induce exciting and unexpected changes in the motion of the photisms.

6.2.4. Translating and Reverse-Engineering

Through my newfound understanding of how various musical parameters affect my synaesthetic experiences, and how, in turn, these experiences affect my decision-making during the composition process, I learned to 'reverse-engineer' my synaesthetic experiences. This enabled me to translate visual images and artworks into ideas for music compositions. I initially tried translating entire artworks into music compositions, remaining as accurate as possible to my synaesthetic auditory-visual correspondences. However, I found that this rendered the composition process procedural and unenjoyable. Alternatively, translating only select forms in a visual image or artwork allowed for a more creative and enjoyable approach to music composition.

6.3. Contribution of the Research

This is the first autoethnographic research into auditory-visual synaesthesia and its impact on music composition processes and outputs. It explores aspects of auditory-visual synaesthesia other than the already extensively researched musical note-induced colours, such as timbrally-induced shapes, colours, and textures. This PhD research is the first to discuss the synaesthetic consequences of timbral mutations and transmutations (Roads 2015). It contributes new terms to the auditory-visual synaesthesia discourse, including 'photism multiplication' and 'photism emergence', denoting the perception of, respectively: multiple photisms induced by a single sound; and photisms emerging from within other photisms. It is the first to explore the perceived state of matter and weight of timbrally-induced photisms, and the first to link discussions around predictions of texture and weight from visual observation (e.g., Sun et al. 2016 and Gallivan et al. 2014), with the concept of the synaesthetic object, or photism (e.g., Chiou et al. 2013, Cytowic 2018, Hochel and Milán 2008, and Colman 2008).

This PhD research contributes to knowledge on the perceived spatial and temporal dimensions of auditory-visual synaesthesia. Although research has previously been conducted into the spatiality of synaesthetic experiences (e.g., see Mohr 2013), and despite the fact that synaesthetic photisms are recognised as often being three-dimensional (e.g., see Chiou et al. 2013), prior to this PhD research there had been limited investigation into the crossmodal mappings between these dimensions and musical parameters (e.g., pitch, panning, and volume). My PhD research is the first to use Gibson's (2019) audio-spatial theory to explain the spatial dimensions of auditory-visual synaesthesia. It is also the first to investigate auditory-visual synaesthetic reverse-engineering in the translating of visual images into musical ideas for new compositions. The only other documented case of this creative application of synaesthesia is James Wannerton's reverse-engineering of his lexical-gustatory synaesthetic experiences in his translating of flavours into objects to be photographed for food journal *The Gourmand* (Nowness 2013). My PhD uniquely explores synaesthetic reverse-engineering in a music composition context, combining Gordon's (1999) theory of audiation with Nikolić's (2009) theory of ideaesthesia to explain how this is possible.

Overall, this PhD research has contributed to knowledge on the nature of auditory-visual synaesthetic visualisations of music and the impact the phenomenon can have on music composition processes and outputs. Prior to this research, there existed no academic first-person account of auditory-visual synaesthesia and its role in the music composition process. I hope that my research will encourage other synaesthetic artists to explore how their experiences impact on their creative practice.

This research has also contributed a new album of electronic music for listeners to enjoy. Although *Photisms* was composed and produced for research purposes to learn how my synaesthetic experiences affected my musicking, my compositions are also appreciated by myself and others. I took great pleasure in the creation of the album, and still enjoy listening back to my work and 'watching' the synaesthetic visualisations the music induces. Throughout the composition process, I shared my work with other electronic music composers and synaesthetes for feedback. I was especially intrigued by the diverse range of experiences reported by the synaesthetes as a result of listening to my music. These, unsurprisingly, tended to be very different from my own visualisations. Since emerging from the COVID-19 lockdowns, my compositions have also soundtracked many evenings with friends. I am very pleased that my work is enjoyed by friends, peers, and other synaesthetes, but ultimately what matters most to me is that *I* enjoy listening back to my compositions. I am reminded of the advice I frequently impart to my students: 'compose the music that you would want to listen to'. I find that if I don't enjoy listening back to the music I have created, I am never particularly proud of my work, regardless of what others may think of it. I am, however, very confident that the compositions I created for this research are, in my opinion, my best to date.

6.4. Limitations and Suggestions for Future Research

Since this research concentrates on my own musicking, naturally there is a focus on electronic music: the type of music I tend to listen to and compose. Composition in other genres and styles of music are therefore not a focus of this research, but could be explored in future studies.

As the primary sonic factor that determines the appearance of my photisms, timbre is a significant focal point of this research. To limit the scope of the project to a manageable proportion, I have not explored in much detail my synaesthetic perceptions of melody, harmony, lyrics, dynamics, and other musical concepts, and have instead focussed on the aspects of music that: (1) have the most significant impact on my synaesthetic experiences; and (2) I am most interested in exploring in my compositions. Future research could explore my visualisations of these other musical concepts.

This research project also does not spend much time exploring grapheme-colour synaesthesia: another form of the phenomenon that I experience (colours induced by the perception of letters and numbers). With the exception of my musical keys/notes-colour associations, as briefly discussed in 2.2., my grapheme-colour synaesthesia has little bearing on my musicking. Going forward, I intend to investigate the interplay between my auditory-visual synaesthesia and grapheme-colour synaesthesia in the context of lyrics and song or album titles.

