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RECOMPOSING REALITY:

THE COMPOSER AS ILLUSIONIST

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DECLARATION

I, the student, grant powers of discretion to the School Librarian to allow the thesis to be copied in whole or in part without further reference to the author.

SUBMITTED WORK

Scores of the following pieces are submitted alongside this dissertation. Permission to publish recordings of some pieces as part of the library submission has been withheld.

Jīng (精) (2017), 6'00", conducted by Richard Baker, performed by members of the LSO and the Orchestral Artistry course. Recording redacted.

After Images (2017), 11'51", conducted by me and performed by students at the Guildhall as part of the Guildhall New Music Society winter term concert.

Ghoulish Airs (2019), 4'10", composed for the LSO Panufnik scheme, conducted by François Xavier-Roth and performed by the LSO. Recording redacted.

Jab (2021), 19'04", commissioned by the Park Lane Group, performed by Ben Smith. A copy of the score with Ben's annotations is included and also a MIDI version of the piece that gives an idea as to what a player piano performance would sound like.

Georgimorphosis (2021), 11'56", performed by Raymond Brien.

Witherbud (2021), 7'50", composed as part of the LPO Young Composers' Scheme, conducted at the premier by Jack Sheen, rehearsed by Brett Dean (who was due to premier the piece but was forced to stay at home because of coronavirus), and performed by the LPO. Recording redacted, although a performance of the piece can be found by following this YouTube link: https://www.youtube.com/watch?v=OmS-HpnFWRI.

An Interview with a "Puppet" and his "Maker" (2022), ca. 20'00", libretto by Gareth Mattey, due to the difficulties of organising a performance amidst coronavirus, the submission of this score without a recording has been permitted.

ABSTRACT

In this dissertation I seek to explain the aesthetic and technical rationale behind the portfolio of scores and recordings which it accompanies. This body of works is preoccupied with illusion in several guises. While peripherally examining optical illusions and drawing inspiration from them, I attempted to use structures and principles found in performance magic to aid my composing with psychoacoustic illusions. This dissertation describes the process of composing in such a manner and identifies the problems, challenges, strategies, aesthetic notions and musical philosophies that arose from compositionally engaging aural illusions.

The first chapter defines what is meant by illusion within the context of this research project and sets out my research questions. The second surveys existing research on psychoacoustic illusions and performance magic, while also discussing instances where psychoacoustic illusions have been adapted into compositional contexts. These existing adaptations are evaluated according to how palpable the adapted illusion is within the context of the piece, the manner in which the illusion's effect is communicated to the listener, and the imagination with which the illusion is musically adapted. In this chapter, it is shown how these evaluations impacted upon my approach to illusion and the ways in which I as a result felt that current compositional adaptations might be improved. In the third chapter, the submitted pieces are analysed and assessed by the standards formulated in the second chapter. The ways in which the works were crafted are explained, along with the research intentions that I was attempting to enact by crafting the pieces in such a way. The lessons I learned from the compositional process of each piece is also documented in this chapter. In the fourth and final chapter, the whole research enterprise is contextualised and evaluated. My research goals are reviewed and the evolution of my changing approach to compositional illusion is illustrated.

It is my hope that this thesis may shine a light on some of the curiosities which live in the loopholes of our perceptual faculties; share methods of adapting psychoacoustic illusions into compositional contexts; draw previously undrawn parallels between the practises of performance magic and music; and inspire wonder and awe in the amazing phenomena which constantly surround us.

CHAPTER 1 – PRELLUSION

'A moment of ecstatic bliss where every thought was pulled from my face leaving nothing more than empty space.'[1]

Professional magician Paul Harris describes what he experienced the first time he witnessed a magical illusion as a child. He goes on to give this 'moment of ecstatic bliss' a name: astonishment. Harris views the elicitation of this astonishment as the sole purpose of his craft. It is the desired effect of illusion. For me, a composer, music has the same purpose. I have used my research in this project to investigate methods of integrating illusions into my creative musical work so that I too may astonish. To that end, I have studied the phenomenon of illusion in its various guises and mediums. These guises include performance magic, optical, psychoacoustic and multisensory illusions. I have drawn upon these studies and used them to compose (with) musical illusions.

1.1 ILLUSIONS ARE ELUSIVE

A Google search of the phrase "the illusion of" reveals that a wide selection of metaphysical topics are claimed to be illusions. These include life, choice, time, free will, conscious will, control, safety, self and perception. Given such a potentially broad frame of reference, it is necessary first to establish clarity in the practical definition of the term illusion.

'Illusion, *n.*
The action of illuding, the condition of being illuded; that whereby one is illuded.
1. The action of deriding, or mocking; derision, mockery.
2. a. The action, or an act, of deceiving the bodily eye by false or unreal appearances, or the mental eye by false prospects, statements, etc.; deception, delusion, befooling, *Obs.*
b. The fact or condition of being deceived or deluded by appearances, or an instance of this; a mental state involving the attribution of reality to what is unreal; a false conception or idea; a deception, delusion, fancy.
3. Something that deceives or deludes by producing a false impression; a deceptive or illusive appearance, statement, belief, etc... An unreal visual appearance, an apparition, phantom.
4. Sensuous perception of an external object, involving a false conception: strictly distinguished from *hallucination*, but in general use often made to include it, and

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[1] (Harris, 2011) p. 5

hence = the apparent perception of an external object when no such object is present, or of attributes of an object which do not exist.'[2]

Definition 2a splits illusion into two categories: 'those with a physical cause and cognitive illusions due to misapplication of knowledge.'[3] Cognitive deceptions are common in performance magic. Magicians use misdirection, trick props or concealment to lie to us, so that "impossible" feats appear to be have been achieved when instead they are made possible by unseen means. Illusions which deceive the bodily eye, on the other hand, exploit perceptual flaws or glitches. These can be observed in the work of artists such as Bridget Riley, an exponent of the Op Art movement which arose in the 1960s.[4] As can be observed in her work *Currents* (1964)*,* (figure 1), Riley uses the Doppler effect to give two dimensional still images the illusion of movement.[5] I have attempted in my compositions to deceive both the bodily and mental ear.
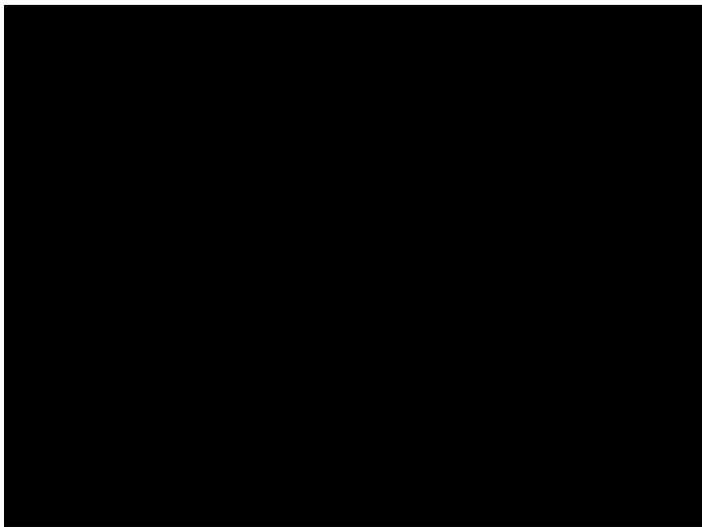
Fig. 1 Bridget Riley, *Currents* (1964)

Definition 2b, on the other hand, is a reading of illusion as a 'delusion' or 'fancy'. The use of the term illusion is taken to mean dream, fabrication, fantasy, or chimera. It is this understanding of the term illusion that leads certain psychologists to claim that "perception is an illusion". Ernst Gombrich uses arguments from Karl Popper to make this claim in *Art and Illusion*:

'…Popper has shown, that confirmations of these "hypotheses" can never be more than provisional while their refutation will be final. There is no rigid distinction,

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[2] ('Illusion, n.', 1989)
[3] One could consider this a paraphrase by the psychologist Richard Gregory (Gregory, 1997) p. 2.
[4] Op Art, short for optical art, is 'art in which the artist deliberately tries to provoke a pronounced visual psychological response in the viewer' (Oster, 1971) p. 398
[5] The Doppler effect 'is the apparent change in the frequency of emitted waves relative to an observer' (Birmingham & Micchelli, 2014). Sonic doppler effects are discussed in 2.2.4.

therefore between perception and illusion. Perception employs all its resources to weed out harmful illusions, but it may sometimes fail to "disprove" a false hypothesis – for instance when it has to deal with illusionist works of art.'[6]

By this line of logic, to perceive is to construct an understanding of reality based on educated perceptual guesses. We attain certainty by sorting through sensory stimuli and dismissing what we perceive to be unlikely – it is a process of elimination. Therefore, Gombrich and Popper argue that perception is an illusion because so often it is viewed to be an objective truth when it is in fact an estimation. As a result, many will extrapolate that, as an object of perception, "music is an illusion".[7] If I were to accept this, the legitimacy of my research project would become questionable. It is therefore more fruitful to consider perception as separate from illusion and reject definition 2b.[8]

Definition 3 is similar to 2a. Both definitions use the word 'statement', saying that if said statement deceives, it can assist in creating illusion. For instance, the card trick called *Unshuffling Rebecca* begins with a magician convincing an audience that a face-up deck of cards is face down. Then, the magician shuffles this seemingly face down deck only to reveal a face-up deck. The illusion is created by the successful fooling of the audience into believing that the magician has magicked a face-down deck into a face-up deck.[9] False statement is an integral component of performance magic illusions.

A different kind of statement that befools is paradox.[10] One such paradox is the Epiminedes Paradox: Epiminedes, a Cretian, said: "All Cretians are liars." Douglas Hofstadter, the mathematician, describes the paradox as a "strange loop." According to him, '[the] "Strange Loop" phenomenon occurs whenever, by moving upwards (or downwards) through the levels of some hierarchical system, we unexpectedly find ourselves right back where we started.'[11] In the case of Epiminedes, the loop is small: the statement leads the reader to believe that Epiminedes is lying, and yet if he is lying he must be telling the truth. However, if the truth is that he is lying, then he must be lying, etc. The statement

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[6] (E. H. Gombrich, 1986) p. 24

[7] At a presentation of my research at the Guildhall School of Muisc and Drama on 02/10/17 it was put to me that all music is essentially illusory because it is perceived. The talk was entitled "Reality check for a composer who is trying to warp your sense of reality but who never really had a very healthy grasp upon reality in the first place".

[8] Arguments against the assertion that "perception is an illusion" can be found in (Gregory, 2009) pp. 9 – 10: 'We may say that illusions are *departures from reality* – but what reality? Appearances are very different from the deep realities of physics. If these are taken as reference truths we would have to say that all perceptions are illusions. This is as pointless as saying perception is a dream'.

[9] (Harris, 2011) p. 23

[10] A paradox is '[a]n argument, based on (apparently) acceptable premises and using (apparently) valid reasoning, which leads to a conclusion that is against sense, logically unacceptable, or self-contradictory'. ('Paradox, n. and Adj.', 2005)

[11] (Hofstadter, 2000) p. 25

presents an unresolvable problem and produces a cognitive dissonance which is similar to the effect produced by illusion, as will be discussed later.[12]

Definition 4, which identifies hallucination as an instance of illusion, is of limited but distinct use to this research project. Hallucinations can be both visual and aural. It could be argued that working either of these types of hallucination into a musical composition could be practically – not to mention ethically – problematic: sonic hallucinations are often an affliction caused by mental or physical impairment such as schizophrenia or hearing loss. They are sources of psychological distress caused by physical harm.[13] However, the understanding of hallucination as 'the apparent perception of an external object when no such object is present'[14] is useful for understanding the effect of various psychoacoustic illusions, as will be discussed in chapter 2, subsection 2.2.6.

1.2 RESEARCH QUESTIONS

Now that the working concepts of illusion for this dissertation have been clarified, my research questions for this project can be better understood. They are as follows:

1. How can illusion be integrated into an organic, sophisticated and imaginative musical language? Can I achieve this whilst ensuring my illusions are heard?
2. How can conflicting aural and visual information be exploited to create illusion and adapted into performance contexts?
3. How can performance magic be used as a model for the presentation and development of aural illusions into musical structures and narratives?

The first question points to a careful balance, a tightrope that one must walk when composing with illusions. That balance is between clarity of presentation and musical imagination.[15] This balance will be elaborated upon in chapter 2, subsection 2.3. The second question points towards the compositional incorporation of illusions which result from conflicting multisensory information and will be discussed in 2.2.4 and 2.2.5. The final question introduces performance magic as a potential model for musical composition. Ways in which performance magic practices might influence musical composition will be discussed in 2.4.

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[12] The effect of illusion will be discussed later in chapter 2, subsection 2.4 for the explanation of "Belief-discordant alief".
[13] (Sacks, 2011) p. 62
[14] ('Illusion, n.', 1989)
[15] It is of course impossible to authoritatively decide what is and is not musically imaginative. The matter is completely subjective. In chapter 2, I will endeavour to explain my personal criteria for what constitutes as being musically imaginative with the aim of illustrating my aesthetic preoccupations in this research project.

CHAPTER 2 – LITERATURE REVIEW

2.1 INTRODUCTION

There are many types of illusions that fool our senses of sight and sound. Whilst many are relevant to this research project, only two were central to my actual compositional processes: psychoacoustic illusions and magical illusions. Psychoacoustic illusions affect our perception of sound. They are well researched by scholars such as Albert Bregman, Stephen McAdams, David Wessel, Diana Deutsch, Roger Shepard, Harry McGurk, John MacDonald and Gary L. Dannenbring, who have produced aural tests pertaining to their research.[16] These audio demonstrations, however, are not musical compositions and have no pretension of being so. Nonetheless, as the perception of sound is the basis of music perception, the incorporation of psychoacoustic illusions into the composition of music seemed logical.

Psychoacoustic illusions have been employed in existing compositions but with varying degrees of intentionality and success. At times, such illusions have been rendered in ways which obscured their intended effect through instrumental misbalancing and an excess of subsidiary details. Sometimes, psychoacoustic illusions have been more faithfully executed, but aural information that is crucial for the listener's comprehension of the psychoacoustic illusion has been withheld, and so no illusion is experienced by the listener. In still other cases, the compositional rendition of the aural illusion, whilst clear, has lacked musical imagination, producing an effect of aesthetic indifference.[17]

The above delineated problems indicate numerous challenges facing any composer interested in exploiting such illusions creatively. A key problem arises from a lack of real integration of the illusions into the compositional syntax. All too frequently, the illusions appear to be neither central to the music, nor compositionally developed. This indicates a lack of established procedure and structure for application.

The above dilemma prompted me to consult performance magic literature, because performance magic is an artform where the communication and development of an illusion's effect through narrative structures, otherwise known as magic tricks, is the sole focus.[18] The artform is particularly useful because, similar to music, it is temporal. To the best of my knowledge, the literature on performance magic has, as of yet, not been consulted by composers as a procedural influence. It operates according to broad concepts which include belief, misdirection and suspicion. I believe that this body of literature is essential to bettering the integration of illusion into musical composition. I therefore suggest that the theoretical concepts employed by performance magic may provide fresh solutions to adapting psychoacoustic illusions into musical contexts. By considering

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[16] See (Deutsch, 1999), (Bregman, 1990) and (Pierce, 1983), the last of which has an accompanying CD of audio demonstrations. Deutsch and Bregman have also released their own audio CDs, see (Deutsch, 2003) and (Bregman & Ahad, 1996).

[17] Precise instances of these are given in subsection 2.3

[18] In-depth explanations of this are given in subsections 2.3 and 2.4.

these concepts, I sought to compose musical works that imaginatively incorporate psychoacoustic illusion into communicative musical structures.

2.2 PSYCHOACOUSTIC ILLUSIONS

For the purposes of this research project, I have divided the researched psychoacoustic illusions into the following categories, based on the impossible effect that each produces:

1. Transformation: one sonic object transforms into another.
2. Mimesis: a sound or a sequence of sounds from nature or the external world is imitated when it is not present.
3. False infinities: strange loops create the impression that infinite processes are occurring.
4. Meta-illusions: phenomena which appear to be physically impossible and yet are vividly present in the perceived sound.
5. Ventriloquism: a visual stimulus is erroneously perceived as the source of a sound.
6. Hallucination: a sonic object is created in the mind which does not exist.
7. Appearance and vanish: a sonic object is made to appear and disappear.[19]

Although most of these psychoacoustic illusions have been compositionally applied in many existing pieces, certain hallucinations, ventriloquisms and appearance and vanish illusions have not been compositionally adapted. At the outset of my research, I intended to adapt these under-explored illusions for use and finesse the application of those already utilised by others.

2.2.1 TRANSFORMATION ILLUSIONS

A common method for creating transformation illusions is a process called auditory stream segregation. Bregman and McAdams define the resulting perceptual process as exploring 'how the auditory system determines whether a sequence of acoustic events results from one, or more than one, "source."'[20] The term "stream" denotes 'a psychological organisation that mentally represents… a [sound] sequence and displays a certain internal consistency, or continuity, that allows that sequence to be interpreted as a "whole".' The term "source" denotes the location/body from which the sounds come.[21] Auditory streams are sonic entities which are understood by the auditory system to be coherent and distinct. As such, the transformation of one into another should be impossible. The act of

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[19] These categories were made to parallel those used in (Lamont & Wiseman, 1999) pp. 3 – 6 to taxonomize magical illusions. Certain categories such as transformation, appearance and vanish are common to both lists, but the remainder are not and have been self-fabricated.
[20] (Bregman & McAdams, 2014) p. 26
[21] Ibid.

convincingly transforming one auditory stream into a separate one is therefore an illusion. Auditory stream segregation offers fruitful possibilities for creating the effect of sonic transformation in music.

Auditory stream segregation is a flexible process influenced by many acoustic factors. Timbral differentiation, pitch/register proximity and spatial redistribution can all cause the segregation of sonic phenomena into distinct streams.[22] In 1978, Wessel discovered that timbre-based stream segregation could be used to transform one auditory stream into two: a process now called the Wessel Illusion. In its original form, this is a repeated sequence of three ascending tones – originally perfect fourths – repeated at a steady, unvarying rate of pulsation. It is played in two successive ways:

    a)   All the pitches have an identical timbre. The ear perceives them as a single melodic stream.

    b)   Alternate pitches are assigned a new timbre, which whilst consistent amongst these pitches, is sharply contrasted with the timbre of the rest.

When the latter sequence is played at even moderately fast speeds, two distinct streams of melody are heard: "x" note-heads are heard as one melodic stream, and "+" note-heads are heard as a separate melodic stream (figure 2a). As a result, a single ostinato (figure 2c) is transformed into counterpoint between two ostinatos (figure 2d). This in turn affects how the sequence's speed is perceived. When the sequence of pitches is played using a single timbre, the pitch sequence is heard in a fast 3/8. However, when the pitch sequence is segregated in the manner described above, the tempo is halved and the streams are heard as being in 3/4.[23]

Fig. 2a The Wessel illusion.[24]
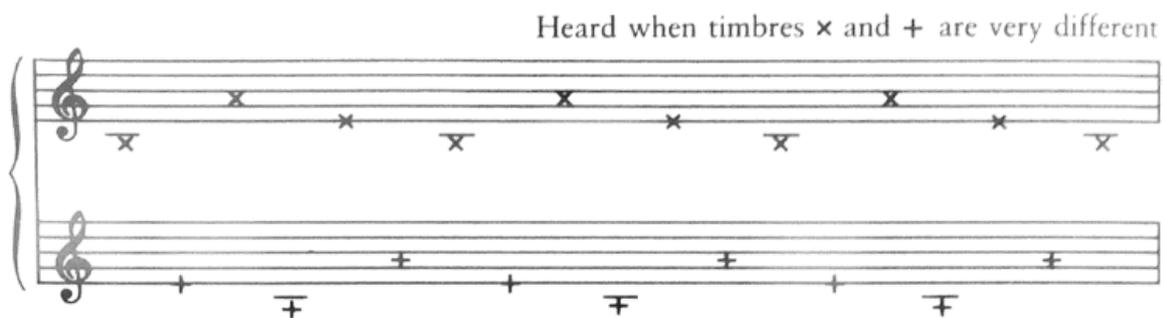
Fig. 2b. Perception of melodic streams post timbral-segregation.[25]

[22] (Huron, 2001) pp. 50 - 51 (for timbral differentiation), 22 - 24 (pitch/register proximity), 48 - 49 (spatial redistribution).
[23] (Anderson, 1996) p. 162
[24] (Pierce, 1983) p. 212
[25] Ibid.