With the exception of the rudimentary animations included in the Appendices, the practice-based element of this thesis does not include visual depictions of my synaesthetic perceptions of the compositions I created. Although I originally considered creating an album of audiovisual compositions, with the visual aspect consisting of animations representing my synaesthetic visualisations of the music, this idea was quickly abandoned primarily due to my inexperience with animation software. Ultimately, I do not believe that animations are necessary to explain what it is that I 'see' when listening to music. Furthermore, the main purpose of this research is not to merely describe my synaesthetic visualisations; it is to investigate how they impact on my music-making. However, following the completion of this PhD research, I intend to spend time learning how to use animation software in order to create audiovisual compositions that portray my synaesthetic experiences.

The findings of this PhD research are specific to my own synaesthesia and creative practice and do not necessarily apply to others. I carried out this research primarily for the benefit of myself and for the betterment of my own creative practice. The purpose of this research was never to produce a 'how-to' guide for synaesthetic composers. While it is possible that some synaesthetes and/or electronic music

composers may be able to relate to some of the findings, this research focuses on my own experiences and practice and, as a result, findings cannot be universally applied to all auditory-visual synaesthetic composers. Due to the idiosyncratic nature of the phenomenon, further research into other synaesthetic artists' practice would provide a fuller and more accurate picture of the role synaesthesia can play in creative practice. Future studies could, for example, investigate the prevalence of the previously unexplored phenomenon of synaesthetic reverse-engineering in synaesthetic artists' creative practice.

Since the neurological and psychological explanations of synaesthesia are beyond the scope of this research project, I have not investigated the causes of my synaesthetic experiences or proposed an explanation for my auditory-visual synaesthetic correspondences (see Figure 6.1 below).

Auditory inducer	**Visual concurrent(s)**
Timbre of sound	Shape, colour, texture, state of matter, size, and weight of photism
⇒ Waveform	Shape of photism
⇒ Filter	Colour lightness, sharpness, and size of photism
⇒ ADSR envelope	Weight and duration of photism
⇒ Harmonicity	Number of colours and/or shades of a colour in a photism
⇒ Formant structure	Compression/expansion of photism
⇒ Noisiness	Roughness of texture of photism
Pitch of sound	Brightness, size, weight, and position of photism on Y axis
Loudness of sound	Size, weight, and position of photism on Z axis
Stereo position of sound	Position of photism on X axis
Reverberation of sound	Shadow and position of photism on Z axis
Rhythm of sound	Rhythm of flickering, flashing, and pulsation of photism
Musical note of sound (if known)	Colour hue of photism
Key of music (if known)	Colour hue of all photisms

Figure 6.1.

Table of my auditory-visual synaesthetic correspondences.

Auditory-visual synaesthetic correspondences – in particular, those not previously studied in depth (e.g., timbre-texture and timbre-state of matter) – could be explored in future neurological and psychological research.

7. References

Abbado, A. (2017). *Visual Music Masters: Abstract Explorations: History and Contemporary Research*. Skira Editore, Milan.

Adams, T.E., Jones, S.H. & Ellis, C. (2014). *Autoethnography (Understanding Qualitative Research*. Oxford University Press, Oxford.

Adeli, M., Rouat, J., & Molotchnikoff, S. (2014). 'Audiovisual correspondence between musical timbre and visual shapes', *Frontiers in Human Neuroscience*, 8(352). doi:10.3389/fnhum.2014.00352.

Akiva-Kabiri, L., Linkovski, O., Gertner, L. & Henik, A. (2014). 'Musical space synesthesia: Automatic, explicit and conceptual connections between musical stimuli and space', *Consciousness and Cognition*, 28(2), 17-29. doi:10.1016/j.concog.2014.06.001.

Anderson, C. (2019). Facebook message to Ella Yolande, 16 September.

Apple (2021a). *Pages (Version 11.1)*. [Software].

Apple (2021b). *Logic Pro (Version 10.6.3)*. [Software].

Asher, J.E. & Carmichael, D.A. (2013). 'The genetics and inheritance of synesthesia' in *The Oxford Handbook of Synesthesia*, eds Simner, J. & Hubbard, E.M., Oxford University Press, Oxford, 23-45.

Autechre (2002). 'Gantz Graf', *Gantz Graf* [Spotify]. Warp Records, London. Available at: https://open.spotify.com/track/5OyrWto6OxYrxHGm93W3fE?si=b86bc85746db49b1 [accessed 13/04/23].

Bartleet, B.L. & Ellis, C. eds (2009). *Music Autoethnographies: Making Autoethnography Sing / Making Music Personal*. Australian Academic Press, Queensland.

Bernard, J.W. (1986). ‘Messiaen’s Synaesthesia: The Correspondence between Color and Sound Structure in His Music’, *Music Perception*, 4(1), 41-68. doi:10.2307/40285351.

Bicep (2017). *Bicep* [Spotify]. Ninja Tune, London. Available at: https://open.spotify.com/album/4psDRFbIlUM1KUb1omccXo?si= 65celU3QuqoGt8o0rHGSQ [accessed 13/04/23].

Bicep (2017b). ‘Kites’, *Bicep* [Spotify]. Ninja Tune, London. Available at: https://open.spotify.com/track/6JwjGna6Xl463INNMr4anO?si=33fa5b35921a4758 [accessed 13/04/23].

Bicep (2021). *Isles* [Spotify]. Ninja Tune, London. Available at: https://open.spotify.com/album/0EdtTRCl3J22AnWrNpH1w9?si=SCe1lmrDQlmFuTXhja57uA [accessed 13/04/23].

Bicep, Four Tet (2018). ‘Opal – Four Tet Remix’, *Opal (Four Tet Remix)* [Spotify]. Ninja Tune, London. Available at: https://open.spotify.com/track/3VtTuQ6lypMoOBcm6VMzdh?si=874406e7a0be470f [accessed 13/04/23].

Boards of Canada (2013). *Tomorrow’s Harvest* [Spotify]. Warp Records, London. Available at: https://open.spotify.com/album/07Ckd8KDDxcbY5iUXjhuex?si=lk6MQhE6Rpiqn-EDYbPUtA [accessed 13/04/23].

Breaden, M. (2020). *Figurenotes and children with autism: using reflective practice in a music intervention*. PhD thesis, Western Sydney University. Available at: https://researchdirect.westernsydney.edu.au/islandora/object/uws:56410/ [accessed 02/09/21].

Burial (2007). *Untrue* [Spotify]. Hyperdub, London. Available at: https://open.spotify.com/album/1C30LhZB9I48LdpVCRRYvq?si=czm7zCgBQQCppJOmjQnjMQ [accessed 13/04/23].

Burial, Four Tet (2022). *Nova/Moth* [Spotify]. Text Records, London. Available at: https://open.spotify.com/album/17nT2QOQmMPEETOsNDK1Bp?si=rqWrfe2ET1OEGW0lMlWt2g [accessed 13/04/23].

Carisi, G., Timpano N. & Brogaard, B. (2021). *'Living Art' – Giulia Carisi's Sound-Color Synesthesia Paintings Unpacked* [webinar]. 11 March, University of Miami.

Cavallaro, D. (2013). *Synesthesia and the Arts*. McFarland & Company, Inc., Jefferson.

Chang, H. (2008). *Autoethnography as Method: Developing Qualitative Inquiry*. Routledge, Oxon.

Chiou, R., Stelter, M. & Rich, A.N. (2013). 'Beyond colour perception: Auditory-visual synaesthesia induces experiences of geometric objects in specific locations', *Cortex*, 49(6), 1750-1763. doi:10.1016/j.cortex.2012.04.006.

Collins, H. (2010). *Creative Research: The Theory and Practice of Research for the Creative Industries*. AVA Publishing SA, Lausanne.

Colman, A.M. (2008). *A Dictionary of Psychology*. 3rd ed. Oxford University Press, Oxford. [Online]. Available at: https://www.oxfordreference.com [accessed 19/07/22].

Cooper, M. (2017). 'Resynthesis', *World Passing By* [Spotify]. Mesh, London. Available at: https://open.spotify.com/track/48U4rQ0dGSLxNerOm5Vsva?si=65e7c01e1f4c43fd [accessed 13/04/23].

Cooper, M. (2019). *Yearning for the Infinite* [Spotify]. Mesh, London. Available at: https://open.spotify.com/album/2qOai8aBLM3813p4luleGt?si=Zc67-gIkR2G1R-Ol-0-K Q [accessed 13/04/23].

CoriAnder (2018). *Shapeshifter* [online video]. Available at: https://www.youtube.com/watch?v=B1cBP1EGpfQ [accessed 25/07/22].

Curwen, C. (2018). 'Music-colour synaesthesia: Concept, context and qualia', *Consciousness and Cognition*, 61(2018), 94-106. doi:10.1016/j.concog.2018.04.005.

Cytowic, R.E. (2002). *Synesthesia: A Union of the Senses*. 2nd ed. MIT Press, Cambridge, MA.

Cytowic, R.E. (2018). *Synesthesia*. MIT Press, Cambridge, MA.

Day, S.A. (2013). 'Synesthesia: A first person perspective', in *The Oxford Handbook of Synesthesia*, eds Simner, J. & Hubbard, E.M., Oxford University Press, Oxford, 903-923.

Dittmar, A. (2009). *Synaesthesia: A "Golden Thread" through Life?*. Die Blaue Eule, Essen.

Dixon, M.J., Smilek, D. & Merikle, P.M. (2004). 'Not all synaesthetes are created equal: Projector versus associator synaesthetes', *Cognitive, Affective, & Behavioral Neuroscience*, 4(3), 335-343. doi:10.3758/CABN.4.3.335.

Djonov, E. & Van Leeuwen, T. (2011). 'The semiotics of texture: from tactile to visual', *Visual Communication*, 10(4), 541-564. doi:10.1177/1470357211415786.

Dot Major (2023). 'Bear', *Bear* [Spotify]. Pop Can Records, Los Angeles. Available at: https://open.spotify.com/track/0233tCHQ7wju5xzpQfeb5s?si=da8fc5c1a62444ca [accessed 13/04/23].

Duffy, P.L. (2001). *Blue Cats and Chartreuse Kittens: How Synesthetes Color Their Worlds*. Henry Holt and Company, New York.

Eagleman, D.M. & Goodale, M.A. (2009). 'Why color synesthesia involves more than color', *Trends in Cognitive Sciences*, 13(7), 288-292. doi: 10.1016/j.tics.2009.03.009.

Figurenotes (n.d.). *What is Figurenotes?*. Available at: https://figurenotes.org/what-is-figurenotes/ [accessed 18/09/21].

Figurenotes (2020). *What is Figurenotes?* [online video]. Available at: https://www.youtube.com/watch?v=6bHtt3wei U [accessed 18/09/21].

Fake, N. (2017). *Providence* [Spotify]. Ninja Tune, London. Available at: https://open.spotify.com/album/6m2Yw1xMhp90rwUnOdtBcp?si=3PXuDqZJTjShQ5ZcG5RYDQ [accessed 13/04/23].