Fig. 2c Metric interpretation of the pitch sequence prior to timbral segregation.[26]

Fig. 2d Metric interpretation of the pitch sequence post timbral segregation.[27]

Before Wessel created this illusion, Per Nørgård, a composer deeply interested in perception, developed a technique known as the infinity series which, as embodied in his works, possesses many features similar to the Wessel Illusion.[28] Nørgård's use of the infinity series to create illusion can be found in his *Symphony no. 2* (1970). The infinity series is essentially a melodic construction which contains infinite amounts of canon, both at the unison and inversion. Figure 3 shows bars 59 - 64 of the infinity series used in *Symphony no. 2*. The pitches with normal note-heads are a melodic inversion of pitches with hollow note-heads (see flute part). The infinity series replicates itself in different augmentations and inversions because of this way of melodic construction. In figure 3, every fourth note starting from the G makes an augmentation of the infinity series (with each pitch, however, at a unison with the original series moving four times faster).[29] Nørgård doubles the series at various durational intervals with different timbres to create different augmentations of the series. The oboe plays every fourth quaver of the series from its entry, the clarinet every second, the bassoon every eighth, and the horn every fourth – but all are always at the unison with the original series. It is in this way that Nørgård's use of the infinity series resembles the Wessel illusion.[30] The listener is unsure whether they are hearing a single melody or a multitude of canonic augmentations of that melody each intertwined with the original melody.

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[26] (Anderson, 1996) p. 162
[27] Ibid.
[28] Ibid.
[29] (Nørgård, 1970) pp. 12 – 13, bars 59 - 64
[30] (Anderson, 1996) p. 162

Fig. 3 Infinity series in bars 59 – 64 in Nørgård's *Symphony no. 2*.[31]

The infinity series causes perceptual ambiguity to result from the conflict of the following perceptual principles:

> 'Pitch Proximity Principle. *The coherence of an auditory stream is maintained by close pitch proximity in successive tones within the stream. Pitch-based streaming is assured when pitch movement is within van Noorden's "fission boundary" (normally 2 semitones or less for tones less than 700 ms in duration).*'[32]

> 'Timbral Differentiation Principle. *If a composer intends to write music in which the parts have a high degree of perceptual independence, then each part should maintain a unique timbral character.*'[33]

According to the pitch proximity principle, which consist of mostly conjunct pitch intervals, should be grouped into a single auditory stream. In *Symphony no. 2*, the series' wavelengths are doubled at the

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[31] (Nørgård, 1970) pp. 12 – 13, bars 59 - 64
[32] (Huron, 2001) p. 24
[33] Ibid. p. 49

unison or octave with differing timbres. According to the timbral differentiation principle, this should split the series into distinct auditory streams.[34] However, since the base infinity series in *Symphony no. 2* is heard in a single timbre (the flutes) at the same time as having its wavelengths doubled by contrasting timbres, an ambiguous Necker Cube-like percept is produced: our perception of the streams changes unpredictably between hearing a single melody with echoed resonances and polyphony. This textural flickering between monophony and counterpoint is analogous to the flipping between visual perspectives that one experiences when viewing a Necker Cube (it is hard to distinguish whether the lower left face or upper right face is closer).
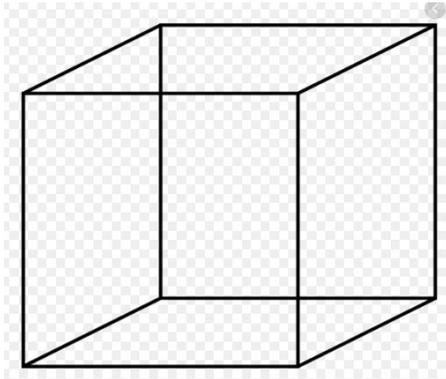
Fig. 4 Necker Cube

Pitches that are separate in register are also likely to segregate into different streams, as has been verified in experiments by Bregman and Campbell. They created an ostinato with three high pitches interleaved with three low pitches (figure 5a). The wide registral gap ensured that test subjects segregated the high and low pitches into separate streams. In addition, when the speed of the ostinato was increased, test subjects reported hearing a transformation in the pitch order, as shown in figure 5b: at accelerated speeds, register-based stream segregation is so powerful that it has the potential to transform the order of which we temporally perceive sonic events.[35] This temporal re-ordering of stratified pitches has not been, to my knowledge, achieved in existing compositions. Register-based stream segregation is, however, commonly found in the baroque solo instrumental sonata genre. Telemann managed to exploit register-based streaming to create the illusion of polyphony in his *12 Fantasias for transverse flute without bass TWV 40: 2-13* (1732 - 1733).[36] Bach does the same in his *Six Sonatas and Partitas for Solo Violin, BWV 1001 – 1006* (1720) – creating three or four voice

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[34] See 2.2.1 for a description of the Wessel illusion, an illusion which demonstrates the powers of timbral stream segregation, and (Anderson, 1996)

[35] (Bregman, 1990) pp. 50, 139, 140, 147, 153. The aural test stimulus can be found on track 1 of (Bregman & Ahad, 1996). Similar experiments were carried out by van Noorden (Noorden, 1977).

[36] (Telemann, 1987a) p. 2-3, bars 11 - 26

fugues in each violin sonata and chaconne in the second partita by similarly illusory means[37] – and his *Six Suites for Violoncello Solo, BWV 1007 – 1012* (1717 – 1723).[38]

Fig. 5a Bregman and Campbell's ostinato of three high pitches interleaved with three low pitches.

Fig. 5b Test subjects' perceived transformation of the aural stimulus's pitch subject.

Furthermore, pitches that are proximate in register are more likely to be perceived as emitting from the same sound source than pitches separate in register. This can also be exploited to deceive the perception of aural space. Deutsch documented this manipulation of perceived space in the scale illusion, which she used as an experimental test stimulus.[39] In this illusion, two voices approach and diverge from one another in a contrary motion scale.[40] These scales are stereo panned so that the pitches switch spatial position with every step of the scale (Figure 6a). Deutsch found that test subjects unconsciously reorganised the spatial position of each pitch so that the scale in the top voice was heard in its totality in one ear, and the scale in the bottom voice was heard in the other ear (figure 6b). She therefore concluded that pitch and register proximity-based stream segregation may transform one's perception of sound source location. Deutsch discovered that the scale illusion appears in the finale of Tchaikovsky's *Symphony no. 6* ("Pathetique", 1893). However, the way in which the illusion is presented does not allow the listener to experience the illusion.[41]
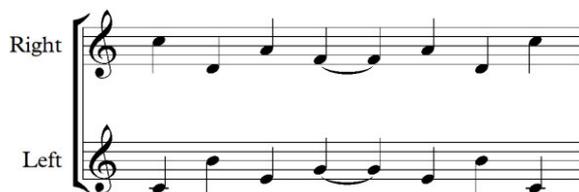
Fig. 6a The test stimulus.[42]

Fig. 6b How the test stimulus was perceived.[43]

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[37] (Bach, 2001) Bach's solo instrumental sonatas spawned many imitations, including Ysäye's *Six Sonatas for solo violin, Op. 27* (1923) and Bartók's *Sonata for solo violin Sz. 117* (1944).
[38] (Bach, 2011)
[39] (Deutsch, 1999) p. 322
[40] In this instance I do not mean voices as in human voices but polyphonic lines.
[41] This will be explained in more detail in subsection 2.3.
[42] (Deutsch, 1999) p. 322
[43] Ibid.

2.2.2 MIMETIC ILLUSIONS

While transformation illusions are primarily produced through the exploitation of auditory stream segregation processes, mimetic illusions are often created using sound synthesis. Technology is used to produce convincing impressions of real sounds found in the natural or external world. These sounds are, in fact, simulated by electronic sequencing software. Computers are used to detect and analyse characteristics of real sounds, and then, using the characteristics, re-synthesise them. For instance, vowel sounds can be simulated. To do so, vowels are analysed, and through this process the formants which shape our perception of the vowel sounds are determined.[44] Formants can be reconstructed through a technique known as additive synthesis.[45] Vibrato[46] and jitter[47] is then added to the synthesised vowel, and a convincing imitation of the human voice is produced. One can use this technique to synthesise whole words and sentences.[48] Similar illusions may be created with subtractive synthesis.[49] Additive synthesis is used in Jean-Claude Risset's *Passages* (1982) to create a 'voice-like timbre'[50], and an 'artificial language' of 'polyglot speaking and interruptions… charring and whispering' in Ligeti's *Artikulation* (1958).[51] Subtractive synthesis is used in Risset's *Sud* (1985) to imprint a pitch scale upon sea sounds and make the sea "sing".[52] In Jonathan Harvey's *Speakings* (2008), live electronics are used to filter acoustic instruments with the formants of human speech.[53]

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[44] Formants are filters which emphasise certain bands of frequency and attenuate others. They are used by the ear to differentiate between different vowels. (Fineberg, 2000) p. 87

[45] Additive synthesis is the addition of sine waves to each other to create complex sounds. (Fineberg, 2000) p. 87

[46] (Bregman & Ahad, 1996) Demonstration 24 was created by John Chowning, a composer of electroacoustic music.

[47] Jitter 'simulates an irregularity of muscle tension' found in the vocal folds, and is created by 'introducing stochastic perturbation to the stiffness coefficients.' (Lucero et al., 2013) p. 588

[48] (Remez et al., 1981)

[49] Subtractive synthesis is where 'extremely complex sounds, often white noise (sounds with equal energy in all frequencies), [are] filtered to leave only the desired portion of the sound.' (Fineberg, 2000) p. 111

[50] (J.-C. Risset, 1994) p. 260

[51] (Wehinger & Ligeti, 1970) p. 7

[52] (J.-C. Risset, 1994) p. 260

[53] (Carpentier et al., 2010) p. 56 - 57

2.2.3 FALSE INFINITIES

Fig. 7 Notational representation of a Shepard tone scale.

The Shepard tone scale (figure 7), an archetypal psychoacoustic illusion, was invented by Shepard in 1964. It is an example of a strange loop[54] that creates the illusion of an infinitely ascending or descending scale.[55] The illusion is created from a repeated sequence of rising or falling frequencies operating within a fixed amplitude envelope. The frequencies are stacked octaves which rise or fall in chromatic scales. The amplitude envelope attenuates high and low frequencies but boosts middling frequencies. This means that as the scale rises, higher partials fade out and eventually disappear. At the same time, lower partials fade in as they enter the middle frequency region (for a descending Shepard tone scale, the frequencies move in reverse).[56] Later Risset developed the Shepard tone scale into an infinitely rising glissando called the Shepard-Risset glissando. He composed with it extensively, as can be heard in *Mutations* (1969) and the second movement of *Computer Suite for Little Boy* (1968).[57] The Shepard-Risset glissando is also found in tape pieces such as James Tenney's *For Ann Rising* (1969) and the fourth region of Karlheinz Stockhausen's *Hymnen* (1966 – 67).[58] Although the Shepard tone scale is most easily and accurately reproduced in electronic music, it has

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[54] For an explanation of strange loops see chapter 1, subsection 1.2. Hofstadter does in fact refer to the Shepard tone scale in *Gödel, Escher, Bach*, stating that it has the potential to be combined with Bach's endlessly rising canon in the *Musical Offering* to create an actually endlessly rising canon. (Hofstadter, 1979) pp. 712 - 713
[55] (Shepard, 1964)
[56] (Pierce, 1983) p. 215
[57] The latter piece will be discussed further in subsection 2.3.
[58] See subsection 2.3.

been widely used in pieces which do not make use of electronics, such as Georg Friedrich Haas's *In Vain* (2000)[59] and Beat Furrer's *Fama* (2005).[60] Ligeti, after an introduction in 1973 to Risset,[61] also composed numerous pieces with Shepard tone textures, including the third movement of the *Violin Concerto* (1993), *L'escalier du diable* and *Melodien* (1971).[62] It should be noted, however, that these acoustic approximations of the Shepard tone scale, whilst musically interesting, have generally been rendered with less accuracy and effectiveness than electroacoustic versions of the illusion.

The Shepard tone scale's rhythmic analogue was devised by Risset in the late sixties.[63] This illusion exploits the perceptual inclination to hear whole number multiples of rhythmic values as being in the same tempo when played simultaneously. Figure 8 shows a crotchet pulse accelerating. As this happens, the semiquavers fade out, while quavers crescendo before they too fade out. The crotchets crescendo across the bar. The resulting effect is one of a total increase in tempo, despite the final pulses being slower than the initial semiquavers.[64] The Risset rhythm can be stretched across longer spans of time. As slower values accelerate into faster values, multiples of the faster rhythmic values reached are faded in (figure 9); a strange loop creates the illusion of infinite acceleration. Infinite decelerations can also be achieved by playing what is represented in figure 15 backwards whilst continuously decelerating. The Risset rhythm is implemented in Risset's *Moments newtoniens* (1977)[65], a work for ensemble and tape, and Haas's *In Vain* (2000), a piece for chamber orchestra.[66] The Risset rhythm is similar to a technique used in Javanese gamelan called the 'change in *irama*'.[67] The technique is essentially the same, except that the change in *irama* has no fade-outs or fade-ins. A proto-Risset rhythm can be found in Beethoven's *Sonata no. 32 in C minor Op. 111* (1822). It is a theme and variations which progressively gets faster across the whole piece. Beethoven uses progressively smaller note values until a maximum speed is reached, at which point Beethoven uses tremolos to sustain the speed. Here, a return to the opening tempo is perceived, because the harmonic rhythm has remained consistent throughout the entire movement.[68]

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[59] (Haas, 2000) pp. 210 – 217, bars 627 - 653
[60] (Furrer, 2005) pp. 52 – 57, bars 224 - 249
[61] (Steinitz, 2003)
[62] (Ligeti, 2002) p. 38, (Ligeti, 1971), (Ligeti, 1993)
[63] (J. Risset, 1986)
[64] (Pierce, 1983) p. 216
[65] (J.-C. Risset, 1994) pp. 259 - 260
[66] (Haas, 2000) pp. 162 – 178, bars 503 – 530
[67] (Brinner, 2008) p. 41 Brinner describes this process when discussing a piece called *Ladrang Asmaradana*: 'As the drummer slows down from *irama* 2 to 3, a process begun eight beats before the gong, the length of each successive beat increases. By the time the gong is reached, the beat is about twice as long as it was at the beginning of the cycle. The *saron* players continue to play at this slower pace for the first *kenongan* (line ending with the *kenong* stroke) and then double their pace, effectively returning to the speed they were playing before the drummer led them in the transition to *irama* 3.' (Brinner, 2008) p. 71
[68] (Beethoven, 1822)

Fig. 8 Notational representation of the Risset rhythm.[69]
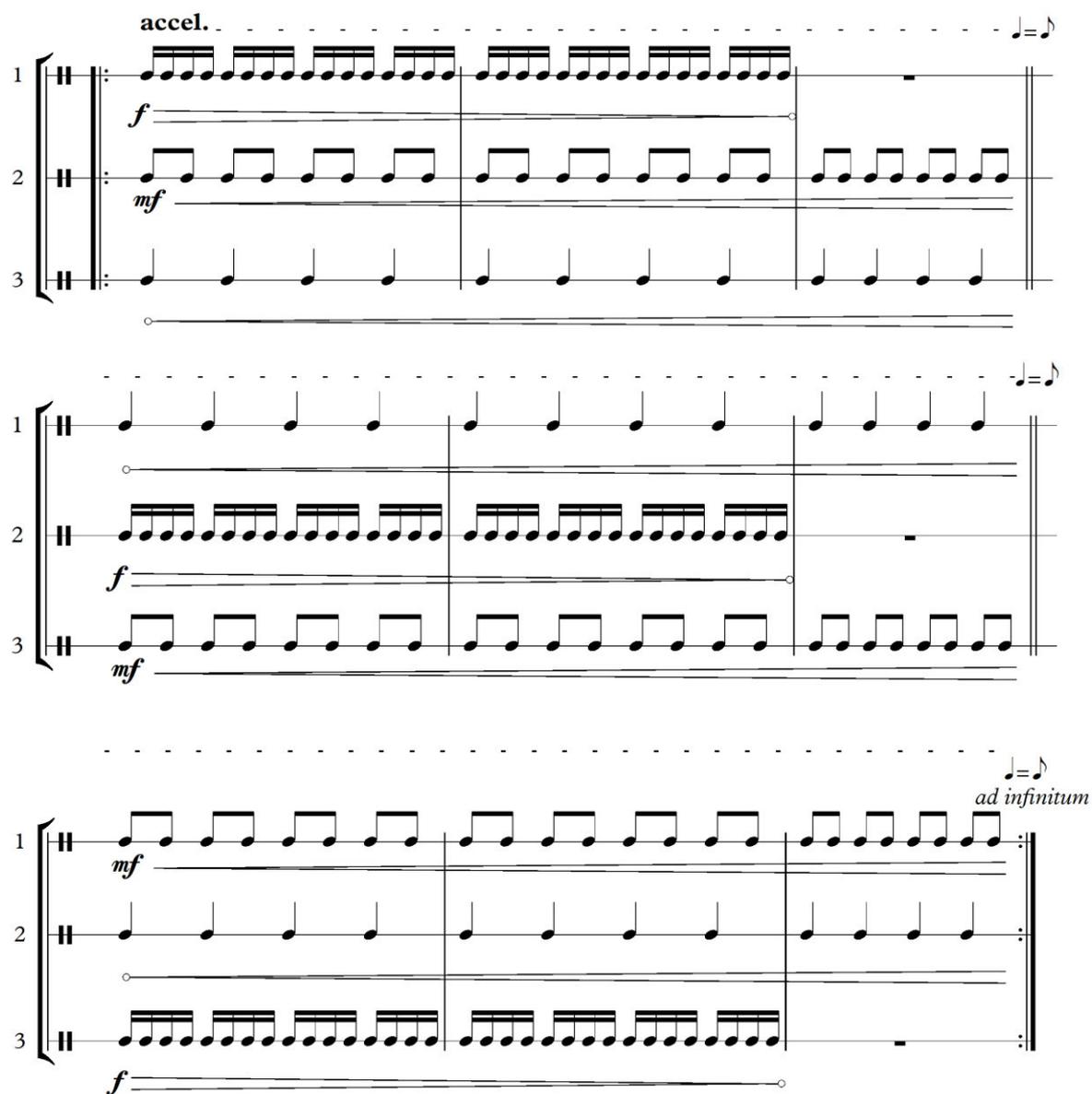
Fig. 9 Risset rhythm stretched over a longer span of time.