Fake, N. (2020). *Blizzards* [Spotify]. Cambria Instruments, UK. Available at: https://open.spotify.com/album/0AG0R1Ig9RcoqVFLJIvoSz?si=F0WBctMvTqKktL95cKtiBw [accessed 13/04/23].

Fake, N. (2023). *Crystal Vision* [Spotify]. Cambria Instruments, UK. Available at: https://open.spotify.com/album/2HWJ3GxRVzmiu4pDY5Zezc?si=sfwl0zTaTNWffFVC bXgA [accessed 13/04/23].

FitzGerald, G. (2022). *Stellar Drifting* [Spotify]. Double Six Records, London. Available at: https://open.spotify.com/album/10R86B7gmlS7yVf8IBx9uE?si=iaFuA8B7QbiA6sucPJz7w [accessed 13/04/23].

Fixmer, T. (2012). 'When the Sun', *When the Sun* [Spotify]. Electric Deluxe, Netherlands. Available at: https://open.spotify.com/track/2N6X5nmi28mqtW6Gvw78re?si=79f60d5e081945cc [accessed 13/04/23].

Four Tet (2017). *New Energy* [Spotify]. Text Records, London. Available at: https://open.spotify.com/album/74r6JJ97ipO0CREXP9PMqZ?si=TwWdY81RTd6h7R622Zx9Kg [accessed 13/04/23].

Four Tet (2020a). *Sixteen Oceans* [Spotify]. Text Records, London. Available at: https://open.spotify.com/album/5gIa8hTQGPwVeNYjDwrraZ?si=RGh0rWkrQ4eKcDO1YVLafA [accessed 13/04/23].

Four Tet (2020b). 'Baby', *Sixteen Oceans* [Spotify]. Text Records, London. Available at: https://open.spotify.com/track/0wPfUQUkWcguy2iUH0BWOT?si=d91685b8d05c4092 [accessed 25/11/21].

Gajjala, R. (2004). *Cyber Selves: Feminist Ethnographies of South Asian Women*. AltaMira Press, Walnut Creek, CA.

Galeyev, B.M. (2007). 'The Nature and Functions of Synesthesia in Music', *Leonardo*, 40(3), 285-288. doi:10.1162/leon.2007.40.3.285.

Gallivan, J.P., Cant, J.S., Goodale, M.A., & Flanagan, J.R. (2014). 'Representation of Object Weight in Human Ventral Visual Cortex', *Current Biology*, 24(16), 1866-1873. doi:10.1016/j.cub.2014.06.046.

Garro, D. (2020). 'Connected media, connected idioms: The relationship between video and electroacoustic music from a composer's perspective', in *Sound and Image: Aesthetics and Practices*, ed Knight-Hill, A, Routledge, Oxon, 1-12.

Gibson, D. (2019). *The Art of Mixing: A Visual Guide to Recording, Engineering, and Production*. 3rd ed. Routledge, New York.

Gordon, E.E. (1999). 'All about Audiation and Music Aptitudes', *Music Educators Journal*, 86(2), 41-44. doi:10.2307/3399589.

Gottschalk, J. (2018a). 'Monoliths: Laurie Spiegel's The Expanding Universe and André O. Méller's *musik für orgel und eine(n) tonsetzer(in)*' in *Being Time*, eds Glover, R., Gottschalk, J. & Harrison, B. Bloomsbury, London.

Gottschalk, J. (2018b). 'Granulated Time: Toshiya Tsunoda's *O Kokos Tis Anixis*' in *Being Time*, eds Glover, R., Gottschalk, J. & Harrison, B. Bloomsbury, London.

Harris, L. (2022). *Composing Audiovisually: Perspectives on Audiovisual Practices and Relationships*. Routledge, Oxon.

Harrison, J. & Baron-Cohen, S. (1994). 'Synaesthesia: An Account of Coloured Hearing', *Leonardo*, 27(4), 343-346. doi:10.2307/1576010.

Haywyre (2016). 'Do You Don't You', *Two Fold Pt. 2*. [Spotify]. Monstercat, Vancouver. Available at: https://open.spotify.com/album/508vBreqIFKqU5lG1m2Xxv?si=mW8_X272QBigkyUECuVSzQ [accessed 25/07/22].

Hill, L.C. II. (2006). *Synesthetic Music Experience Communicator*. PhD thesis, Iowa State University. Available at: https://core.ac.uk/download/pdf/38916779.pdf [accessed 27/05/22].

Hochel, M. & Milán, E.G. (2008). 'Synaesthesia: The existing state of affairs', *Cognitive Neuropsychology*, 25(1), 93-117. doi:10.1080/02643290701822815.

Hopkins, J. (2009). *Insides* [Spotify]. Just Music, London. Available at: https://open.spotify.com/album/124tr6mYSuv4yCQUKfyKTF?si=pT63q43yQ6aDJXLCZmx7GQ [accessed 13/04/23].

Hopkins, J. (2013a). *Immunity* [Spotify]. Domino Recording Company, London. Available at: https://open.spotify.com/album/1rxWlYQcH945S3jpIMYR35?si=JQrurXWnRYCUVaJ7OLNNUA [accessed 13/04/23].

Hopkins, J. (2013b). 'Open Eye Signal', *Immunity* [Spotify]. Domino Recording Company, London. Available at: https://open.spotify.com/track/6wMTeVootJ8RdCLNOZy5Km?si=6b4398ac8f86417d [accessed 13/04/23].

Hopkins, J. (2013c). 'Collider', Immunity [Spotify]. Domino Recording Company, London. Available at: https://open.spotify.com/track/2WjkOw9JVbvAdKKUaGs3OK?si=d4728b61763f4588 [accessed 13/04/23].