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[69] (Pierce, 1983) p. 215

2.2.4   META-ILLUSIONS

The next category of illusions is comprised of phenomena which appear to be physically impossible, yet are vividly present in the perceived sound. I have described them as meta-illusions because the belief that they are illusions is the real illusion. Stockhausen's summarisation of audience responses to spatial effects in his *Kontakte* (1960), a tape piece, is indicative of how meta-illusions are experienced:

> '…they say, well, the walls have not moved so it is illusion. I say to them, the fact that you say the walls have not moved is an illusion, because you clearly have heard that the sounds went away very far, and that is the truth. Whether the walls have moved at all has nothing to do with this perception, but with believing in what we hear as absolutely as we formerly believed in what we see or saw.'[70]

At the twenty-fourth minute mark of *Kontakte*, a layer of sound is revealed behind another layer of sound, creating what listeners believe to be an illusion of distance.[71] Even though the listeners have heard a physical change in the sound layer's spatial position, they choose to believe that this is an illusion, because they do not *see* a change in their spatial surroundings. After all, 'seeing is believing'.[72] Stockhausen has argued that in this instance, our choice to believe vision over audition is the real illusion. Belief is an integral component required for the creation of illusion that is, to my knowledge, not commonly engaged with by composers. Belief's role in the psychological effect of illusion will be further discussed in subsection 2.5.

The Doppler effect, which is 'the apparent change in the frequency of emitted waves relative to an observer', is an example of a well-known meta-illusion.[73] As an ambulance approaches, the pedestrian experiences the pitch of the siren getting higher, and the alternation of its tones faster. Then, as the ambulance drives away, the pedestrian hears the siren's pitch get lower and the alternation of tones faster. To the ambulance driver, however, the siren's pitch remains consistent and the alternation of tones steady. This is because the ambulance's siren produces sound waves which lose energy with distance, and so the sound waves literally have a lower frequency by the time they reach the pedestrian's ear. Still, even with a scientific understanding of the phenomenon, that two people perceive the same sound differently seems implausible. John Chowning used quadrophonic speakers and spatial panning to simulate the Doppler effect in *Turenas* (1972).[74]

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[70] (Stockhausen, 1989) p. 108
[71] (Stockhausen, 1993)
[72] (Simpson & Speake, 2008)
[73] (Birmingham & Micchelli, 2014)
[74] (Chowning, 2011) pp. 3 - 4

2.2.5 VENTRILOQUISM

Just as in Stockhausen's *Kontakte,* ventriloquism illusions are caused by the perceptual dominance of sight over sound. Ventriloquists make audiences believe that speech is coming from a dummy's mouth by masking their own facial movements and moving the dummy's mouth. As such, audience members correlate the speech sounds made by the ventriloquist and the facial movements of the dummy, and the dummy is determined as the sound source.[75] Illusion can therefore result from the miscorrelation between sight and sound. I use the term ventriloquism to describe illusions that result from this miscorrelation. A similar illusion includes the McGurk effect. In an experiment, recorded audio of the speech syllable [ba] is dubbed onto lip movements making the syllable [ga]. Subjects reported hearing the syllable [da].[76] The visual stimulus – the filmed lip movement – changed their perceptions of the aural stimulus.

Literal ventriloquism illusions are found in Kate Soper's *Only the Words Themselves Mean What They Say* (2011). In the first movement, the soprano is instructed to hum a B in the back of her throat, but at the same time mouth, "what the words say". As she mouths these words, the flautist whispers the same phrase into the bass flute. As a result, listeners believe the words to be whispered by the soprano and the sustained B to be played in the flute, when in fact the opposite is true. Illusions caused by the false connection between visual stimuli and sound sources are also found in Tom Johnson's *Scene for Tape and Piano* (1969), which is a comic, semi-theatrical conversation between a loudspeaker and pianist. At points, the pianist mimes playing the piano when instead piano sounds are coming from the loudspeaker.[77] In both examples, visual actions are falsely perceived as producing aural stimuli.

2.2.6 HALLUCINATIONS

Hallucinations are created by the mind's perception. A hallucination is 'the apparent perception of an external object when no such object is present'.[78] Deutsch showed that hallucination-like illusions can be created by phase-shifting speech in her phantom words illusion, which was made as an experimental test stimulus.[79] In this illusion two copies of a speech sequence, each of which comprises two syllables, are repeated *ad infinitum*. They are panned stereo left and right and overlaid in such a way that when the first syllable is played in one channel, the second syllable is played at the same time in the other (figure 10). Study participants initially reported hearing a meaningless jumble of syllables, but over time they began to recognise words and phrases

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[75] (Bregman, 1990) p. 183
[76] (McGurk & MacDonald, 1976) p. 746
[77] (T. Johnson, 1969)
[78] ('Illusion, n.', 1989)
[79] Phase-shifting is a compositional technique invented by the early minimalists.

which seemed to morph and mutate into others. This results from the spatial distribution of the two speech sequences which mix in the air before they reach the ear.[80] Such Phantom words are also found in Steve Reich's *It's Gonna Rain* (1965). The phrase "it's gonna rain" is panned stereo left and right, as the two samples are gradually shifted out of phase. At first, when the time-interval between the two samples is small, the 'illusion of an acoustic echo is created'.[81] As the time interval between the two samples widens, phantom words emerge amongst 'psychoacoustic fragments that your brain organises in different ways'.[82]

Fig. 10 A transcription of the phantom words illusion.[83]

Similar illusions are created through phase-shifting in Reich's *Drumming* (1971). They are referred to by Reich as 'resulting patterns' and 'can be understood as the psychoacoustic by-products of repetition and phasing'.[84] Reich explains how this manifests in *Drumming*:

'The women's voices sing patterns resulting from the combination of two or more marimbas playing the identical repeating pattern one or more quarter-notes out of phase with each other. By exactly imitating the sound of the instruments, and by gradually fading the patterns in and out, the singers cause them to slowly rise to the surface of the music and then to fade back into it allowing the listener to hear these patterns, along with many others, actually sounding in the instruments.'[85]

Resulting patterns exploit auditory stream segregation processes to create hallucinatory illusions. In *Drumming*, timbre is used to highlight proximate pitches within phase-shifted repeating patterns and make listeners aware of these internal pitch patterns. As a result, when the highlighting timbres fade away, listeners continue hearing these hallucinatory melodies.[86]

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[80] (Deutsch, 2003) Tracks 1 - 8
[81] (Reich, 2002) p. 5
[82] (Reich, 2002) p. 21
[83] Ibid. Made with reference to track 1
[84] (Reich, 2002) p. 26
[85] Ibid. p. 63
[86] This begins to occur essentially from the introduction of the women's voices until the end of the score. When Reich introduces glockenspiels the singers are asked to whistle. At times resultant patterns are brought to the surface by piccolos (Reich, 1971) pp. 19 – 79.

Drumming raises the question: if sounds which are claimed to be hallucinations are actually present, in this case as resulting patterns sung by voices, how can they be hallucinations? This shows that my idea of hallucination is a flexible interpretation of the definition found above and in the opening chapter of this dissertation;[87] the qualitative experience of an illusion is considered in addition to the exact psychoacoustic phenomenon.[88] In *Drumming*, though the highlighting voices are present, their fading in and out of the texture plays with the liminality of audition: at what point can one say the sung patterns are definitely present? Furthermore, after they have been faded out, the resulting patterns continue to be heard: a hallucination. Arguably the sounds are still present in the instruments playing the composite pattern, but one could make a similar case for Deutsch and Reich's phantom words. In these instances the mind is joining together phonetic stimuli that are physically present. The only difference is Deutsch and Reich's materials allow for more subjective interpretations of materials due to the more ambiguous nature of language. *Drumming* shows that the way in which an illusion is communicated or presented shapes its effect.[89]

Reich is an important forebear to this research project. As is shown by *It's Gonna Rain* and *Drumming*, works in his early oeuvre imaginatively adapt psychoacoustic illusions – which are clearly perceived – into a sophisticated musical language.[90] The processes, which *are* the pieces, make the resulting psychoacoustic illusions the central purpose of each piece. Reich's work had a particular impact on Ligeti's compositional output.[91] The work of the early minimalists, which Ligeti first encountered in 1972, matched his own interest in pattern-making, which was at the time being nourished by a preoccupation with Escher's optical illusions.[92] These interests culminated in *Three Pieces for two pianos,* or *Monument-Selbstportrait-Bewegung* (1976). *Monument* combines Reich-ian phase-shifting with a Webern-ian gradual introduction of chromatic pitches to create many resulting patterns borne of polyrhythm.[93] In *Selbstportrait* or 'Self-portrait with Reich and Riley (and Chopin in the background), Ligeti combines mobile key blocking[94] with phase-shifting a la *Piano Phase* (1967)

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[87] See 1.1.
[88] See 3.4 for discussion on how an illusion's effect might change according to how it is experienced.
[89] See 2.3 for an expansion on how integral the communication and presentation of an illusion is to the experience of an illusion.
[90] Reich views phase-shifting as an extension of canonic technique (Reich, 2002) p. 5. The manipulation of canonic technique to create illusion links Reich with Nørgård's infinity series, which is explained in subsection 2.3. This preoccupation with canon was also shared by Ligeti. The link between Nørgård, Reich and Ligeti is made in (Anderson, 1996) p. 162.
[91] Ligeti first heard *It's Gonna Rain* in 1972 alongside Reich's *Violin Phase* (1967) and Terry Riley's *In C* (1964) (Duchesneau & Marx, 2011) pp. 131 – 132.
[92] Ligeti was particularly struck by Escher's *Métamorphoses nocturnes* (1939 – 1968), which became the title of his first string quartet (Steinitz, 2003) p. 206.
[93] Ligeti describes the resulting patterns as '"second-order" illusory effects produced by the interaction of divergent patterns' (Steinitz, 2003) p. 210.
[94] Mobile key blocking is where Ligeti asks the pianists to use their 'left hand to depress and hold silent clusters. Meanwhile, the right hand plays fast continuous quavers criss-crossing the depressed keys. Since keys depressed do not resound, the flow of performed quavers emerges as a pattern of sounding and silent notes'. (Steinitz, 2003) p. 209

and Riley/Escher-esque pattern transformation.[95] Even before 1972, Ligeti was using micropolyphony to create illusory gestalts in *Apparitions* (1959) and *Atmosphères* (1961). In these pieces micropolyphony creates 'new timbres, new colours, which are not due to the colour of the instruments, but which are a result of a transformation of a rhythm in timbre, because there are some successions of 15 – 20 attacks per second'.[96] In these pieces, Ligeti certainly displayed a will to hallucinatorily 'deceive the ears of the listener' over the course of his output.[97]

Another hallucinatory phenomenon that musicians have been aware of for centuries is the combination tone, which is a 'faint tone produced in the inner ear by two simultaneously sounded musical tones. Because such tones are caused by the ear rather than by the external source of the sound, they are sometimes called subjective, or resultant, tones. There are two varieties: difference tones (D) and summation tones (S), generated respectively by the frequency differential of the two pitches or the sum of their frequencies.'[98] Combination tones were thought to be discovered independently by three figures: the German organist Georg Andreas Sorge in 1745, the Italian violinist Tartini in 1754 and the French scientist Jean-Baptiste Romieu in 1752.[99] There are two ways that combination tones are produced and Hermann L. F. Helmholtz, the physician, distinguishes between the types.[100] What he describes as 'subjective combination tones' are created by an 'auditory non-linear' response 'located in the amplification mechanism in the cochlea' – they are triggered in the ear.[101] The second type, described as 'objective combination tones', are generated by the musical instrument itself and 'mechanically coupled'.[102] Again, one might ask, if combination tones are physically present, then how can they be described as hallucinations? An answer to such a hypothetical could be that combination tones are still *experienced* as illusions, whether or not they are produced by the instrument itself or triggered in the ear. To hear tones which are not seeming to be physically played is to witness a phenomenon which should be impossible.[103]

Maryanne Amacher is one composer who made extensive uses of combination tones in her work. She often refers to them as 'Otoacoustic Emissions', 'additional tones' and 'ear tones', as she found that contemporary research by William E. Brownell increasingly showed that combinations

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[95] Ibid. p. 209
[96] (Sabbe, 1979) p. 34
[97] Ibid. p. 22
[98] (Hosch, 2013)
[99] (A. T. Jones, 2005)
[100] (Helmholtz, 2009) p. 411 – 413
[101] (Caselli et al., 2020) p. 1
[102] Ibid. In the above article, Caselli et al replicated an experiment of Tartini's. A dyad is played as a double stop on a single violin and recorded. The same dyad is split among two violins and recorded again. A Fourier transform (spectral analysis) of the single double stop reveals that the combination tones are physically present in the recorded sound, as the combination tones are 'mechanically coupled' (the dyad is played by the instrument and therefore the resonance between tones produces additional combination tones *in* the instrument). On the other hand, the combination tones are not physically present (again, measured with spectral analysis) when the dyad is split among violins. This confirms Tartini and Helmholtz's research.
[103] These loops of logic are curiously reminiscent of the preceding Meta-illusions in 2.2.4.

tones are emitted from within the ear.[104] Her album, *Sound Characters – Making the Third Ear* (1999), is a virtuosic musicalisation of combination tones. Kirk notes:

> '*Chorale 1* presents an arpeggiated and microtonal F triad (seemingly major) through the creation of QDTs [Quadratic Difference Tones]. The piece opens with two simultaneous sinusoidal chords resulting in QDTs of an alternating fifth in the left channel and an alternating third in the right channel (left channel: $f2 = 3026$ Hz and $f1 = 2762$ Hz yielding fDT of 264 Hz and $f2 = 2016$ Hz and $f1 = 1841$ Hz yielding fDT of 175 Hz; right channel $f2 = 2234$ Hz and $f1 = 2144$ Hz yielding fDT of 90 Hz and $f2 = 2680$ Hz and $f1 = 2572$ Hz yielding fDT of 108 Hz). As the piece progresses, Amacher maintains the low F 'tonality,' but tunes the right channel frequencies much closer so that the audible beating slows thus creating a rougher texture. While the CDTs [Cubic Difference Tones] are significantly masked at the beginning, they become more prevalent as the piece progresses, adding to its sonic complexity and leading to a more interesting interplay within the ear.'[105]

Furthermore, at 43:30 of the album, during *Muse Orchestra 1*, Amacher remarkably manages also to make combination tones rise and fall in scales.[106] The album truly embodies her will to make combination tones '*perceptually* more than an accident of acoustics in a room [and instead] attain *conscious interplay* with them.'[107] This goal aligns my own general approach to illusions, as is evidenced by my research questions.[108]

The 'picket fence effect' is a hallucination illusion less well known to musicians. When one sees an image obscured by a picket fence, one can still discern the image. In the same way, when one hears a highly predictable pitch pattern obscured by periodic bursts of noise, one can still recognise the pattern. In 1976, Dannenbring tested the picket-fence effect on a tone gliding between two fixed frequency points. He tested two stimuli: in the first, midpoints of the pitch glide were deleted, and in the second, the peaks and troughs were deleted. Test subjects heard restorations of the deleted sections when they were replaced with bursts of noise in both experiments.[109] The restorations were heard because the auditory system believes that there is information being obscured by the noise-bursts. As

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[104] (Amacher, 2008) pp. 10 – 11. In fact, combination tones are described by clinicians as otoacoustic emissions and are used to test hearing (Lonsbury et al., 1991).

[105] Quadratic and Cubic Difference Tones are distinguished by methods of calculation. The calculation for QDTs is fQDT $= f2 - f1$, where $f2 > f1$ and for CDTs the calculation is fCDT $= 2f1 - f2$ (Kirk, 2010) pp. 316 – 317. *Chorale 1* can be found at 51:19 of Amacher's album (Amacher, 1999).

[106] (Amacher, 1999)

[107] (Amacher, 2008)

[108] See 1.2 for my research questions.

[109] (Dannenbring, 1976) p. 99

such, it estimates what this aural information is, and then uses these estimations to fill the gaps in the pitch pattern.[110] To my knowledge, the picket-fence effect has not yet been compositionally employed.

2.2.7 APPEARANCE AND VANISH ILLUSIONS

In hallucination illusions, aural stimuli appear to be present when instead they are created in the mind. By contrast, appearance effects require a real physical object to appear. The harmonic series can be used to create appearance and vanish effects. This is because partials of the harmonic series, when tuned correctly, tonally fuse.[111] Bregman demonstrates how tonal fusion (or a lack thereof) can be used to make a tone appear and disappear in an experiment called 'Isolation of a frequency component based on mistuning.'[112] Bregman begins with the first 8 partials of a harmonic spectrum. These 8 partials fuse together completely and are perceived as a single tone. Bregman then detunes the frequency of every partial except the third. As this occurs, the third partial separates and seems to appear out of nowhere. Bregman creates a vanish illusion by reversing the process and retuning the detuned partials to their original frequency position. As a result, the third partial re-fuses with the rest of the tones and seems to vanish. Tonal fusion as such provides a concealed sonic sleeve in which a pitch can be hidden. To my knowledge, no composers so far have used detuning spectra to create appearance or vanish illusions. This is in part because the illusion is impossible to achieve in purely acoustic music: the fusion of partials into a single sound requires a level of accuracy in terms of balance and intonation that cannot be achieved with only acoustic instruments.

2.2.8 IN SUMMARY

During this research project, I planned to incorporate the picket fence effect, McGurk effect and appearance and vanish illusions into original compositions since they display unrealised potential for musical adaptation. However, it emerged that other illusions, which had been previously composed with, were more compatible with my compositional aesthetic. Still, perhaps this compiled compendium of psychoacoustic illusions will be of use to composers who in the future will compose with the above identified unused illusions. While discussing hallucinations, Reich's early works are identified as positive compositional adaptations of illusions, as the psychoacoustic illusions which are shaped by processes are the *raison d'être* of the pieces themselves.[113] In the following subsection I

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[110] George Miller and Joseph Licklider, researchers in the field of psychoacoustics, created similar illusions with speech in 1950. (G. A. Miller & Licklider, 1950) p. 167

[111] (Dewitt & Crowder, 1987) p. 73 Tonal fusion is the 'tendency for some concurrent sounds to cohere into a single sound image.' (Huron, 2001) p. 18

[112] (Bregman & Ahad, 1996) Demonstration 18 a variant on the test stimulus for experiments by Moore, Glasberg and Peters (Moore et al., 1986).

[113] See 2.2.6

will continue to evaluate existing applications of illusion to music and identify how they could be optimised.

2.3 EXISTING APPLICATIONS OF PSYCHOACOUSTIC ILLUSIONS IN MUSIC

Compositions which employ illusions in the above-described ways demonstrate that a careful balance needs to be struck between creativity, comprehensibility and accuracy. If the illusion is adapted too liberally, the illusion is lost. If the listener does not notice any illusions occurring, then the illusions are redundant. If the psychoacoustic illusions are not musically developed or varied, then the composition becomes aesthetically uninteresting. The above problems stem from a lack of integration of the aural illusions into a compositional syntax and form which allows for both clarity and imaginative development.