Hopkins, J. (2018a). *Singularity* [Spotify]. Domino Recording Company, London. Available at: https://open.spotify.com/album/1nvzBC1M3dlCMIxfUCBhlO?si=8Ed5mB6OTsO61L66EDnuRQ [accessed 13/04/23].

Hopkins, J. (2018b). 'Everything Connected', Singularity [Spotify]. Domino Recording Company, London. Available at: https://open.spotify.com/track/3oWBMOzkjjkCmV6abncBUd?si=6de923b769b546a6 [accessed 13/04/23].

Hubbard, T.L. (2010). 'Auditory Imagery: Empirical Findings', *Psychological bulletin*, 136(2), 302-329. doi:10.1037/a0018436.

Ihde, D. (1990). *Technology and the Lifeworld: From Garden to Earth*. Indiana University Press, Bloomington.

Itzkoff, D. (2010). 'Hans Zimmer Extracts the Secrets of the 'Inception' Score', *The New York Times*, 28 July [online]. Available at:

https://archive.nytimes.com/artsbeat.blogs.nytimes.com/2010/07/28/hans-zimmer-extracts-the-secrets-of-the-inception-score/ [accessed 20/07/19].

Jacobs, L., Karpik, A., Bozian, D. & Gøthgen, S. (1981). 'Auditory-Visual Synesthesia Sound-Induced Photisms', *Archives of Neurology*, 38(4), 211-216. doi:10.1001/archneur.1981.00510040037005.

Johnson, D., Allison, C. & Baron-Cohen, S. (2013). 'The prevalence of synesthesia: The consistency revolution', in *The Oxford Handbook of Synesthesia*, eds Simner, J. & Hubbard, E.M., Oxford University Press, Oxford, 3-22.

Jonas, C.N. & Price, M.C. (2014). 'Not all synesthetes are alike: spatial vs. visual dimensions of sequence-space synesthesia', *Frontiers in Psychology*, 5(1171). doi:10.3389/fpsyg.2014.01171.

Kandinsky, W. (1913). *Farbstudie-Quadrate mit konzentrischen Ringen* [Watercolour, gouache, and crayon on paper] [online]. Available at: https://www.moma.org/interactives/exhibitions/2012/inventingabstraction/?work=12 [accessed 24/02/22].

Kandinsky, W. (1977). *Concerning the Spiritual in Art: translated with an introduction by M.T.H. Sadler*, Dover Publications, New York.

Ko, T. (2020). *Tonia Ko on 'Cultivating a Personal Interdisciplinary Practice'* [webinar]. 28 October, City, University of London.

Kuo, Y-T. & Chuang, M-C. (2013). 'A proposal of a color music notation system on a single melody for music beginners', *International Journal of Music Education*, 31(4), 394-412. doi:10.1177/0255761413489082.

Lee, C.H. (2018). *Synaesthesia Materialisation: Approaches to Applying Synaesthesia as a Provocation for Generating Creative Ideas Within the Context of Design*. PhD thesis, Royal College of Art. Available at: https://core.ac.uk/download/pdf/196592014.pdf [accessed 25/10/20].

Linkovski, O., Akiva-Kabiri, L., Gertner, L. & Henik, A. (2012). ‘Is it for real? Evaluating authenticity of musical pitch-space synesthesia’, *Cognitive Processing*, 13(1), 247-251. doi:10.1007/s10339-012-0498-0.

Magnusson, T. (2009). ‘Of Epistemic Tools: musical instruments as cognitive extensions’, *Organised Sound*, 14(2), 168-176. doi:10.1017/S1355771809000272.

McCracken, M. (2016). *Painting a Song* [online video]. Available at: https://www.youtube.com/watch?v=EDzvPmAap8M [accessed 25/07/22].

Meier, B. & Rothen, N. (2015). ‘Developing synaesthesia: a primer’, *Frontiers in Human Neuroscience*, 9, 1-2. doi:10.3389/fnhum.2015.00211.

Menouti, K., Lilach A-K., Banissy, M.J., & Stewart, L. (2015). ‘Timbre-colour synaesthesia: Exploring the consistency of associations based on timbre’, *Cortex*, 63(2015), 1-3. doi:10.1016/j.cortex.2014.08.009.

Mills, C.B., Boteler, E.H. & Larcombe, G.K. (2003). ‘‘Seeing things in my head’: A synesthete’s images for music and notes’, *Perception*, 32(11), 1359-1376. doi:10.1068/p5100.

Moholy-Nagy, L. (1925). *Composition A XXI* [oil on canvas] [online]. Available at: https://www.wikiart.org/en/laszlo-moholy-nagy/composition-a-xxi-1925 [accessed 01/04/19].

Mohr, C. (2013). ‘Synesthesia in space versus the “mind’s eye”: How to ask the right questions’, in *The Oxford Handbook of Synesthesia*, eds Simner, J. & Hubbard, E.M., Oxford University Press, Oxford, 440-458.

Moir, Z. (2020). ‘Found Sounds: Music from The Mundane’, in *The Music Technology Cookbook: Ready-Made Recipes for the Classroom*, ed. A.P. Bell, Oxford University Press, Oxford, 119-224.

Moos, A., Simmons, D., Simner, J. & Smith, R. (2013). ‘Color and texture associations in voice-induced synesthesia’, *Frontiers in Psychology*, 4(568). doi:10.3389/fpsyg.2013.00568.

Mori, M. (2012). ‘The Uncanny Valley’, *IEEE Robotics & Automation Magazine*, 19(2), 98-100. doi:10.1109/MRA.2012.2192811.