In his *Double Concerto for Harpsichord and Piano with two Chamber Orchestras* (1961), Elliott Carter created many temporal illusions. Speed illusions are at the core of the piece's concept; the speeds of the harpsichord, paired with one chamber orchestra, and the speeds of the piano, paired with the other, are often at odds with each other. For sections of the *Adagio*, Carter successfully creates the illusion of simultaneous acceleration and deceleration.[114] In bars 2 – 4 (figure 11), however, instrumental misbalancing and an excess of event density contradicts the intended illusion of simultaneous acceleration and deceleration. In bars 2 – 4, the third percussionist, who is playing the tenor military drum, accelerates. At the same time, the second percussionist, who is playing the temple blocks, snare drum, cymbal and tambourine, decelerates. Listeners focus their attention on the tenor military drum because it is so much louder than any of the instruments in the second percussion part. As a result, no simultaneous acceleration and deceleration is heard; listeners only perceive an acceleration. Furthermore, other rhythmic activity – the cymbals in the first and fourth percussion parts – adds detail which distracts the listener from the potentially resulting illusion in the second and third percussion parts.[115]

A relevant concept from performance magic comes to mind: misdirection. Misdirection is 'that which directs the audience towards the effect [of the illusion] and away from the method [of producing the illusion].'[116] The opening of Carter's *Double Concerto* is an example of misdirection gone wrong: misbalancing and textural congestion direct auditory attention away from the illusion altogether. The loudness of the tenor military drum draws aural attention exclusively to the acceleration, and away from the deceleration. The polyrhythmic cymbals add a further layer of distraction. Magicians are warned that too much misdirection is unfavourable: 'if the spectator is

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[114] (Carter, 1961) p. 108 - 112 bars 453 - 465
[115] Whether Carter intended to compose an illusion in this passage is besides the point I am trying to make. What matters is that there are hidden illusory potentials in this passage that have been obscured by Carter.
[116] (Lamont & Wiseman, 1999) p. 31

diverted too much, the effect is less convincing.'[117] This is certainly the case with respect to the first four bars of the Carter. The listener's attention becomes saturated with the aural stimuli and no illusion is perceived.

Fig. 11 Bars 2 – 6 of Carter's *Double Concerto*.[118]

Unlike the speed illusions in the first four bars of Carter's *Double Concerto,* the scale illusion in the finale of Tchaikovsky's *Symphony no. 6* is more faithfully rendered. The first and second violin parts constantly cross, and so do the viola and violoncello parts (figure 12a).[119] However, the passage is heard as four conjunct polyphonic lines that do not cross each other (figure 12b), because, as mentioned in subsection 2.2.1, proximate pitches are grouped into the same auditory stream, and the pitch material is spatially reconfigured in accordance with the perceived streams. Still, the scale illusion is not noticed. The illusion is technically functional, but the listeners remain unaware that they have experienced an illusion.

This example shows the importance of communication: in an effective magic trick, audience members are always made aware that they have experienced an illusion. *Torn and restored coin*, for

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[117] (Lamont & Wiseman, 1999) p. 43
[118] (Carter, 1961) pp. 1 - 2
[119] (Tchaikovsky, 1893) p. 186 bars 1 - 4

instance, is a magic trick created by Paul Harris, the magician. Three separate pieces of a broken coin are transformed into a whole, unbroken coin.[120] If a magician were to merely hand the spectator an unbroken coin, no illusion would be experienced. The initial presentation of broken coin pieces to the audience member is integral to the magic trick: in order for the audience member to experience an illusion, they must witness broken coin pieces being transformed into an unblemished coin. The spectator must be shown the "before" and "after". In the above-mentioned passage, if Tchaikovsky were to show listeners the individual polyphonic lines before combining all four parts, the listener would realise that the total texture heard is an illusion, and a transformation illusion would be experienced.[121] Magic tricks illustrate effective ways of presenting illusions to audience members, and therefore provide models for the musical contextualisation of psychoacoustic illusions.

Fig. 12a Tchaikovsky *Symphony N.o 6*
Finale, bars 1 – 4 as written.[122]

Fig. 12b Tchaikovsky *Symphony N.o 6*
Finale, bars 1 – 4 as aurally perceived.[123]

An example of an undeveloped psychoacoustic illusion used in a musical composition is Tenney's *For Ann (rising)* (1969).[124] This tape piece consists of several Shepard-Risset glissandi overlaid in various pitch intervals. The scales at first enter one at a time and rise consistently for circa 12 minutes. Then, each scale disappears one by one, and a final scale trails off into the high register.[125] Rather than trying to manipulate the material, Tenney reproduces the psychoacoustic illusion quite literally.

To generalise, this literalness is aesthetically typical of American experimentalism and is at odds with the aesthetic standpoint of post-war European avant-garde figures.[126] Horatiu Radulescu,

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[120] (Harris, 1996) p. 145
[121] Admittedly, it is unlikely that Tchaikovsky would want listeners to hear what each individual part sounds like.
[122] (Tchaikovsky, 1893) p. 186
[123] After (Deutsch, 1999) p. 325 – the lower two parts are not from Deutsch and are of my own devising.
[124] Here the discussion of Tenney and *For Ann (rising)* becomes regrettably disparaging. However, it has been left as is to show some of the aesthetic prejudices which I held at the beginning of this research enquiry. In chapter 4 I confront these prejudices.
[125] (Tenney, 2003) Track 8
[126] Tenney himself makes this aesthetic distinction clear in an interview discussing the work of the Spectralists in relation to his own: 'I heard a couple of pieces and they seemed very… European to me… Like, all the

Tenney's contemporary and colleague, expressed reservations about this aspect of Tenney's work: 'with James Tenney I find his music is sometimes too theoretical, it's like a theorem, like a demonstration of a theorem in mathematics. It's not totally music, you understand?'[127] This resonates with a sentiment of Stockhausen's; that the difference between a composer and physics professor is that the former is more musically imaginative than the other.[128] Whilst Tenney's aesthetic position is valid, I feel that my own is more akin with Radulescu's and Stockhausen's. [129] Furthermore, had I adopted Tenney's stance then there would have been very little to add from a research perspective: if I were to compose a Shepard tone scale piece in such a literal manner, then the resulting outcome would be unlikely to differ from *For Ann (rising)* in any significant way. Therefore, in my own work, I decided to treat psychoacoustic illusions as musical materials which can be developed instead of reproduced.

More expressionist uses of the Shepard tone scale can be found in the fourth region of Stockhausen's *Hymnen* (1966 – 1967), the second movement from Risset's *Computer Suite from Little Boy* (1968), Ligeti's *L'escalier du diable* (1993) and Haas's *In Vain* (2000). In these pieces, the Shepard illusions are illustrative: they convey emotionally demanding situations. The Shepard-Risset glissando used in the fourth region of *Hymnen* sears noisily downwards amidst numerous sound samples which includes the Swiss, British and Indian national anthem,[130] breathing, rumbling, vibrations, soft sine tones, girls' laughter and five shouted names. At the climax of the Shepard-Risset glissandi a casino croupier announces, "Messieurs et 'dames, rien ne va plus" (no more bets) and later, "Faites votres jeu, Messieurs et 'dames, s'il vous plait" (place your bets).[131] With *Hymnen*, Stockhausen intended to 'produce models that herald the stage after destruction [and] go beyond collage, heterogeneity and pluralism to find unity… that is going to be badly needed during the time of… the fantastic catastrophe that will come… killing hundreds of millions of the human race'.[132] The combination of the above samples with the noisy rendition of the Shepard-Risset glissando produces a

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assumptions about how the form of the piece needs to be full of surprising, unexpected changes, keep you on the edge of your seat and stuff like that. And I'm not interested in that.' (Dennehy, 2008) pp. 82 - 83

[127] (Gilmore, 2003) p. 106. Tenney's response to this was, 'that's perfect, that's fine for me. *[Laughs]* The way mathematicians use the term 'elegant', that's an elegance that I strive for. (Dennehy, 2008) p. 83

[128] (Stockhausen, 1989) p. 96

[129] Tenney was a vital precursor to my current research. Not only did he hold influence in Reich's early minimalist circle as a composer, performer and ensemble member, but he also was involved in computer music research at Bell laboratories alongside Risset, Shepard, Pierce and Max Matthews. A testament to his impact is shown by and described in a long list of tributes, to which both Reich and Risset contributed (Reich, 1987) & (J.-C. Risset, 1987). In his contribution, Reich cites Tenney as a performer, confidant and psychoacoustics teacher, whereas Risset describes Tenney's advances in sound synthesis, and details how Tenney influenced Risset compositionally.

[130] *Hymnen* quotes the national anthems of France (both Internationale and 'Marseilles), Federal Republic of Germany, Austria, Russia, America, Spain and Switzerland. Switzerland notably remained neutral throughout both World Wars.

[131] (Harvey, 1975) pp. 107 - 108

[132] Ibid, p. 108

deeply disturbing depiction of desolation in the face of what Stockhausen makes clear in no uncertain terms to be the threat of nuclear war.

The theme of *Hymnen* is similar to that of *Computer Suite for Little Boy*, which was composed for Pierre Halet's play entitled *Little Boy*; Little Boy was the codename for the Hiroshima atomic bomb. It is in the second movement, entitled *Fall*, that the Shepard illusions are used to portray the mental collapse of a reconnaissance pilot who is reliving the Hiroshima raid in a psychiatric hospital.[133] Furthermore, the Shepard tone scales are mixed with Shepard-Risset glissandi (both made of sine-tones and white-noise) and the scales are redistributed in space; the psychoacoustic illusion is developed and varied.[134] The Shepard tone scales of Ligeti and Haas are used for similarly distressing reasons. *L'escalier du diable* was composed after an El Niño weather system hit the coast of Santa Monica, amidst which Ligeti remembers struggling up the stairs to his apartment. He used the Shepard tone scale to depict this 'endless climbing, a wild apocalyptic vortex, a staircase [that] was almost impossible to ascend'.[135] Haas's *In Vain* protests the rise of the far-right Freedom party in the 1999 Austrian elections, the Shepard tone scales and Risset rhythms being used as metaphors for the apparent political progress or lack thereof since the third Reich.[136] The above four pieces make use of the Shepard tone scale's natural expressive character to portray endless distress, hopelessness and despair. This is not to say that programmatic uses of illusions are more favourable. In *In Vain*, it could be argued that Haas does not always succeed in convincingly integrating his illusions with the rest of his musical material, not least since the other materials in the work are so musically unlike the Shepard-style illusions. By contrast, the Shepard tone scale in *L'escalier du diable* are a constant feature of the étude. Strictly considered as illusions, Ligeti's Shepard tones are less convincing than Risset's, Stockhausen's and Tenney's, [137] as they are 'tempered by Ligeti's instinctive sense of development'.[138] Still, in the above pieces, illusions are used to imbue the music with an expressive intensity that would not otherwise be present.

Alternative methods for the imaginative incorporation of illusion into music can again be found in performance magic. Magic tricks can be interpreted as temporal structures through which a single or limited number of illusions are developed and varied to create an overarching narrative. The trick entitled *Coins and Fish*, performed by Raymond Teller of Penn and Teller, is an example of such a structure. The magic trick is as follows:

1. An audience member is selected and given a clear fishbowl.

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[133] (J.-C. Risset, 1996) p. 35
[134] (J.-C. Risset, 1988) Track 5
[135] (Steinitz, 2003) p. 308
[136] (*London Sinfonietta*, 2016)
[137] Although, this is in part the case because Ligeti must submit to the playing limits of a single pianist whereas Stockhausen and Risset had computers available to them
[138] (Steinitz, 2003) p. 309

2. Teller, in short sleeves, makes a coin appear from a clear water tank and places the coin in the bowl.

3. Teller plucks a number of coins from the empty water tank and places them in the bowl.

4. Teller plucks a coin from thin air and places it in the bowl.

5. Teller empties a coin from his tie into the bowl.

6. Teller makes a number of coins appear from the audience member's clothing and glasses.

7. Having amassed a number of coins, Teller throws them into the empty water tank. Nothing happens.

8. Teller makes still more coins appear from the empty fish bowl. Teller again throws the coins into the empty water tank. This time the coins are transformed into fish.

9. Finally, as the audience member is about to leave, Teller takes some fish to put in the bowl, and transforms them back into coins.[139]

The first illusion is the appearance of a coin. This illusion is developed by varied repetition: multiple coins are made to appear at once, coins are plucked from thin air and from the audience member's person. Furthermore, these appearance illusions have a purpose, which is the amassment of coins. These coins are used to create a transformation illusion: the coins are transformed into live fish. Some of these fish are then transformed back into coins. In this way, a number of illusions, which create contrast and interest, are imaginatively woven together to create a narrative thread that subverts expectation. Tenney's *For Ann (rising)* is a single, repeated, unvaried illusion. If *Coins and Fish* were to be structured in a similar manner, the performance would consist of making a coin from the clear water tank appear repeatedly and in the same manner. It seems that magical illusions typically have more in common with European aesthetics than American experimentalism.

The above musical examples show that clarity of aural information and its presentation is vital to the success of aural illusions. The opening of Carter's *Double Concerto* shows that in order to successfully fool the listener, one must not distract the audience's attention from the illusion itself. The example from Tchaikovsky demonstrates that the communication and presentation of an illusion has a direct impact on whether an illusion's effect is experienced. Tenney's *For Ann (rising)* is exemplary of a psychoacoustic illusion in need of compositional development. Stockhausen's *Hymnen,* Risset's *Computer Suite from Little Boy,* Ligeti's *Automne à Varsovie* and Haas's *In Vain,* show that psychoacoustic illusions have been adapted into more expressive contexts but, in some cases, there are still problems with the manner of adaptation. Composition with illusions requires a delicate balance to be struck between creative adaptation, and accurate rendition.

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[139] (*Penn & Teller Fool Us - Coins & Fish Trick*, 2015)

Magic tricks can serve as analogies and partial models for this manner of balanced adaptation. By referring to the broader, formative concepts in performance magic, psychoacoustic illusions can be adapted for composition in fresh and innovative ways. In the following subsection, I will explain how the impossible is made possible in performance magic, the psychological effect created by witnessing the impossible, and how knowledge of performance magic methods and concepts might be applied to the composition of impossible music.

2.4 – PERFORMANCE MAGIC AS A MODEL FOR FURTHER IMPROVEMENT

The temporal factor in performance magic is central to its usefulness as a possible model for incorporating psychoacoustic illusions in music. The performance magic concepts of belief, misdirection and suspicion are key tools for this process of cross-fertilisation. The cognitive effect that we have in response to perceiving an illusion is caused by a conflict of beliefs regarding what is and what is not physically possible. Similarly, the consideration of what we believe to be aurally true can inform how a psychoacoustic illusion is presented to the listener. Misdirection, as defined in 2.3, is proposed as a method of controlling aural attention in compositions to create fresh musical illusions. Equally, the neutralisation of an audience member's suspicion is a crucial component of an effective magic trick. The effect of an illusion is weakened if the audience member knows how the trick is done. Therefore, it is important to neutralise any suspicions that audience members might have regarding the method of creating the illusion. Furthermore, the neutralisation of suspicion provides a compelling structural narrative through which an illusion may be developed.

Illusion is created in performance magic when the audience witnesses something previously believed to be impossible. Subverting expectations of reality in such a way generates a cognitive dissonance in the mind of the audience member. Jason Leddington, a magician, describes this dissonance as a "belief-discordant alief."[140] He adapted the concept from an article by Tamar Szabó Gendler,[141] a professor of philosophy, psychology and cognitive science, to describe a psychological tension between belief and alief, where alief is 'a mental state with associatively linked content that is representational, affective and behavioural, and that is activated – consciously or unconsciously – by features of the subject's internal or ambient environment.'[142] The emotional, primal 'alief' is a counter to logical 'belief.' Belief-discordant alief describes being confronted with an "impossible" event, firmly believing that the event should not be happening, and yet undeniably witnessing the event and therefore alieving that it is happening. The resulting cognitive dissonance which is generated by this

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[140] (Leddington, 2016)
[141] (Gendler, 2008)
[142] Ibid. p. 642

conflict between belief and alief is unresolvable. This is the most essential component in the successful creation of a magical illusion. A similar cognitive dissonance is produced by paradoxes.[143]

Belief-discordant alief can be used to explain why the effects of some psychoacoustic illusions are more immediate than others. The effect of the Shepard tone scale, for instance, is much more immediate than the scale illusion. Through instinct and learned knowledge, we know that an eternally rising scale is impossible, because there are upper and lower limits to pitch. We firmly believe that it is impossible, and yet when we hear it, we alieve that a scale is eternally rising. When we hear the scale illusion as presented in the finale of Tchaikovsky's *Symphony No. 6,* however, no conflicting alief is created, because we have no reason to believe that the spatial distribution of pitch should be any different than how we perceive it.

In performance magic, the main technique used to create belief-discordant alief is misdirection. Aural misdirection is used to create false infinities. In the Shepard tone scale, dynamics direct aural attention away from partials which are fading out or fading in, and towards the partials in the middle frequency band which are still able to rise (or fall, depending on the direction of the scale). In the Risset rhythm, dynamics are used to direct aural attention away from rhythmic values which are fading out/fading in, and towards the rhythmic values that still have the capacity to continue accelerating/decelerating. These are examples of volume being used to direct aural attention away from the method of creating the illusion, and towards the effect of the illusion. Other than these examples, misdirection is largely unused in composition to create illusion. The lack of compositional engagement with misdirection is disconcerting, especially since there has been extensive research into how we attend to aural events.[144]

When attention is effectively misdirected, surprisingly large details are easily missed. This 'striking failure to see large changes that normally would have been noticed easily' is called change blindness.[145] One instance of change blindness was observed by the magician Richard Wiseman, and cleverly named "The Colour Changing Card Trick." Wiseman appears to perform a simple card trick with the help of an assistant, where the backs of a deck of cards are turned from blue to red. The card trick is a mere distraction from the true illusion. As the card trick takes place Wiseman and his assistant put on different coloured jumpers and change the cloths on the table and background. These changes are unnoticed because the viewer attends solely to the card trick.[146] The scale illusion from Tchaikovsky's *Symphony no. 6* is an example of aural change blindness. In this passage, our aural attention is drawn to the pitches moving in scalic motion and distracted from the spatial distribution of these pitches. This suggests that misdirection in one parameter of sound could induce aural change blindness in another.

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[143] See chapter 1, subsection 1.2
[144] (M. R. Jones & Yee, 1993)
[145] (Simons & Rensink, 2005) p. 16
[146] (Wiseman, 2012)

The next vital step in maximising the cognitive dissonance already created by the initial trick is the neutralisation of suspicion. An audience member's suspicion can be neutralised by the reproduction of the same illusion but with a variety of methods.[147] An analysis of the magician David Copperfield's flying illusion from the audience's perspective provides an example of this neutralisation:

> 'Stage I. Lying face up, Copperfield rises stiffly off the stage. A reasonably intelligent spectator thinks: "He must be lying on a board."
> Stage II. Twenty feet in the air, Copperfield rotates into a vertical position. The spectator thinks: "So, no board; but of course there are wires attached to his back."
> Stage III. Copperfield does a full somersault in midair. Spectator: "Ah, so the wires can't be attached to his back; still, there must be wires."
> Stage IV. Copperfield flies through a series of spinning metal hoops. "Huh? How can there be wires? Maybe they somehow rotate them to avoid the hoops?"
> Stage V. Copperfield flies into a glass box, is shut inside, flies around inside the box, and flies out when the cover is removed. "What the…? Clearly there can't be wires. What else? Magnets? A fan? No. None of that makes sense. I'm completely baffled. This seems altogether impossible. And yet, it's happening."'[148]

Copperfield uses mixed methods so that as soon as the audience member formulates a theory as to how the trick is done, the theory is neutralised. None of the above-mentioned musical compositions use mixed methods to create variations on the same illusion. It is possible that mixed methods creating the same illusion would allow a composer to similarly counter any theories that the listener may conceive regarding the illusion's mechanism and develop illusory material in a way that maximises the effect of the illusions created.

Research into the formative concepts of performance magic allowed me to identify the creation of belief-discordant alief in the minds of listeners as a compositional goal. This goal gave my illusions purpose. To my knowledge, this does not seem to be the goal of other composers who employ illusions. The neutralisation of suspicion is totally unconsidered in illusory composition. It is necessary for the maximisation of belief-discordant alief and provides a model for the structural development of an illusion.

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[147] Ibid. pp. 99 - 100
[148] (Leddington, 2016) pp. 258 - 259

2.5 CONCLUSION

In the process of surveying the relevant literature, numerous compositional aims crystallised. Ultimately, the aim to adapt previously unused illusions into compositions was not fulfilled but the goals of misdirecting aural attention, neutralising suspicion and inducing belief-discordant alief did influence the composition of the submitted portfolio, as the ensuing chapter will elucidate. Pre-used illusions were composed with, but the influence of performance magic literature inspired me to attempt fresh compositional adaptations of these pre-used illusions. At times, as will become evident, the research framework that emerged from this literature review proved restrictive. However, even these restrictions became useful in producing distinct illusory compositions. I attempted to ensure that the psychoacoustic illusions that I employed were unhindered, clear, well-communicated, developed, enhanced for maximum potency and central to the method of each composition. However, as will be explained in the following chapter, the resultant compositions created from my research have themselves exhibited variable rates of success in precisely these regards. I have faith that my research has the potential to form a basis for others to compose effectively with psychoacoustic illusion.

CHAPTER 3 – COMMENTARY

3.1 INTRODUCTION

The submitted compositions are discussed in the order that they were composed. In *Jīng*, transformations are attempted; in *After Images* speed illusions are worked with; in *Ghoulish Airs* the concepts of appearance and vanish are explored; in *Jab* the research framework is called into question and multiple illusions used; in *Georgimorphosis* transformations are approached from another angle; in *Witherbud* false infinities are returned to and mimetic illusions attempted; and in *An Interview with a "Puppet" and his "Maker"*, ventriloquisms are used with numerous illusions to create a theatrical piece. At times, the compositions fail to demonstrate or embody the ethos explained in the literature review. However, in striving for the goals outlined in the previous chapter, I have composed (mostly) illusory percepts which illustrate fresh perceptual and aesthetic insights into composing with illusion.

3.2 JĪNG (精)

In this short work for orchestra, I investigate auditory stream segregation.[149] I attempted to adapt streaming illusions caused by both the pitch proximity between crossing streams and the segregation of streams via timbral segregation. The piece's title comes from the last character in the Chinese phrase *Hú Lí Jīng* (狐狸精), which loosely translates to "fox spirit." The *Hú Lí Jīng* is a mischievous fox spirit capable of shapeshifting and with a proclivity for playing tricks on humans. It seemed a fitting symbol to convey the piece's illuding character. Furthermore, the fox spirit has nine tails and I felt the florid overlapping of these tails could serve as a metaphor for the entwinement of auditory streams.

3.2.1   FORM

The form of *Jīng* is as follows:

Section	Bars	Occurrences:	Attempted Illusions
Intro	1 – 16	Scalic descents, thick string chords, and descending string triplets	

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[149] See chapter 2, subsection 2.2.1 for a definition of this term

A	17 – 59	Emergence of the double clarinet melody	Streaming illusions in the E-flat clarinets
B	60 – 109	Introduction of false cuts	Continuing streaming illusions in clarinets, and false cuts
C	110 – 128	Respite from thick, bass heavy chords, introductions of swells in the bassoons	Continuing streaming illusions in clarinets. Attempted reveal that streams are illusory with timbral differentiation
D	129 – 160	Reintroduction of bass heavy, slow-moving chords	Reintroduction of false cuts, attempted timbral segregation of streams
Coda	161 – 171	Unison violin melody, with timbral doublings at various durational intervals	Wessel illusion
Codetta	172 – 176 (end)	Partial recapitulation of the opening material	Proto-Risset rhythm (constant deceleration illusion from bar 86 to the end of the work)

Fig. 13 Structure of *Jīng.*

3.2.2   ATTEMPTED ILLUSIONS

A large proportion of the piece is composed around a E-flat clarinet duet. The two parts constantly cross throughout most of the piece to create illusory streams (figure 14). The melody starts in bar 34 and ends in bar 135. My intention was to transform the audience's perception of the pitch material and reveal that the two clarinet lines were constantly crossing each other. In bars 65 – 162, string harmonics are used to double the first clarinet part at the octave and fifth, because these are the intervals which are most likely to sonically fuse.[150] My intention was to fuse the harmonics with the first clarinet sound, and transform the timbre of the first clarinet, thereby revealing that the listeners' perceptions of the double clarinet melody were illusory. However, in that passage, the harmonics do not balance against the textural density of other instruments playing in that section. Therefore, no timbral change is perceived in the material played in the first clarinet line. The streams do not

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[150] (Dewitt & Crowder, 1987) p. 73

segregate, the two clarinet lines are not revealed to be illusory, and no transformation illusion is perceived. Just as in the opening of the Carter *Double Concerto*, an excess of textural detail distracts the listener's aural attention from the intended illusion. The result is that the streaming illusions are not noticed, just as the scale illusion is not noticed in the finale of Tchaikovsky's *Symphony No. 6*.[151] Similarly, if I had shown the listener each individual clarinet part before combining them, my illusions might have been more readily perceived in the two clarinets.[152]

Fig. 14a Bars 39 – 42 of *Jīng* as written   **Fig. 14b** Bars 39 – 42 of *Jīng* as heard.
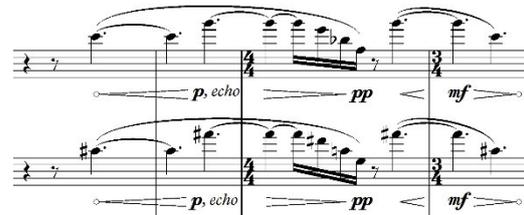
I attempted to create another transformation illusion within this piece, in which a static, repeated chord is perceived as transforming into two alternating chords. This idea was inspired by a passage of Sibelius's *Tapiola* (1926). In bars 106 - 129, violins reiterate dyads built of major seconds stacked in octaves. The first and second violin sections are both divided into four parts. The outside players of the first violins jump an octave down as the inside players jump an octave up, and the second violins do the same. The effect is a chord reiterated with a uniquely smooth legato articulation.

Fig. 15 Sibelius Tapiola, bars 106 – 115.[153]

I felt that I could use similar methods to create a transformation illusion in *Jīng* by dividing a chord amongst the string players so that each pair of strings is allotted two of the chord's pitches. Within each pair, one member changes from one of the two pitches to the other, at the opposite time as their partner. One member in each pair remains at a consistent dynamic, and the other member either fades in or out, thereby transforming a static repeating chord into two chords rocking back and forth from one to the other. I propose to call this transformation illusion a "false cut", because this method of separating a chord into two is similar to a technique of the same name used to apparently

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[151] See chapter 2, subsection 2.2
[152] Ibid.
[153] (Sibelius, 1926), p. 10, bars 106 - 115

cut a pack of playing cards without changing the order of the cards. The technique leads the audience to believe that the cards have been randomised when they have not.[154] Unfortunately, this illusion does not work in the submitted recording. In the allotted rehearsal period, there was no time to address the balancing of these chords because the piece is technically demanding. I believe that with more rehearsal time, these false cuts could be executed effectively.

In *Jīng*'s coda, I attempted to create a Wessel Illusion. I did so by composing a single melodic line and doubling it with different timbres at various durational intervals as follows. In bars 161 – 169 (figure 16), the violins share a unison melody which, at various intervals, is doubled by the flutes, oboes, clarinets, bassoons, trumpets, marimba, tubular bells and piano. The illusion is only fleeting, however, because it fails to follow two very important rules of the Wessel Illusion. Firstly, the timbral doublings do not occur at durationally regular intervals, whereas they do in the Wessel illusion.[155] The entry of timbres are intended to split the single stream played by the violins into many streams. However, the aperiodicity of entry weakens the sense of oneness between pitches horizontally grouped according to timbre. It is therefore harder for each stream to be perceived as distinct because the entry of contrasting doublings is not predictable enough. Secondly, the violin melody consists of a wide and various pitch class pool. The original Wessel illusion, by contrast, is an extremely limited pitch pattern – it consists of three tones each separated by the perfect fourths. The procedure is a tangible transmutation of a predictable pitch pattern into two repeating durationally augmented permutations of the same pattern in counterpoint. In this passage of *Jīng*, there is no pattern to transmute and there is no relation between violin melody and any would-be transmuted pattern. As a result of these two factors, the Wessel illusion is only unpredictably created in this passage.

Fig. 16 Bars 161 – 169 of *Jīng* (精)

3.2.3   CONCLUSIONS

Whilst I was aware of various precedents to this composition, I did not adequately assess their strengths and weaknesses. As a result, my intended streaming illusions were unsuccessful.

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[154] (Kawamoto, 1017)
[155] See chapter 2, subsection 2.2.1 for a more detailed explanation of the Wessel illusion

Nonetheless, I believe that with more rehearsal time, the false cuts have the potential to create some interesting transformation illusions. I also had not properly considered the properties of both the Wessel illusion and infinity series which made them successfully illusory.

At the time of composition, I had not compared the passage from the finale of Tchaikovsky's Symphony No. 6 with the magic trick *Torn and Restored Coin* and so did not realise that presenting pre-transformed material is just as important as showing transformed material when creating a transformation illusion.[156] I therefore learned through the composition of this piece that an essential challenge of composing with transformation illusions is the communication of their effects. In order for listeners to experience my intended illusions, they must be provided with all the necessary aural information, so that they comprehend that an illusion has just occurred. Through composing this piece, I learned the virtue of clarity when composing with illusion, and that an excess of textural detail distracts the listener's aural attention from some of the illusions that I have attempted to incorporate.

Since I failed to communicate any illusions to my listeners, I was unable to create any cognitive dissonance in the mind of the listener. The creation of belief-discordant alief was not achieved. However, I believe that this piece establishes unique sound-worlds which, I hope, have a conviction and thrust of their own. Even though my psychoacoustic illusions were not literally rendered, the piece does evoke the character of the *Hú Lí Jīng,* a creature of ebullience, exuberance and slyness. As such, it is rather fitting that the fox chewed the illusions beyond recognition. The composition of this piece was a vital learning curve, over which I was able to assess my creative priorities and reconsider my reasons for incorporating illusion into composition. My experiences of composing *Jīng*, certainly influenced how I approached composing *After Images*.

3.3   AFTER IMAGES

After Images (for 17 instruments)[157] explores different methods of creating illusions in musical speed. The piece has several precedents, all of which were useful compositional models in making decisions regarding technique and structure. This is the first piece in which concepts from performance magic influenced my compositional process in detail. I explored neutralising suspicion in the listeners' mind by using a variety of methods to create the illusion of infinite acceleration.[158] In doing so, I attempted to maximise the cognitive dissonance caused by my illusions. This goal determined my choice of musical materials, and the piece's structure. Since every element in the piece

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[156] See chapter 2, subsection 2.3
[157] Seventeen players is possibly the maximum sized ensemble that could play this piece; a full orchestra would not be able to reliably change tempo so often due to the number of musicians.
[158] See chapter 2, subsection 2.4 for an explanation of suspicion neutralisation.

focussed ruthlessly on creating illusions of speed, I believe that my illusions were presented with more clarity here than in *Jīng* and that they were correspondingly more comprehensible.[159]

3.3.1   EXTRA-MUSICAL STIMULI

When an object is moved at high speed its image distorts. Eadweard Muybridge developed the first moving image by exploiting this distortion in 1878. He created the illusion of movement by flipping through still images at high speeds.[160] The title *After Images* pays homage to Muybridge's invention. It puns on the fact that we are living in a post (*After*) still-photograph (*Images*) era.

After I began composing the piece, I discovered that an afterimage is an optical illusion in itself; it is 'a visual which stays present even after a stimulant [an image] ceases or is taken away'.[161] The closest aural parallel of the afterimage is the echo – which duly forms a part of the evolving structure in *After Images*.[162]

3.3.2   COMPOSITIONAL PRECEDENTS TO *AFTER IMAGES*

The pieces discussed in 2.2.3 were useful models and provided points of comparisons for *After Images*. An important precedent not discussed in chapter 2 is Andriessen's *De Snelheid* (1983). The piece is a long process of acceleration driven by a sequence of tempo modulations (figure 17) which are articulated by two percussionists playing woodblocks. At bar 1098, the percussionists reach a maximum playing speed that cannot be exceeded, they play a tremelo. At this point, the initial pulse (45 bpm) is articulated by the rest of the ensemble both rhythmically and harmonically.[163] Essentially, the piece accelerates until it reaches its starting tempo, which is impossible. Andriessen's method of creating this illusion is similar to that used in Beethoven's *Op. 111*.[164] I learned from these pieces that there are multiple ways in which speed can be articulated. Musical speed can be judged by the rate of sonic impulse, but at the same time our perception of it can be influenced by the rate of harmonic change.

I use this strategy on a much smaller scale in bars 197 to 206 of *After Images*, where the tubular bell triplets accelerate to the point of tremelo. As the rate of impulse increases, individual attacks become harder to perceive, and this is due to the tubular bell's slow decay. As such, at bar

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[159] Though other illusions feature in *After Images*, which include Wessel-inspired illusions at bar 280 and Shepard-tone descents in bars 312 – 332, illusions of speed are focussed on in this subchapter, as commentaries on other pieces better describe my attempts at Wessel illusions and Shepard tone scales.
[160] Ligeti was similarly inspired by this same concept when composing *Continuum* (Duchesneau & Marx, 2011) p. 91.
[161] (Nugent, 2018)
[162] See 3.3.5.1
[163] (Andriessen, 1984) p. 1090
[164] See 2.2.3

206, the tremelo F and A flat dyad is almost perceived as a sustained chord. At the same time, the harmonic rhythm – as articulated by the tubular bell's rate of pitch change and the surrounding ensemble – sustains the feeling of acceleration.

SYSTEM OF ACCELERATION

The acceleration

page	bar	beat	pulse	
1	5/16	= 45	= 225	
14	6/16	= 45	= 270	quicker pulse
20	5/16	= 54	= 270	shorter bar
26	6/16	= 67.5	= 405	quicker pulse, longer bar
41	5/16	= 81	= 405	shorter bar
54	2/4	= 135	= 540	quicker pulse, longer bar
63	3/8	= 90	= 540	shorter bar
87	2/4	= 90	= 270	quicker pulse, longer bar
95	3/8	= 120	= 720	shorter bar
109	3/8	= 90	(540)	pulse = tremelo, bar slows down
112	5/4	= 45	(900) =	= 225

The acceleration accelerates (10 bars on each page)

Fig. 17 Andriessen's tempo summary of *De Snelheid*. At first there are 5 impulses per beat at 45 bpm. At page 14, the number of impulses per beat is increased to 6 and the speed of impulse quickens. At page 20, 1 impulse is removed from the repeating cell and the total length of beat is shortened and is therefore perceived as quickening from 45 bpm to 54 bpm. This process of temporal redivision followed by truncation repeats across the piece until the maximum tremolo at page 109 is reached.[165]

Another model for *After Images* was Carter's *Variations for Orchestra* (1955) which also makes use of proto-Risset rhythms. In variation 6 (bars 289 - 360), Carter creates a recurring six-bar tempo loop: over six bars of 3/4 the tempo accelerates from crotchet = 80 to crotchet = 240. Then, via a tempo modulation, the crotchet becomes the new dotted minim, and the tempo is brought back to crotchet = 80. [166] Within this variation, Carter composes an atonal fugato with clear, recurring subjects and countersubjects. The subject consists of crotchets and lasts the length of the six-bar tempo loop.[167] At the end of the tempo loop, the subject becomes the countersubject. The crotchets carry on at the

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[165] (Andriessen, 2002) p. 183, see (Brendan Faegre, 2015) for a demonstration of Andriessen's acceleration process.
[166] (Carter, 1955) p. 71 bars 289 – 295.
[167] Ibid. bars 289 – 294, clarinet.

same speed but are notated as triplet quavers. At the same time, the answer enters, which accelerates according to the tempo loop.[168] This occurs every time there is an entry of the subject or answer.[169] An infinite acceleration is almost experienced, except there are no volume fades, which means that the Risset illusion is only partially experienced. Carter's example demonstrates the importance of volume in misdirecting aural attention.[170] However, Carter's illusions are made more immediately recognisable than the speed illusions of Andriessen or Beethoven as the tempo loops used are much shorter. As such there are more iterations of the loop which makes Carter's loops seem more infinite. The rate of acceleration is faster and so the listener expects the upper limit of speed to be reached sooner – yet this limit is never reached. In this way Carter's illusion seems more "impossible". Therefore, I used shorter tempo loops with faster rates of acceleration in *After Images*.

For the first 92 bars in *After Images*, a tempo modulation occurs after every bar. This is not the first piece within which constantly changing tempi are used. Birtwistle's *Silbury Air* (1977, revised 2003) and Stockhausen's *Inori* (1974) are in this way non-illusory precedents to *After Images*. In *Inori,* Stockhausen used his chromatic scale of tempi, a scale of tempi which corresponds to the frequency proportions of the chromatic scale.[171] Birtwistle, on the other hand, controlled his tempo modulations with his pulse labyrinth.[172] Both Stockhausen and Birtwistle's methods allowed them to shift rapidly between contrasting tempi. The key difference between *After Images* and these two precedents is that the tempo modulations in *After Images* are designed to facilitate the illusion of constant acceleration. As a result, my tempo modulations are mostly unidirectional. In order to compose *After Images* it was necessary to create a map of tempi similar to Birtwistle's pulse labyrinth – this tempo map, shown in appendix A.[173]

3.3.3 FORM AS DETERMINED BY A GERMINAL TEMPO STRUCTURE

Prompted by the second movement of Beethoven's *Op. 111*, I structured *After Images* as a set of variations. The chosen structure is a metaphor for an afterimage: each variation is an afterimage of the initial theme.[174] The following variations represent afterimages or echoes of the theme which

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[168] Ibid, bar 295 – 300, countersubject in the clarinet and answer in the cello.
[169] Ibid. pp. 71 – 77, bars 289, 295, 301, 307, 313, 319, 325, 331, 337, 343, 349 & 355
[170] See chapter 2, subsection 2.4
[171] (Stockhausen, 2014) pp 99 – 139 The scale of tempi was devised for use in *Gruppen* (1957) but the aperiodic rhythmic material destroys any sense of pulse, just as in earlier drafts of *After Images*. Stockhausen learned from *Gruppen* and, as a result, the pulse in *Inori* is articulated with a much greater degree of clarity. *After Images* could not have been composed without the aid of the Stockhausen metronome, an app which can be programmed to beat both changing tempi and Stockhausen's chromatic scale of tempi (Ihara, 2014).
[172] (Birtwistle, 1977) pp. iv
[173] See appendix A and 3.3.5.1
[174] The term theme is applied liberally. The section might be more aptly thought of as a collection of themes, or a section of music which a number of processes is enacted upon.

increasingly distort. I wanted each variation to feel comparatively faster than the last so that in sum, an acceleration would be felt across the entire piece.