Mudge, E.L. (1920). ‘The Common Synaesthesia of Music’, *Journal of Applied Psychology*, 4(4), 342-345. doi:10.1037/h0072596.

Neely, A. (2017). *Musical fractals* [online video]. Available at: https://www.youtube.com/watch?v=mq0z-sxjNlo [accessed 24/03/19].

Neely, A. (2018). *New Horizons in Music: Polyrhythms | Loop* [online video]. Available at: https://www.youtube.com/watch?v=JiNKlhspdKg [accessed 24/03/19].

Neil, J. (2017). ‘Digital Auto-Ethnography: Interview with Self’, *PRISM*, 1(1), 46-72. Available at: https://openjournals.ljmu.ac.uk/index.php/prism/article/view/299/274 [accessed 18/11/20].

Nelson, R. (2013). *Practice as Research in the Arts: Principles, Protocols, Pedagogies, Resistances*. Palgrave Macmillan, Basingstoke.

Nijs, L., Lesaffre, M., & Leman, M. (2013). ‘The musical instrument as a natural extension of the musician’, in *Music and Its Instruments*, eds Castellengo, M., Genevois, H., & Bardez, J.M., Éditions Delatour France, Sampzon, 467-484.

Nikolić, D. (2009). ‘Is synaesthesia actually ideaesthesia? An inquiry into the nature of the phenomenon’, *Proceedings of the Third International Congress on Synaesthesia, Science & Art*, Granada, April 26-29. Available at: http://www.danko-nikolic.com/wp-content/uploads/2011/09/Synesthesia2009-Nikolic-Ideaesthesia.pdf [accessed 26/07/20].

Nikolić, D. (2016). ‘Ideaesthesia and Art’, in *Digital Synesthesia: A Model for the Aesthetics of Digital Art*, eds Gsöllpointner, K., Schnell, R. & Schuler, R.K., De Gruyter, Berlin, 41-52.

Nikolić, D., Lichti, P. & Singer, W. (2007). ‘Color Opponency in Synaesthetic Experiences’, *Psychological Science*, 18(6), 481-486. doi:10.1111/j.1467-9280.2007.01925.x.

Noë, A. (2016). *Strange Tools : Art and Human Nature*. Hill and Wang, New York.

Nowness (2013). *A Synaesthetic Sunday Roast*. Available at: https://www.nowness.com/topic/dominic-davies/a-synaesthetic-sunday-roast [accessed 06/07/21].

Orlandatou, K. (2015). 'Sound characteristics which affect attributes of the synaesthetic visual experience', *Musicae Scientiae*, 19(4), 389-401. doi:10.1177/1029864915593334.

Pollock, J. (1948). *Number 5, 1948* [oil on fibreboard] [online]. Available at: https://www.jackson-pollock.org/number-5.jsp [accessed 19/07/22].

Pratt, C.C. (1930). 'The Spatial Character of High and Low Tones', *Journal of Experimental Psychology*, 13(3), 278-285. doi:10.1037/h0072651.

Püschel, A. (2017). *Layers of Reality: Perception Study of a Synaesthete*. The Eriskay Connection, Breda.

Ramachandran, V.S. & Hubbard, E.M. (2001). 'Synaesthesia – A Window Into Perception, Thought and Language', *Journal of Consciousness Studies*, 8(12), 3-34. Available at: https://www.researchgate.net/publication/318494178 Synaesthesia---AWindow Into Perception Thought and Language [accessed 28/03/19].

Rival Consoles (2018). *Persona* [Spotify]. Erased Tapes, London. Available at: https://open.spotify.com/album/1BI2mpiBt99NINvLka4QhG?si=Rsp7Bx0NQauv5Y7GjuKdOw [accessed 13/04/23].

Rival Consoles (2022). *Now Is* [Spotify]. Erased Tapes, London. Available at: https://open.spotify.com/album/5volqabPjMCyMnT1GZKYgz?si=JMNCj9g4Ri2a3Le7OR5qkg [accessed 13/04/23].

Roads, C. (2003a). 'Volt Air, Pt. 3', *Point Line Cloud* [Spotify]. Presto!?, Milan. Available at: https://open.spotify.com/track/6vbt6Q5yq9uhITt8PoeMWj?si=f7fd0563150140fa [accessed 08/04/23].

Roads, C. (2003b). ‘Now’, *Point Line Cloud* [Spotify]. Presto!?, Milan. Available at: https://open.spotify.com/track/4PN3wu5QReCHa2iLxGjowN?si=21b6d470cb504d32 [accessed 08/04/23].

Roads, C. (2010). *Never*. Available at: https://www.curtisroads.net/music [accessed 08/04/23].

Roads, C. (2013). *Always*. Available at: https://www.curtisroads.net/music [accessed 08/04/23].

Roads, C. (2015). *Composing Electronic Music*. Oxford University Press, Oxford.

Rodriguez, N. & Ryave, A. (2002). *Systematic self-observation*. SAGE Publications Inc., California.

Roland (1984). *Juno 106*. [Synthesiser].

Rouw, R. (2022). IASAS Community [Facebook], 18 April. Available at: https://www.facebook.com/groups/iaosas/permalink/2202060129946927 [accessed 18/04/22].

Rudenko, S. & de Córdoba Serrano, M. J. (2017). ‘Musical-Space Synaesthesia: Visualisation of Musical Texture’. *Multisensory Research*, 30(3), 279-285. doi:10.1163/22134808-00002562.

Rudenko, S., Layden, T., McDonnell, M. & Ward, J. (2021). *Music Consciousness: what synaesthesia tells us about emotions and visualisation of senses* [webinar]. British Neuroscience Association. Available at: https://www.youtube.com/watch?v=aoIzGNFg kM [accessed 30/04/21].

Rusconi, E., Kwan, B., Giordano, B.L., Umiltà, C. & Butterworth, B. (2006). ‘Spatial representation of pitch height: the SMARC effect’, *Cognition*, 99(2), 113-129. doi:10.1016/j.cognition.2005.01.004.

Saenz, M. & Koch, C. (2008). ‘The sound of change: visually-induced auditory synesthesia’, *Current Biology*, 18(15), R650-R651. doi:10.1016/j.cub.2008.06.014.

Scoates, C. (2013). *Brian Eno: Visual Music*. Chronicle Books, San Francisco.

Scuba (2012). ‘Gekko’, *Personality* [Spotify]. Hotflush Recordings, London. Available at: https://open.spotify.com/track/2qhnBtd3dLRpa86cJZ1RuN?si=237cbb3899a54450 [accessed 13/04/23].

Seaberg, M. (2011). *Tasting the Universe*. New Page Books, Pompton Plains.

Shiraga, K. (1970). *Sorin* [oil on canvas] [online]. Available at: http://www.artnet.com/artists/kazuo-shiraga/sorin-qjO62FWBX8ZDcgaeYRcRKw2 [accessed 15/05/20].

Sigrist, M.J. (2012). ‘Dream Time: Inception and the Philosophy of Time’, in *Inception and Philosophy*, ed Johnson, D.K., John Wiley & Sons, Hoboken, 199-214.

Simner, J. (2012). ‘Defining synaesthesia’, *British Journal of Psychology*, 103, 1-15. doi:10.1348/000712610X528305

Simner, J., Mulvenna, C., Sagiv, N., Tsakanikos, E., Witherby, S.A., Fraser, C., Scott, K. & Ward, J. (2006). ‘Synaesthesia: The prevalence of atypical cross-modal experiences’, *Perception*, 35(8), 1024-1033. doi:10.1068/p5469.

Sinha, J. (2009). ‘E is Not the Same as E, or: 8 + 8 = 19’, in *Synaesthesia: A “Golden Thread” through Life?*, ed Dittmar, A., Die Blaue Eule, Essen, 194-208.

Skains, R.L. (2018). ‘Creative Practice as Research: Discourse on Methodology’, *Media Practice and Education*, 19(1), 82-97. doi:10.1080/14682753.2017.1362175.

Skrillex (2010). ‘Scary Monsters and Nice Sprites’, *Scary Monsters and Nice Sprites* [Spotify]. Big Beat Records, New York. Available at: https://open.spotify.com/track/4rwpZEcnalkuhPyGkEdhu0?si=cfd8a10b0f4144fc [accessed 25/11/21].

Skrillex (2011a). ‘First of the Year’, *More Monsters and Sprites* [Spotify]. Big Beat Records, New York. Available at: https://open.spotify.com/track/5i7fZq3chLyCHo3VeB6goD?si=c912dc673fbc48b1 [accessed 25/11/21].

Skrillex (2011b). ‘Summit’, *Bangarang* [Spotify]. Big Beat Records, New York. Available at: https://open.spotify.com/track/1SbqxemPdwGlvmirtQVkCU?si=ad12c4859c994a99 [accessed 25/11/21].

Small, C. (2011). *Musicking: The Meanings of Performing and Listening*. Wesleyan University Press, Middletown, Connecticut.

Smalley, D. (1986). ‘Spectro-morphology and Structuring Processes’, in *The Language of Electroacoustic Music*, ed Emmerson, S., Macmillan Press, Basingstoke, 61-93.

Smilek, D., Dixon, M.J., Cudahy, C. & Merikle, P.M. (2001). ‘Synaesthetic Photisms Influence Visual Perception’, *Journal of Cognitive Neuroscience*, 13(7), 930-936. doi:10.1162/089892901753165845.

Spiegel, L. (1980). ‘The Expanding Universe’, *The Expanding Universe*. [Spotify]. Unseen Worlds, New York. Available at: https://open.spotify.com/album/1oiMfhS7X0MJSjowR49VPK?si=nNUti jsTPWDSgFoh37GAw [accessed 28/07/19].

Spotify (2022). *Spotify for macOS (Intel) 1.1.94.872.g7a9200fe*. [Software].

Steen, C. & Berman, G. (2013). ‘Synesthesia and the artistic process’, in *The Oxford Handbook of Synesthesia*, eds Simner, J. & Hubbard, E.M., Oxford University Press, Oxford, 671-691.

Strachan, R. (2017). *Sonic Technologies: Popular Music, Digital Culture and the Creative Process*. Bloomsbury, New York.

Stroop, J.R. (1935). ‘Studies of interference in serial verbal reactions’, *Journal of Experimental Psychology*, 18(6), 643-662. doi:10.1037/h0054651.

Sulser, E. (2009). ‘Coloured Notes and Sweet-Tasting Thirds’, in *Synaesthesia: A “Golden Thread” through Life?*, ed Dittmar, A., Die Blaue Eule, Essen, 181-187.

Sun, H-C., Welchman, A.E., Chang, D.H.F. & Di Luca, M. (2016). ‘Look but don’t touch: Visual cues to surface structure drive somatosensory cortex’, *NeuroImage*, 128, 353-361. doi:10.1016/j.neuroimage.2015.12.054.