Section	Bars:	Number of cycles of the tempo loop	Number of bars/beats in each tempo	Approximate duration
Introduction	1 – 10	2	1	0'20"
Theme	11 – 45	9	1	1'40"
Bridge 1	46 – 51			0'15"
Variation 1	52 – 86	7	1	1'30"
Bridge 2	87 – 103			0'35"
Variation 2	104 – 143	4	2	1'25"
Bridge 3	144 – 153			0'25"
Variation 3	154 – 186	3	3 bars become 1 bar of 3 beats	1'10"
Bridge 4	187 – 196			0'20"
Variation 4	197 – 218	2	4 bars become 1 bar of 4 beats	0'40"
Bridge 5	219 – 222			0'5"
Variation 5	223 – 244	$1\frac{4}{5}$	4 bars become 1 bar of 4 beats	0'30"
Bridge 6	245 – 248			0'5"
Variation 6	249 – 256	$1\frac{3}{5}$	1	0'20"
Bridge 7	257 – 265			0'15"
Variation 7	266 – 272	$0\frac{7}{10}$	1	0'15"
Variation 8	273 – 279	$0\frac{7}{10}$	2	0'10"

| Variation 9 | 280 – 285 | $1\frac{3}{5}$ | 2 | 0'5" |
| CODA | 286 – 338 (end) | | | 2'00" |

Fig. 18 Variation form used in *After Images*

In keeping with the model of Carter's *Variations*, I created a short tempo loop (figure 19).[175] This loop consists of five bars of five pulses. The acceleration through the loop is staggered with four tempo modulations and the fifth brings the tempo loop full circle.[176] As in Carter's *Variations*, the tempo loop is used to facilitate the Risset rhythm.[177]

Fig. 19 Recurring tempo loop as articulated in the second cycle by the temple blocks.

I treated the above five tempi as a germinal set of proportions (figure 20) and used them to generate a tempo map (appendix A).[178] I took these proportions and, on each variation, transposed them so that they began from the next tempo along in the initial loop to create new sets of tempi, as is demonstrated in appendix A. I assigned each newly generated tempo loop to the next variation so that each variation's starting tempo increases, meaning that there is an overall acceleration across the entire piece. These increases in tempo are facilitated by the bridge sections, which typically add an extra tempo modulation to the loop from the preceding variation.

Bars within loop	Tempo ratio
1 → 2	4:5
2 → 3	5:6

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[175] See 3.3.2

[176] Double bars were not used for tempo modulations such as semiquaver = semiquaver since these modulations ultimately amount to a change in metre.

[177] although as explained in 3.3.2, Carter's illusion is more of a proto-Risset rhythm

[178] As mentioned in 3.3.2, this tempo map was modelled on the pulse labyrinth used by Birtwistle in *Silbury Air*. (Birtwistle, 1977) p. iv

3 → 4	3:4
4 → 5	2:3
5 → 1	3:1

Fig. 20 Tempo proportions/ratios used to calculate subsequent tempo loops as depicted in the tempo map (appendix A).

At variation 4, the tempi become too fast for human players to accurately play at or modulate between. As a practical solution to this conundrum, my supervisor suggested multiplying the bars within each tempo from variation 2 – 4.[179] By variation 4, a bar was theoretically supposed to have sped up to the point that its duration could be conducted as a single beat: hence, in the tempo map at variation 4, each tempo is divided by 5.[180] This gradual multiplication of bars per tempi made the realisation of my tempo map possible: the conductor can beat a slower tempo and yet sustain a continuing acceleration. This increasing multiplication of bars per tempi allowed me to create a gradual, paradoxical acceleration from 72 bpm to 43 bpm.[181]

Across the piece, the standard pattern of tempo modulations is distorted, broken and reshaped. This mutation of the tempo pattern culminates in the CODA where the tempo pattern is distorted beyond recognition, disorients the listener, and ultimately creates the illusion of acceleration beyond the point of possibility. By building periodicity into my tempo loops, I was able to lull listeners into a false sense of security - the listener theorises that after a set number of bars, the tempo decreases and begins speeding up again. By gradually destroying that periodicity, I was able to neutralise this theory and shatter the listeners' sense of security in a way that maximally disorients them.

3.3.4 PITCH STRUCTURES

The structure of the piece is articulated by a contraction in pitch register (figure 21). The contracting pitches delimit the register within which each section must operate. The selected pitches are derived from a single falling motif found in bar 11. One may observe that the first five pitches in the upper stave of figure 21 are mostly the same as those in figure 22.[182] I took these first five pitches

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[179] See figure 18 for the exact number of bars per tempo in each variation.
[180] Four bars of 5/4 at crotchet = 216 can be rethought of as a single bar of 4/2 at minim = 43 – each crotchet becomes a quintuplet quaver. Each tempo is rounded to a whole number.
[181] If one refers to variation 4, however, one does not find a bar of 4/2 at minim = 43, but four bars of 3/4 at crotchet = 130. This re-notation was a pragmatic decision: it is easier for an ensemble to play together when the conductor is beating a moderately fast tempo instead of an extremely slow tempo. In order to make the score practical to perform, the tempo map was often rendered in alternative ways. It is for this reason that the tempi found in the map do not always correspond exactly to those found in the score.
[182] This was a "mistake", but one that I preferred to the "correct" version.

and reflected them across F sharp 4 to get the first five notes of the bottom stave. This determined the register limits for the theme section and variations 1 – 4. I then repeated these 5 dyads but reordered and compressed them in register; this gave me the register limits for variations 5 - 9. These contracting pitches create a pull towards the pitch axis around which they are symmetrically structured: F sharp 4. Thus, I set up a pitch goal to be fulfilled over the course of the piece. Furthermore, this compression of pitch register runs in parallel with the above-mentioned compression of sectional duration (figure 18). As a result, the length of time spent within each pitch limit steadily decreases.

This diminishing of duration enhances the feeling of large-scale acceleration across the piece. By the time variation 9 is reached, each pitch limit lasts roughly 5 seconds. At the Coda, I gradually re-expand the register according to the pitch funnel (bars 286 – 301), and then contract it again (bars 301 – 304), and then continue expanding and contracting the register at faster and faster rates. The duration spent within each pitch limit shortens to the length of a bar (bars 297 - 299), then a crotchet (bars 303 - 306) and then to quavers and tuplet quavers (bars 307 – 311) until the durations cannot realistically get any shorter. At this point a large-scale pitch structuring device has been sped-up into a small-scale motif, melody or ostinato. At bar 312, I expanded the pitch register to its widest outer limits – D flat 1 and B7. The dyad is a familiar one; C sharp and B are used to delimit the pitch register in variations 4 and 8. Finally, in the last chord of the piece (bar 337), I further expanded the pitch register to C1 and C8 and announced the arrival of the pitch goal (F sharp 4) in the tubular bell.[183]

Fig. 21 Contraction in register across the course of the piece.

Fig. 22 Principal motif of the theme section upon which the contraction in register is loosely based.

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[183] Added emphasis is placed on F sharp 4 because the tubular bell is allowed to ring, whereas the rest of the ensemble play staccato.

3.3.5 SMALLER SCALE STRATEGIES FOR INFINITE ACCELERATION

The primary small-scale technique used in *After Images,* as previously discussed, is the Risset rhythm. In bars 11 – 16 a Risset rhythm is partially teased out. The piccolo, oboe, clarinet, violins and temple blocks play the descending motif outlined in figures 19 and 22. They accelerate until bar 15 where they collectively play five quavers at quaver = 216. From bars 15 to 16 the quaver becomes the triplet quaver and so the winds carry on playing triplet quavers to sustain this faster tempo but fade out as the violins and temple blocks articulate the crotchet pulse. An acceleration back into the starting tempo is achieved. This use of fadeouts is a typical characteristic of Risset rhythms which occur on a more localised scale in *After Images*.

Ostinatos are used to subvert listeners expectations. The falling motif (figures 22 and 23) is made an ostinato in rhythm and contour. It pervades the theme section and variation 4. In variation 1, the motif is inverted and turned into a rising ostinato. In variations 2, 3, 5 and 6 the gestures are combined into a falling and then rising ostinato. It is constantly present and articulates the pulse. With this motif I was also able to imply false meters. For instance, at bar 40, the falling motif is played on the temple blocks as quavers. From bars 40 to 41 the quavers become triplet quavers, and so the temple block continues to play the falling motif in triplet quavers. Bars 41 – 45 are therefore metrically reinterpreted and heard as notated in figure 23b. The ostinatos give a clear indication of pulse and meter: listeners are entrained to associate the peaks and troughs of the falling and rising ostinatos with the first beat of the bar. I exploited this association to create illusion.

Fig. 23a Falling motif in the temple block, bars 40 – 45.

Fig. 23b Falling motif in the temple block, bars 40 – 45 metrically re-notated.

Figure 24. Bars 20 – 25 of Temple Block part, the rate of pitch change strengthens the acceleration illusion.

Lastly, rates of pitch change are exploited to strengthen the illusion of constant acceleration, as is shown by the temple block in bars 20 – 25 (illustrated in the figure above). In bar 23, the rate of pitch change in the temple block corresponds to the speed of the pulse. In bar 24, each dotted quaver is a different pitch. Overall, the rate of pitch change increases from a crotchet to a dotted quaver and an acceleration is experienced, even though the actual speed of impulse has decreased. Increases in the rate of pitch change are used to distract from decreases in the rate of impulse throughout *After Images*.

3.3.6 CONCLUSIONS

In a sense, the approaches from Andriessen and Carter are formally combined in *After Images*, which makes use of both short tempo loops and an over-arching tempo map which facilitates increases in speed at the large scale. Birtwistle's pulse labyrinth provided a methodological basis for my tempo map, and the Stockhausen metronome, which would not exist without Stockhausen's work,

proved to be a vital compositional tool. From Andriessen and Beethoven I learned that the perception of musical speed is not merely measured by the rate of impulse but also by several factors which include harmonic rhythm and the rate of pitch movement.

I learned that clarity of pulse and meter is crucial to our perception of musical speed, especially when the speed constantly changes. I observed that pulse and meter are patterns of expectation that can easily be exploited to create illusion. The need to clearly signify pulse and meter prompted me to create the falling ostinato figure from which the contracting pitch register device is derived. The ostinato allowed me to exploit patterns of expectation and continue to temporally compress the ostinato, even while the beaten pulse slows, and extend the sense of acceleration beyond what a listener feels should be possible.

I aimed to strengthen the effect of my illusions with the performance magic concept of pre-emptive suspicion neutralisation. I did this by building periodicity into my tempo loops and gradually destroying that periodicity across the piece. As such, I allowed listeners to believe they knew exactly where the tempo had been reduced, only for that certainty to be subverted. I also employed a wide variety of techniques and devices to create similar acceleration illusions. These included the tempo structure, the shortening of sectional duration, the contracting pitch register, smaller scale manipulation of pitch change rates, acceleration into tremolo and the Risset rhythm. These methods are all techniques of misdirection used to draw aural attention away from reductions in tempo and toward the accelerations. My use of mixed methods was another pre-emptive measure: if listeners form a hypothesis regarding one method's mechanism, they may be dissuaded from this hypothesis if they notice another method which does not conform to their hypothesis.

3.4 GHOULISH AIRS

Where *After Images* is concerned with speed, when composing *Ghoulish Airs*, I was determined to discover whether appearance and vanish illusions could feasibly be implemented in a piece of orchestral music. Appearance and vanish illusions have certainly been electro-acoustically constructed,[184] but the computerised methods of creating them are not easily reproduced by orchestras, or any other purely acoustic ensembles.[185] Despite knowing this, I still found the prospect of hearing and seeing musical ideas vanishing from and appearing in different orchestral areas conceptually beguiling. Therefore, I endeavoured to make *Ghoulish Airs* a conceptual and psychoacoustic exploration of appearance and disappearance.

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[184] As discussed in 2.2.7.
[185] Precisely tuned sine tones are required to carry out the method which is explained in 2.2.7. Instrumentalists cannot tune with the precision required for this method, and the overtone structure of their instruments' timbres are too complex.

A number of illusory devices rigidly structure the piece: a regular tempo loop runs like a temporal passacaglia throughout most of the piece and facilitates the Risset rhythm. Counterpoint is controlled by a single pitch series with properties analogous to Nørgård's infinity series. The series is analogous insofar as it is a self-contained augmentation canon that replicates its own specific sequence of pitches within itself at regular periods in the series, and so it has the potential to reproduce itself at augmented durational intervals ad infinitum. It also contains a distorted canon at the inversion and therefore infinite augmentations of that inversion canon. I distorted the intervallic content of the inversion canon because I wanted the series to cohere with a regularly repeating cycle of harmonies, and so the inversion canon is one of contour. My series further differs from Nørgård's infinity series in that its construction has been altered to absorb the Shepard tone scale. As such, I have named my series the "ShMInfinity series", which stands for "Shepard Mixed with Infinity Series.[186] I attempted to make melodies seem as if they had appeared from nowhere by suddenly clearing out textures or registral spaces. Lastly, I incorporated an orchestration device which I refer to as the "trojan horse": by combining differing attacks and decays of different orchestral timbres or hiding and then revealing quieter textural layers behind louder layers, sonorities are made to seem as if they have appeared from nowhere. My implementation of this last device was an attempt to disorient listeners' conceptions of sound and source. I was motivated to employ all these techniques in an effort to misdirect aural attention so that listeners' might be deceived into hearing sounds appearing from nowhere and vanishing into nothing.[187]

One may note that the Risset rhythm and Shepard tone scale, familiar now from previous piece commentaries and the literature review, have not so far been described as appearance or vanish illusions.[188] However, through composing this orchestral piece, I came to realise that the effect of one psychoacoustic illusion may be manipulated to yield multiple illusory effects and thus be reinterpreted. The Risset rhythm and Shepard tone scale have previously been described as false infinities because they create false impressions of impossibly infinite processes. Yet when one considers the mechanisms involved, one might argue that these false infinities' effects are the result of sonic entities seeming to appear from nowhere and vanish into nothing. In a rising Shepard tone scale, scales in higher octaves are faded out and are made to seem as if they've vanished, whilst scales in lower octaves fade in and are heard as if they've appeared from nowhere. In an accelerating Risset rhythm, faster rhythmic values fade out (disappear into nothing), and slower rhythmic values fade in (appear from nowhere). As such, the Risset rhythm and Shepard tone scale are instances where appearance and vanish illusions are employed to create the false impression of infinite pitch and tempi trajectories.

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[186] See 3.4.2 for comparisons in construction between my canonic melody and the infinity series.
[187] See 3.4.2 for more in-depth descriptions of my use of these devices in *Ghoulish Airs*.
[188] Notably in chapter 2, see 2.2.1 where the infinity series is described as a transformation illusion and 2.2.3 where Shepard tone scales and Risset rhythms are referred to as "False infinities".

Fig. 25 Reduction of bars 1 – 10.

I similarly reconceptualised the by now equally familiar infinity series.[189] Although the augmentation properties of my ShMInfinity series are less directly related to the concepts of appearance or disappearance,[190] I tried to create appearance and vanish illusions with it by applying volume fades to the pitch structure. For example, in bars 1 – 10 (figure 25), the Celesta plays the melody and the harp, violin harmonics, flute and piccolo double different augmentations of the melody. In this passage, my orchestration makes the doublings understood at first as faint echoes of the Celesta melody because initially the doublings are relatively quiet. However, throughout bars 1 – 10, I increase the dynamic of these doublings and as a result, the melodic augmentations solidify as independent streams within themselves. In other words, as the augmentations begin to be recognised as augmentations rather than echoes, five independent auditory streams seem to emerge out of one auditory stream without the point of emergence being noticed.[191] The slow increase in dynamic means that polyphonic lines are heard as materialising from nowhere. As this example shows, the full effect of an illusion can only be appreciated when the significance of what is sonically occurring is properly communicated. The "before" and "after" states must be clearly given in any illusion.[192] In this case,

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[189] See 3.2.2 and 3.3.4.4

[190] See 2.2.1, where I compared the infinity series with the Wessel illusion and described it as a transformation illusion. The same section includes an example of Nørgård's Wessel-like employment of the infinity series in his *Symphony no. 2* (1970).

[191] See 2.2.1 for a definition of the terms "auditory stream segregation" and "auditory stream".

[192] See 2.3 for the importance of presenting "before" and "after" states in a magic trick and how similar methods of presentation are necessary if one wants the proper effect of an auditory illusion to be similarly communicated.

the monodic "before" texture is clearly stated (albeit with some echoes) and so is the resultant polyphonic "after" texture.

Ghoulish Airs marks an interest in the narrative structures that magic tricks provide, which were discussed in 2.3 and 2.4. While composing the piece, I began reading Jim Steinmeyer's *Hiding the Elephant* (2004), from which the nascent idea for this orchestral piece stemmed. The concepts I absorbed from this book thoroughly shaped the piece's material, structure and conceptual premise.

3.4.1   LESSONS FROM *HIDING THE ELEPHANT*: WILDE STRUCTURES AND METHODICAL REINVENTIONS.

Jim Steinmeyer's *Hiding the elephant* (2004) was the main performance magic text that I read whilst composing *Ghoulish Airs*.[193] The book is partly a historical account of methods which have been used to create appearance and disappearance illusions in magic – hence my interest in the book – and partly a speculation on the unknown method behind Houdini's famous vanishing elephant trick which he performed at the New York Hippodrome between 1916 – 1917.[194]

A particular passage in the book where Steinmeyer compares two magical illusions, *the Proteus Cabinet* and *the Sphinx*, showed me that the relationship between illusory method and magical effect could be thought of more flexibly, which led me to reconceptualise previously used aural illusions in the ways described above. As Steinmeyer reveals, *Proteus* and *The Sphinx*, two seemingly contrasting illusions, use related methods based on similar optical principles. In *the Proteus Cabinet*, a person is made to appear from inside a previously empty cabinet. Then once the doors are reclosed, they are made to disappear.[195] On the other hand, in *the Sphinx*, a magician places an ornate Egyptian box on a "normal" three-legged table with nothing visible beneath it except for the plain empty stage. The box is opened to reveal the head of a sphinx. The magician moves to the other side of the stage, and rouses the sphinx, "Awake!", to which the sphinx responds by opening its eyes. The magician commands the sphinx to smile and recite twenty lines of dramatic verse and the sphinx obliges. Then, the sphinx retires and closes its eyes. The box is reopened, only for the head to have turned to a pile of ash.[196] Although these magic tricks read very differently, the method which facilitates each illusion is one and the same. In both illusions, mirrors are used to make a performer invisible.

Steinmeyer's comparison of *Proteus* and *the Sphinx* showed me that narratives elevate magic tricks by imbuing them with structure and context. When the illusions were first premiered, *the Sphinx* was received better by audiences than *Proteus*. 'Proteus was perceived as a trick cabinet. It was

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[193] (Steinmeyer, 2004)
[194] (Houdini, 1974)
[195] (Steinmeyer, 2004) pp. 78 – 79
[196] (Steinmeyer, 2004) pp. 83 - 84

introduced as a novel invention by a scientific lecturer… But the Sphinx was received as a perfect mystery.'[197] Steinmeyer attributes this to the skill of the first magician who originally performed *the Sphinx*, John Stodare, and the manner in which he performed *the Sphinx* to the audience. 'Stodare arranged the presentation upon building surprises: the opening eyes, the moving mouth, then words and expressions until finally, with the audience anxious to glimpse the head one last time, it had turned to dust. The illusion created a haunting memory for audiences, reminding them of tales of decapitated heads, Egyptian mummies, the terrifying images of life and death.'[198] *The Sphinx* has a narrative structure comprised of simple steps which lead the audience through the trick, guiding them to a surprising and impossible conclusion. The narrative itself is imbued with cultural context since it refers to exoticist Egyptian mythologies. At the time of premiere, the illusion's cultural associations acted to heighten intrigue and served as a form of misdirection: audience members assumed that there was something special about the Sphinx head, that it was an impossibly living exotic object and not an actor hidden partially by mirrors placed between the table legs. On the other hand, in *Proteus* there was nothing in the trick itself that reminded onlookers of anything fantastical. It was simply someone hiding in a cabinet. On reading Steinmeyer's qualitative distinction between these two tricks, I resolved to use narrative as a tool to heighten the effect of my sonic appearance and vanishing illusions and searched for a programme to attach to my orchestral piece.

In literature, ghosts typically appear from nowhere or vanish into nothing, and so I felt that they made natural symbolic metaphors for the sonic illusions that I was attempting to create. I settled on a tale by Oscar Wilde, *The Canterville Ghost*.[199] The story tells of an American family which moves into an old, haunted Tudor manor. The resident Elizabethan ghost, Sir Simon, repeatedly attempts to scare them but the family foil him at every turn. As the tale progresses, Virginia, the family's only daughter, bonds with Sir Simon and learns that he may only die if a pure maiden begs the angel of death for mercy upon the ghost's soul. Out of kindness, Virginia agrees to help the ghost and he leads her into a ghoulish void filled with evil spirits. Virginia absolves Sir Simon of his sins, her return from this other realm being accompanied by peals of thunder, a 'strain of unearthly music' and the manor's clocktower bell striking at midnight.[200] I chose this story because of its multi-layered nature: it's a slapstick comedy and yet it touches on serious themes like the common want for absolution and steadfast purity in the face of extreme evil. I wanted the sonic illusions in this piece to strike a similar tone, evoke the supernatural elements in the story, and to be vested with a similar thematic richness. I also saw that I could potentially derive a musical structure from this narrative

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[197] Ibid. p. 85
[198] Ibid, p. 85
[199] Although, I initially chose Houdini's vanishing elephant trick, the central motive of Steinmeyer's book, as my programme. The plan involved spectral resynthesis of an elephant's roar but this proved impractical.
[200] (Wilde, 2003)

which would allow my sonic illusions to depict extramusical environments, characters, actions and events and therefore give my illusions function and meaning.[201]

     Ghoulish airs begins the moment Virginia and Sir Simon enter the realm of evil spirits and ends at Virginia's return. I felt my illusions could most effectively depict this portion of the narrative because Wilde does not describe what takes place inside the realm. This omission gave me creative license to set events which I had imagined occurring in this part of the story to music. The form and programme of the piece is described in the following table:

Section	Bars	Poetic summations of the narrative[202]	Imagined programme	Illusory devices, how they depict narrative events and other methods of musically rendering the programme
Intro	1 – 10			ShMInfinity series and Risset Rhythm are introduced.
A	11 – 30	*They stepped into eternity,…*	Virginia and the ghost step into the "great black cavern", an eternal void which I imagined to be filled with evil spirits swirling around.[203]	The ShMInfinity series and Risset Rhythm acoustically mimic the environment of an endless cavern and generates a constantly accelerating texture which depicts a swirling mass of evil spirits. At bar 26 descending Shepard tone scales cascade with maximum speed and density.[204]
B	31 – 50	*…her purity un-swayed.*	Virginia persists in her quest to gain mercy for Sir Simon and refuses to succumb to the horde of ghouls.	The texture clears. A new melodic theme, symbolising Virginia, emerges in the solo viola and alto flute. Virginia's theme decelerates against the conductor's beaten acceleration. This temporal dissent represents

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[201] Interestingly Shostakovich made plans for an opera with Wilde's story. Influenced by Stockhausen's *Hymnen* (1966 – 67), he intended to use electronics to evoke the ghosts (Shostakovich & Glikman, 2001).

[202] These phrases were composed by me for the piece. They appear in the score at the bars indicated.

[203] (Wilde, 2003)

[204] In the workshop, the conductor described this moment as a "tsunami".

				Virginia's steadfast purity and bravery in the face of the surrounding evil. 'Trojan horses' simulate the sudden appearance of ghosts. The density of activity increases, the surrounding spirits becoming more malevolent again.
C (A' + B')	50 – 70	*Though submerged in a ghoulish void, she held her resolution.* (Then, at the piece's climax, bar 68) *As midnight pealed she returned,...*	Evil spirits attempt to consume Virginia. At bar 68, the midnight bell tolls and thunder strikes.	ShMInfinity material and Virginia's theme are elaborated upon and superimposed. The superimposed materials vie for textural dominance: ghost materials (cascading/surging gestures and ShMInfinity series) chase Virginia's theme to different registral spaces, attempting to extinguish it. Virginia's theme persists, constantly finding new registral ground. The musical materials play out imagined dramatic events. At bar 68, double-bass rumbling and the tam-tam emulate thunder. Tubular bells mimic the strikes of midnight. A secondary climax mirrors the piece's first at bar 26 but here both ascending and descending Shepard tone scales are overlaid.
Coda	71 – 86 (end)	*'...and a strain of unearthly music floated*	Virginia's return to the mortal realm of ghosts is accompanied by 'a strain of unearthly music [floating]	Luminous octave staccato attacks (trace augmentations from the ShMInfinity series) played by the oboes, glockenspiel, tubular bell,

| | | *through the air.'* | through the air.' [205] Sir Simon enters the garden of death which Wilde describes: 'There the grass grows long and deep, there are the great white stars of the hemlock flower, there the nightingale sings all night long. All night long, he sings, and the cold, crystal moon looks down, and the yew-tree spreads out its giant arms over the sleepers.'[206] | piano, harp and violin harmonics from bar 74 onwards evoke the cold crystal moon and the white stars of hemlock. A flute trio imitates nightingale song. Previously unheard events demarcate the Coda as a new musical atmosphere: a D flat pitch centre, microtones and tempo deceleration are introduced. The change signifies that Sir Simon has been granted rest in the garden of death. A 'trojan horse' closes the piece. |

Fig. 26 A table describing the piece's musical and corresponding narrative structure.

The table shows that in certain portions of the piece, namely the Coda, my compositional efforts are concentrated on the evocation of an external programme rather than creating psychoacoustic illusions. Based on the Steinmeyer literature, I argue that the narrative elements contextualise my psychoacoustic illusions in a narrative, give them poetic purpose and enhance their effectiveness. Just as *the Sphinx* reminded audience members of ancient Egyptian mythology, a culture which they already thought of as mysterious and supernatural, the extramusical narrative attached to *Ghoulish Airs* prepares listeners to expect that this piece of music will contain sonic simulations of ghostly behaviour.

So far, the illusory devices in *Ghoulish Airs* have been described in general terms. I shall now endeavour to further demonstrate the details of their mechanism within *Ghoulish Airs*.

3.4.2   DEVICES

The most central device in *Ghoulish Airs*' construction is the ShMInfinity series, which I created whilst attempting and failing to replicate Nørgård's two-tone infinity series.[207] A two-tone infinity series is constructed by projecting intervals from the budding series onto the series itself,

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[205] (Wilde, 2003)
[206] Ibid.
[207] Nørgård has used more than two tones to generate infinity series and demonstrates how one might construct such series in *Inside a Symphony* (Nørgård, 1974).

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creating an infinite pitch fractal within which one can find an infinite array of augmentations. [208] My ShMInfinity series is based on a simpler implanting of my own pitch series' augmentation at regular durational intervals within itself, as shown in figure 27. If one compares the series' base sequence of pitches with the sequence of cross-marked pitches, which occur every four pitches, one can see that both pitch sequences are the same. In this way, the series' own durational augmentation is sewn into itself.[209] Similarly, this durational augmentation contains its own augmentation within its own sequence of pitches. One implantation of the series' own augmentation within itself at 4 note intervals produces larger and larger series augmentations at durational intervals corresponding to ascending powers of 4. This fractal process occurs ad infinitum.

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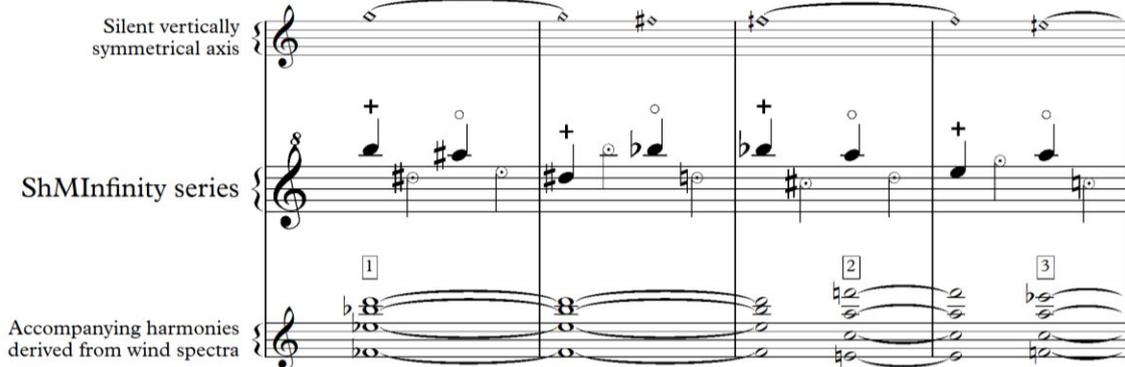
[208] Nørgård himself describes how he first discovered the two-tone infinite series: 'Briefly expressed, *it can be said that every interval appearing on the time axis* [in his article the time axis simply shows that the projected tones chronologically succeed each other] *is successively projected from an odd-numbered tone in original version to the position of the next odd-numbered tone, and from an even-numbered tone, and from an even-numbered tone in inversion to the position of the next even-numbered tone.*' (Nørgård, 1974) p. 4 He goes on to describe how he modified the principle to allow for greater melodic variety: 'A far more variable ∞ M [a short-hand for the melodic infinity series that he uses in the article] comes about if the odd-numbered tones are permitted to move in inversion and the even-numbered tones in the original version.' (Nørgård, 1974) p. 4. With this modification Nørgård delivers the totally chromatic infinite row found in his *Symphony no. 2* (1970) and the second movement of *Voyage into the Golden Screen* (1970).

[209] Bars are used in Appendix E purely for navigation and do not correspond in any way to bars in the score.

Fig. 27 How the ShMInfinity series is constructed.

Wavelength:[210]	Series pitch number which the wavelength begins on:	Speed in relation to wavelength 1	Property/function:
1	1	1 (fastest layer)	Base ShMInfinity series
2a	1	Half	Two-part inversion canon, upper voice
2b	2	Half	Two-part inversion canon, distorted lower voice
4a	1	Quarter	Base series augmentation

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[210] Though my series differs from Nørgård's, I am borrowing a term which he uses to describe melodies which he derives from the infinity series by isolating the tones found at regular periods: the "wavelength". Wavelength 2 would be derived by isolating every second tone of the series, wavelength 3 by isolating every third tone, etc. Notably, 'any selection of notes from the series at regular intervals will produce new melodies, each one hierarchically repeated… i.e. they will duplicate the same intervals at a tempo four times slower and will produce the inversion at a tempo twice as slow' (Beyer, 1996) p. 77. Though my wavelengths are not hierarchic, they have other properties described in figure 4. I use the term as it conveniently describes linear materials derived from the ShMInfinity series by isolating tones found at regular periods within the series. The terminology is expanded to include letterings which distinguish differing versions of wavelength which start on different pitches in the ShMInfinity series. This produces wavelengths with notably different properties: for instance wavelength 4a, which starts on pitch 1, is a series augmentation but wavelength 4b, which starts on pitch 3, is a Shepard tone scale.

4b	3	Quarter	Shepard tone scale
8a	1	Eighth	Augmentation of 2a
8b	5	Eighth	Augmentation of 2b
16a	1	Sixteenth	Augmentation of 4a
16b	9	Sixteenth	Augmentation of 4b

Fig. 28 Table detailing the series wavelengths used and their function.

Though my ShMInfinity series contains an infinite number of its own augmentations, the orchestra has a finite number of musicians. After considering how each layer should be scored to balance well against and be distinct in timbre from other layers, only 9 wavelengths of the series could realistically be orchestrated: 1, 2a, 2b, 4a, 4b, 8a, 8b, 16a and 16b. These wavelengths, their starting pitches in the series, and their functions are laid out in figure 28. Each wavelength was selected for its special property. The short score, excerpted in figure 30, shows the wavelengths represented in pitch notation on different staves. Figure 29 details the orchestration of each wavelength from bars 11 – 30.[211] These echoing canonic augmentations of the series serve the piece's programme, sonically evoking an infinite chasm by hinting at a spatial vastness. The recurring melodies, which seem to materialise from within themselves, also become musical actors playing spirits which emerge from the ether.

Wavelength	Bars 11 – 15	Bars 16 – 20	Bars 21 – 25	Bars 26 – 30
1	Celesta	Bassoons, harp, pizzicato strings, staccato strings	Harmon muted trumpets & Piccolo. Oboes join with staccatissimo attacks.	Clarinets, and flutes, Harmon muted trombone, piccolo joins in bar 27. Dense, fast, Shepard-tone-like scalic activity in the strings and winds carries the acceleration further.

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[211] Bars 1 – 10 were the last bars to be composed of this piece. The piece initially began at bar 11. However, many of those observing my progress advised that an introduction was required. I opted to open the piece by using the first 36 pitches of the series at a slower speed. It is for this reason that pitch series begins again from the start of the ShMInfinity series at bar 11.

2	a (upper voice in loose inversion canon)	Harp, pizzicato strings, staccato strings. Oboes, Cor Anglais and bassoons join at bar 14	Harmon muted trumpets & Piccolo. Attacks gradually transition to being more and more staccato until they are staccatissimo.	Clarinets, and flutes, Harmon muted trombone, legato.	Crotales, vibraphone joins in bar 28.
	b (lower voice)	Piccolo and flutes	Oboes & Cor Anglais	Tremolo violins, some support from flutter-tongue clarinets.	Horns
4	a (series augmentation at 1/4 of the speed)	Harmon muted trumpet (enters bar 14)	Clarinets, and flutes, Harmon muted trombone, legato.	Crotales	Timpani
	b (Shepard tone scales)	Violins (harmonics and non vib.)	Tremolo violins	Horns	N/A
8	a (upper voice in augmented loose inversion canon)	E flat Clarinet and Flute (enters bar 15)	Crotales	Timpani	N/A
	b (lower voice in augmented loose inversion canon)	Tremolo violins	Horns	Piano	N/A
16	a (series augmentation at` 1/16 of the speed)	Crotales	Timpani	Bassoons & Cor Anglais	N/A
	b (augmented Shepard tone scales 1/4 the speed of those found in wavelength 4b	Violins (harmonics and non vib.)	Violins (harmonics and non vib.). Piano enters bar 19	Violins (harmonics and non vib.)	Violin 2, desks 5 & 6 (harmonics and non vib.) from bar 28

Fig. 29 A table detailing the orchestration of each wavelength through section A.

Fig. 30 Bars 1 – 15 of the short score which show the pitch content and functions of each wavelength detailed in the paragraph above.

Fig. 31 Orchestration of the ShMInfinity series and the Shepard tone scales it contains in bars 11 – 15. At bar 11, desk 5 of the first violins pick out the wavelength 4b Shepard tones. Desks 6 and 7 of the first violins fade in the octave above at bar 12. Desk 5 of the second violins plays the augmented wavelength 16b Shepard tones. Desk 6 of the second violins fades lower octaves of this scale in at bar 13.

Nørgård's series outperforms mine in terms of canonic density: one can find augmentations of any of its wavelengths from any point in Nørgård's series whereas augmentations only emanate from the start of my series. In this respect, my series is "less infinite" than Nørgård's. However, in another my series is arguably "more infinite". Wavelength 4b of my series is a unidirectional scale. This allows octave doublings and volume fades to be applied to the total series and Shepard tone effects to be created, as is shown in figure 31. Since my series has its own augmentation nested within itself, it also has infinite augmentations of these scales moving at differing rates within itself, although I decided only one, 16b, could realistically be orchestrated. My nested scales function in a manner akin to Escher's addition of descending steps to the backdrop of *Waterfall* (1961), where the surrounding downward steps convince the eye that the water in the titular waterfall must similarly be falling downward. Although there is directional variety in my melodic series, due to its in-built inversion canon, the nested scales ensure that, on a macro-level, the series travels downwards. The creation of a series with locally angular melodies but also global downward trajectory was particularly satisfying because aspects of the Shepard tone scale are frustratingly rigid. The unaltered Shepard tone scale

allows no room for any linearly deviant pitch shapes. It was therefore pleasing to realise that synthesising the Shepard tone scale and infinity series principles would afford me linear directional variety without losing the effect of infinite descent.

The ShMInfinity series is harmonised with an external set of chords. My harmonies were derived from recordings of howling wind as these sounds frequently accompany the appearances of ghosts in television and film.[212] I processed a sample of wind sounds through the spectral software SPEAR and used the scrub function to find harmonically suitable vertical instances of the sample. These instances were transcribed in standardised pitch notation and approximated to the closest quartertone.[213] Of the 47 spectra transcribed, 15 were selected (shown in figure 33) and arranged as a chord progression. The placement of spectra with differing intervallic content next to each other produced a progression of varied harmonic content. These spectra form the basis of the harmony in *Ghoulish Airs*. Their use marks an attempt at mimesis, although in practice the harmonies of *Ghoulish Airs* do not sonically resemble wind.[214]
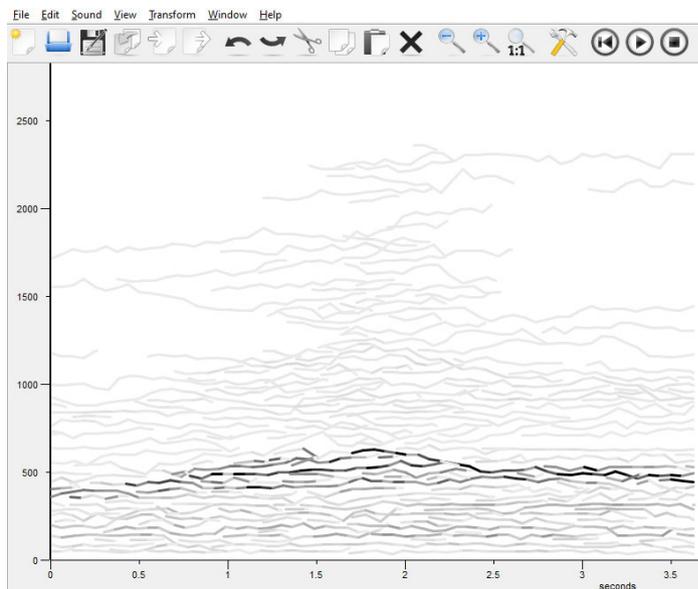
Fig. 32 SPEAR analysis of howling wind

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[212] My sound sample: https://www.youtube.com/watch?v=RBUtBrk7yzo&t=170s

[213] SPEAR, or Sinusoidal Partial Editing Analysis and Resynthesis, is a software which can process an audio file, read its frequency content, and resynthesise a simulacrum of the sample with sine waves. Portions of this sinusoidal simulacrum, as small, large and in whatever shape is required by the user, can be selected, deleted, moved, retuned, filtered and subject to other spectral manipulations. The software was developed by the composer Michael Klingbeil and first released in 2006. (Klingbeil, 2005) The software was downloaded from http://www.klingbeil.com/spear/. In the score these harmonies are often approximated to equal temperament.