Syamori (2017). *What Synesthesia Looks Like #3: Haywyre - Do You Don't You*. Available at: https://www.youtube.com/watch?v=ZhdJitJpuP0 [accessed 25/07/22].

Teichmann, A.L., Nieuwenstein, M.R., Rich, A.N., Gauthier, I. & Enns, J.T. (2017). ‘Digit-Color Synaesthesia Only Enhances Memory for Colors in a Specific Context: A New Method of Duration Thresholds to Measure Serial Recall’, *Journal of Experimental Psychology: Human Perception and Performance*, 43(8), 1494-1503. doi:10.1037/xhp0000402.

Telekom Electronic Beats (2013). *Feature: Jon Hopkins (Electronic Beats TV)* [online video]. Available at: https://www.youtube.com/watch?v=K6VA4PKoC0Y [accessed 02/08/22].

THUMP (2013). *Techno's Jon Hopkins Drops Science - Supersonic - Ep. 2* [online video]. Available at: https://www.youtube.com/watch?v=gzquxwYnDvk [accessed 02/08/22].

Trust, G. (2012). *The Importance of Album Track Order in the Digital Age*. Available at: https://www.billboard.com/music/music-news/the-importance-of-album-track-order-in-the-digital-age-1082814/ [accessed 10/04/23].

Tsunoda, T. (2013). *O Kokos Tis Anixis* [CD]. Erstwhile Records, Jersey City.

Tuuri, K. & Koskela, O. (2020). ‘Understanding Human-Technology Relations Within Technologization and Appification of Musicality’, *Frontiers in Psychology*, 11(416). doi:10.3389/fpsyg.2020.00416.

van Campen, C. (1999). ‘Artistic and Psychological Experiments with Synesthesia’, *Leonardo*, 32(1), 9-14. doi:10.1162/002409499552948.

van Campen, C. (2010). *The Hidden Sense: Synesthesia in Art and Science*. The MIT Press, London.

Vanhalen, M. (2020). ‘When audio is always visual’, in *Music and Synesthesia: Abstracts from a Conference in Vienna, scheduled for July 3-5, 2020*, eds. Jewanski, J., Day, S.A., Siddiq, S., Haverkamp, M. & Reuter, C., WWU Münster, Münster, 67-68. Available at: https://re.public.polimi.it/retrieve/handle/11311/1142795/530166/Riccò DeCordoba 2020 Music%20and%20Synesthesia.pdf [accessed 06/07/20].

Velho, L. (2020). ‘Covid-19 pandemic, enforced isolation and the PhD training’. *Tapuya: Latin American Science, Technology and Society*, 3(1), 286-287. doi:10.1080/25729861.2020.1770533.

Waldeck, M. (2009). ‘Not to Read is Not to Understand! Or: The Importance of ‘Ticker Tapes’ in Conversation’, in *Synaesthesia: A “Golden Thread” through Life?*, ed Dittmar, A., Die Blaue Eule, Essen, 213-214.

Walker, P. & Smith, S. (1985). ‘Stroop interference based on the multimodal correlates of haptic size and auditory pitch’, *Perception*, 14(6), 729-736. doi:10.1068/p140729.

Wannerton, J. (2015). ‘James Wannerton’, in *Teknèsyn: Synesthesia and Visual Arts*, [online], Fundación Internacional Artecittà, 30-31. Available at: https://books.google.co.uk/books?id=9b8GCQAAQBAJ [accessed 24/10/20].

Wannerton, J. (2020). Email to Corin Anderson, 24 October.

Ward, J. (2017). ‘Music and shape in synaesthesia’ in *Music and Shape*, [online], eds Leech-Wilkinson, D. & Prior, H.M., Oxford University Press, Oxford, 306-320.

Ward, J. (2022). Email to Corin Anderson, 19 April.

Ward, J., Thompson-Lake, D., Ely, R. & Kaminski, F. (2008a). ‘Synaesthesia, creativity and art: What is the link?’, *The British Journal of Psychology*, 99(1), 127-141. doi:10.1348/000712607X204164.

Ward, J., Moore, S., Thompson-Lake, D., Salih, S. & Beck, B. (2008b). ‘The aesthetic appeal of auditory-visual synaesthetic perceptions in people without synaesthesia’, *Perception*, 37(8), 1285-1296. doi:10.1068/p5815.

Ward, J., Tsakanikos, E. & Bray, A. (2006). ‘Synaesthesia for Reading and Playing Musical Notes’, *Neurocase*, 12(1), 27-34. doi:10.1080/13554790500473672.

Weiner, J. (2017). ‘The Return of Lorde’, *The New York Times Magazine*, 12 April [online]. Available at: https://www.nytimes.com/2017/04/12/magazine/the-return-of-lorde.html [accessed 16/08/21].

West, K. (2016). Interview by Ellen DeGeneres, 19th May [online]. Available at: https://www.ellentube.com/video/kanye-keeps-it-real-extended.html [accessed 21/09/22].

Wishart, T. (1994). Audible Design: A Plain and Easy Introduction to Practical Sound Composition. Orpheus the Pantomime Ltd, York. [Online]. Available at: https://www.trevorwishart.co.uk/AUDIBLE DESIGN.pdf [accessed 12/04/23].

Zigler, M.J. (1930). ‘Tone Shapes: A Novel Type of Synaesthesia’, *Journal of General Psychology*, 3(2), 277-287. doi:10.1080/00221309.1930.9918205.

Zimmer, H. (2010). *Inception (Music from the Motion Picture)* [CD]. Reprise Records, New York.