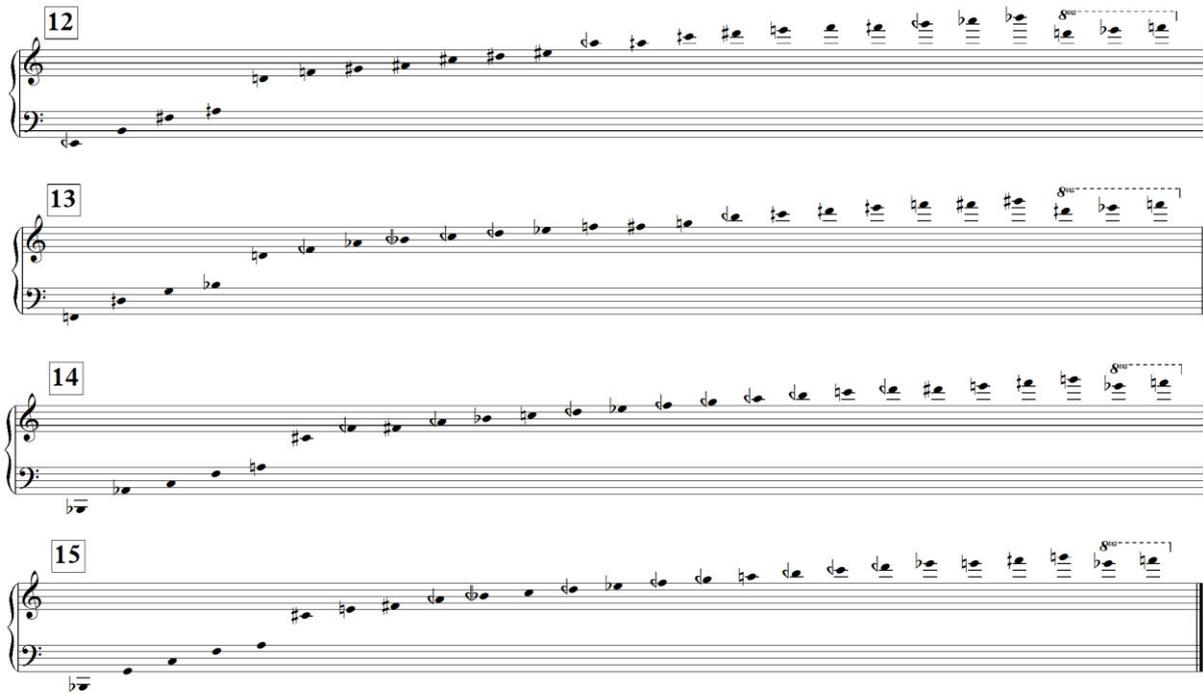[214] Although the descending Shepard tones do unintendedly evoke the howling of wind.

Fig. 33 Sonic spectra transcribed from a sample of howling wind and arranged in a chord progression. The spectra are numbered in progression order, so spectrum 1 begins the progression and 15 ends it.

The above shows that the ShMInfinity series was useful for pitch and texture control. Temporality, on the other hand, was structured by Risset rhythm principles. In service of this illusion, I made the piece a temporal passacaglia (as alluded to above): a five-bar tempo loop, shown with its tempo relations so far in figures 1, 5, 6, 12 and 13, mostly repeats throughout. Figure 34 shows that the length of tempo loop and rate of acceleration remains constant until bar 61, whereafter the loop is durationally compressed more and more for the sake of apotheosis. At bar 71, after a maximum speed of crotchet = 144 is reached, there is a sudden reduction in tempo to crotchet = 86 at bar 71, due to a metric modulation of triplet quaver = quintuplet semiquaver, and a gradual deceleration over the course of the Coda. Since I was writing for orchestra, I opted for a smooth acceleration rather than one staggered by metric modulations, as found in *After Images*, and simplified the tempo relations.

Section	Tempo loop bar numbers	Number of bars in tempo loop	Acceleration (bpm)
Intro	1 – 5	5	60 to 120
	6 – 10	5	60 to 120
A	11 – 15	5	60 to 120
	16 – 20	5	60 to 120
	21 – 25	5	60 to 120
	26 – 30	5	60 to 120

B	31 – 35	5	60 to 120
	36 – 40	5	60 to 120
	41 – 45	5	60 to 120
	46 – 50	5	60 to 120
C	51 – 55	5	60 to 120
	56 – 60	5	60 to 120
	61 – 64	4	60 to 120
	65 – 67	3	60 to 120
	68 – 70	3	60 to 144

Fig. 34 Table showing the bar number length of/rate of acceleration across each tempo loop in *Ghoulish Airs*.

In addition to tempo loops, Risset rhythms also require multiple layers of impulses, each layer being half the speed of the previous, to simultaneously accelerate. Faster layers fade out as they reach maximum speed and slower layers fade in.[215] The ShMInfinity series, like the infinity series, has the capacity to produce multiple layers of speed by producing different wavelengths. The larger the wavelength, the slower it will be in relation to wavelength 1. Figures 4 and 6 shows that wavelength 1 is fastest and each successively numbered wavelength is halved in speed.[216] Therefore, in order to synthesise the Risset rhythm and ShMInfinity series together, one only need feed the layers through an accelerating tempo loop and apply volume fades, as is done in the short score. In this way, both devices are natural technical symbiotes.

The short score (figure 30) shows that upon every cycle of the tempo loop, the wavelengths, and therefore speed layers, rotate. Fast semiquavers in wavelength 1 diminuendo into nothing across bars 1 – 15 and the quavers of wavelength 2a crescendo. Then in bar 16, after the metric modulation, the wavelength 2a quavers retain their speed and become semiquavers. At the same time, the pitch content of the layer changes from that of wavelength 2a to a continuation of wavelength 1. Each slower layer performs a similar rotation of wavelength at bar 16: wavelength 4 becomes 2, 8 becomes 4 and 16 becomes 8. This process is elucidated by simultaneous rotations of the clearly differentiated timbres assigned to each wavelength, as is illustrated in figure 29.[217] These rotations allow the illusions to be sustained over longer time periods.

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[215] See 2.2.3 for an illustration of the Risset rhythm's mechanism.

[216] Note that each wavelength number halves in speed but the wavelengths differing by letter do not. Wavelengths 4a and 4b are the same wavelength number with a differing letter so they are of the same speed even though they start on differing pitches of the series, as is noted in footnote 32.

[217] Some instruments progress through figure 5 exactly in the manner described. For instance, the crotale starts on wavelength 16a at the beginning of section A, and moves through wavelengths 8a, 4a, and ends on 2a. However sometimes the rotation of timbres was made more complex by considerations of instrumentation. For instance, Harp, pizzicato strings, staccato strings, oboes, cor anglais and bassoons play wavelength 2a in bars 11 – 15 but as wavelength 2a becomes 1 at bar 16, the oboes and cor anglaise don't continue. This is because the

In section A the short score was by-in-large orchestrated directly into full score. In section B the short score acts instead as a background structure. Some of the short score in this section is embellished or temporally rearranged, and other section B materials are arrived at by omitting or filtering the short score. The prime example of this is Virginia's theme, shown in figure 35. The melody, which consists of alternating high and low sustained tones, bears little superficial resemblance to anything in the short score. Nevertheless, the theme sources its pitches directly from the *perpetuum mobile* ShMInfinity series. In figure 35, arrows show that although the theme's pitch and rhythms only approximately cohere with the ShMInfinity series at first, from bar 40 the theme sources precise notes of the series at the exact time that they appear in the series. Since Virginia's theme isolates pitches from the ShMInfinity series at irregular periods, one can regard the melody as an irregular wavelength.

Pre-composed rhythms determine which tones are isolated from the series by the theme. One can see in bars 31 – 35, 46 – 50, 51 – 55 and 56 – 60 of figure 35 that as each tempo loop accelerates, the theme's rhythmic values increase. These rhythms were pre-calculated so that they slow down against the continuing tempo loops' accelerations. Arrows show that upon each new rhythmic impulse, Virginia's theme sources another pitch from the series. As mentioned, the melody's deceleration against conducted accelerations is a metaphor for Virginia's resistance against the evil surrounding her.

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series goes too low for them to continue. The layer continues to be perceived as a single stream however, as the timbres which make up the stream are united by their *secco* character.

Fig. 35 Virginia's theme – an irregular wavelength of the ShMInfinity series. Arrows show where the melody's pitch material is sourced from.

Fig. 36 Trojan horse, bar 40.

In section B another device, the trojan horse, is introduced.[218] Attacks and decays with contrasting amplitudes are superimposed. Figure 36 shows one exemplary instance of the device, where the trumpet attack masks the vibraphone's onset. The loud trumpet attack is short, giving way immediately to the vibraphone's sustained resonance. This misdirection divorces the vibraphone's decay from its attack, the intended effect being that the sound appears from nowhere and its source obscured. The vibraphone's decay becomes the "ghost" of the trumpet's attack. The use of the vibraphone's fastest motor makes this metaphor explicit, as popular portrayals of ghosts typically involve voices with wide and fast vibratos.

3.4.3 CONCLUSIONS

It was necessary to use such rigorous techniques to extensively structure *Ghoulish Airs*: otherwise, the audible and cohesive combination of such varied illusions would have been extremely difficult. One can see that the ShMInfinity series brings together multiple conflicting illusory ideas and binds them into a single technique which pushes concepts regarding the infinite to an extreme. The device is linearly constructed by forcing the Shepard tone scale and infinity series together and is then harmonised with principles from orchestral re-synthesis of howling wind. The pitch structure accelerates infinitely through the temporal mould of a Risset rhythm. These four rigid technical processes are to some extent mutually contradictory and therefore not readily susceptible to combination and/or fusion.

Their combination comes at a cost. The ShMInfinity series is not as canonically infinite as the Nørgård infinity series. Its Shepard tone descents and ascents are somewhat obscured by the augmentation canon. Meanwhile, the harmonies resulting from analysis of the howling wind do not in

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[218] This device is used in the first movement of Benjamin's *Dance Figures*. The final chord of the movement, introduced in the violins at bar 23, fades to reveal a layer of cello harmonics playing the same chord underneath. (*Dance figures*, 2006) This moment inspired similar timbral sleights of hand in *Ghoulish Airs*.

themselves resemble the sound of wind.[219] Partial omissions of the series and its wavelengths to accommodate themes and trojan horses blatantly disrupts the perception of the series' illusory properties. However, despite the losses, an illusive texture is, I hope, achieved.

In performance it is at times questionable as to whether the intended effect of each device/illusion was always audible. Though the fore and background layers in section A functioned well enough to conceal reductions in tempo, the detailed harmonic progressions were less obvious. Perhaps too, section C suffered at the hands of its conceptual conceit: though materials are supposed to compete in this section for textural dominance, there is at times too much competition.[220] Whilst I find that the aural result of the piece is exciting, I concede that the piece's focus on illusion drifts somewhat in this section. During the workshop, rehearsal and performance, many elements were re-balanced, re-orchestrated or deleted, and the dynamics re-adjusted. The workshop experience suggested to me that some of these revisions might be taken further to focus the piece's illusions.

Still, *Ghoulish Airs* would not be as it is without its tensions between competing musical, illusory, technical and poetic ideas. The piece embodies a poetic-technocratic identity crisis. In one sense, it is a sonic translation of an imagined scene from an external work of fictional literature. In another, the piece is an investigation into illusion, deception, and misdirection, a direct expression of my research. Paradoxically, the intense multi-layered self-negation of ideas seems to act as an adhesive for the piece. Though the opposing creative forces seem to collide with one another, in actuality they push towards one central goal: the misdirection of aural attention in a way that allows sounds to be perceived as if appearing from nowhere and vanishing into nothing.

3.5 JAB

After completing *Ghoulish Airs*, I began to feel creatively stifled by my research framework. The performance magic models cited in the Literature Review[221] seemed to prescribe a single basic structure to those who might compositionally render illusions:

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[219] In fact, I feel that the piece does evoke the howling of the wind, but not by means of spectral resynthesis. It is perhaps due more to the use of descending Shepard tones.

[220] Time constraints in rehearsal prevented the more thorough rehearsal of/experimentation with materials in bars 56 – 70. Small changes made in rehearsal to other sections made big differences to how I perceived the piece. For instance, harder attacks on the piccolo and violin harmonics ensured that the wavelengths played by those instruments were better perceived. A comment on balance to the orchestra at bar 16 prompted the instruments playing wavelength 1 to be better foregrounded and the overall texture given more focus. At bar 51, adjustments to the string articulation allowed the texture to be better aerated and other layers in the texture to be better heard. Perhaps with some re-composition and an opportunity for bars 56 – 70 to be similarly attuned in rehearsal, my intentions for the section could be better realised.

[221] Analyses of Teller's *Coins and Fish* and Copperfield's *Flying Illusion* in subsections 2.3 and 2.4 of the Literature Review explain which concepts from performance magic might possibly be compositionally appropriated. These concepts mainly relate to structure and as such, within the context of this research project, relate to the ways in which a particular illusory effect might be communicated.

1. Present the psychoacoustic illusion's effect.
2. Successively introduce increasingly varied methods of creating the same illusory effect. In this act, the composer-as-illusionist pre-emptively negates any methods by which the listener may suspect the illusion has been created.[222]

After Images certainly follows this structure. Similarly, in *Ghoulish Airs*, even though the focus shifts towards situating the illusions within an external narrative, structural elements of the above remain: a single device which binds multiple illusions together, the ShMInfinity series, is compositionally fixated upon and, throughout the piece, successively subjected to varying manipulations.

Such structures bring to mind Bach's fugues which display the manifold properties of his subjects and countersubjects. Bach's fugues, if not in aesthetic but approach, share similarities with a great portion of Conlon Nancarrow's output, particularly his *Studies for Player Piano* (1948 – 1992), many of which are sonic renderings of rhythmic ideas expressed by Cowell in *New Musical Resources* (1930).[223] In these works, particular musical phenomena are puritanically realised without the addition of any extraneous elements. Points of commonality might be further seen in Reich's *It's Gonna Rain* (1965) and *Drumming* (1971), which both demonstrate that processes such as phase-shifting will produce constantly evolving psychoacoustic by-products.[224] Similarly, Stockhausen's *Inori* shows how his chromatic scale of tempi can be rendered perceptible with clear pulses and periodic rhythms. The above works use structures which facilitate one's aural concentration on a single phenomenological particularity. The pieces are unified in purpose, which is that of demonstration.

In my research framework, the use of these structures is advocated, as they are apt for communicating the effect of an aural illusion. However, such structures felt stifling and unsuitable for the composition of *Jab*. Structures which allowed quicker contrasts in character seemed more relevant. Other than in the work of Haas, Risset or Ligeti, I am not aware of many works within which both psychoacoustic illusions and stark musical contrasts have been employed side by side. Even so, such works do not necessarily exhibit the same extreme degree of contrast present in pieces such as Stravinsky's *Symphony of Wind Instruments* (1920) or Tippett's *Piano Sonata no. 2* (1962). For compositions which illude, a certain amount of demonstration within them is necessary. However, I began to question, could demonstration and juxtaposition conceptually coexist in a single form? The exercise of rendering multiple psychoacoustic illusions within a form founded on extreme musical contrasts seemed a lively compositional challenge.

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[222] This is what Leddington refers to as the 'neutralisation of suspicion'. (Leddington, 2016)
[223] Pp. 146 – 147 (Thomas, 2000)
[224] See 2.2.6 for more in-depth descriptions of these works. Perhaps it is worth noting also that a point of difference between Reich's work and the structures suggested to me by performance magic models is that technical variety does not seem to be an aim of Reich's.

3.5.1 GESTURES

In *Jab*, the contrasts are achieved through the use of eight gestures. The use of each gesture is documented in the table below. I intended that each gesture would be derived from or related to a particular psychoacoustic illusion. The table and figures 38 – 41 explain the first 5 gestures. Gestures 6 – 8 require more analysis.

Section	Bar numbers	Gesture (or gestures)	Purpose
A	1 – 4	1 (see figure 38)	First demonstration of gesture 1: a diatonic cluster emerges from a chromatic cluster and, subsequently, an illusory un-played scale is heard. This illusory scale results from the measured release of each tone in the diatonic cluster.
	5 – 7	2 (see figure 39)	First demonstration of gesture 2: rhythms distorted by large gaps in register. The gaps cause one stream to segregate into two.
	8 – 20 (beat 2)	3 (see figures 40 and 41)	First statement of gesture 3: characterised by rapidly interchanging tuplets of varying divisions, varying speeds, metric modulations, accelerations, decelerations, resonant chords, wide-leaping figuration and, later, *tremolandi*. The gesture's function is misdirection.
	20 (beat 2) – 21 (beat 2)	2	Consolidates gesture 2 as a recurring idea and connects material.
	21 (beat 2) – 22	1	Consolidates gesture 1 as a recurring idea.
	23 – 32	6 (see figure 42)	First demonstration of gesture 6: a single melody being transformed into two-part counterpoint due to larger and larger register gaps occurring between tones.
	33 – 36	7 (see figure 43a)	First demonstration of Shepard-Risset textures.
	37 – 50	3 (see figure 41)	Consolidates gesture 3, brings section A to a climax, and misdirects from the silent "loading" (an action which 'introduce[s typically an object] surreptitiously'

			with sleight of hand [225]) of tones which are sustained by the sostenuto pedal.
B	51 - 82	1, 2, 3, 4, 5 (see figures 40 and 41) & 7.	The *tremolandi* of gesture 3 trigger gesture 4 by exciting harmonics from the strings sustained by the sostenuto pedal, which seemingly appear from nowhere at bar 51. Appearing harmonics are considered a fourth gesture. First statement of the arpeggiated gesture 5: polymetric ascending and descending arpeggiations which similarly excited harmonics. Gestures 1, 2, 3 and 5 are juxtaposed in quick succession to form new phrases. They excite harmonics from the sustained strings and reinforce the illusion created in gesture 4. Gesture 7 appears in bars 70 – 71 and fulfils a similar function.
C	83 – 104	6	Gesture 6 returns. Pedal is used to toy with perceptions of texture (details about which are expanded upon after the table). The passage builds to a climax.
D	105 – 131	1, 2, 3, 4, 6, 7 (inverse)	The section begins with an explosive restatement of gesture 1. A large-scale acceleration begins. From bars 112 – 131, a long Risset acceleration takes place which is accompanied by a steady rise in tessitura. This large-scale gesture might be regarded as an inverse of gesture 7. Gestures 1, 2, 3, 4 and 6 are used to create the Risset acceleration. The main body of texture is in 3-part counterpoint, at least from bar 112, derived from gesture 6. Fragments derived from gesture 1, 2, 3 and 4 occur periodically. These materials get durationally closer and closer and as such aid the perception of the Risset acceleration.
E	132 – 160	7	Gesture 7 is extended and expanded so that it occurs over longer spans of time. Note that if one places the chords from bars 139, 145, 152 and 161, as has been done in figure 10, one can see that the voicings are

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[225] Rieiro, Martinez-Conde and Macknik use the term "load" in their analysis of Penn and Teller's *Cups and Balls.* They use it to describe the way in which Teller places balls inside cups without the audience realising so that they seem to have appeared where they should not be. p. 1 (Rieiro et al., 2013)

			connected by stepwise descents. This further reinforces the illusion of eternal descent.
F	161 – 172	3 & 5	Gesture 3 and 5 are developed and expanded upon, bringing the piece to an explosive climax.
G	173 – 184	2, 3, 4, 5, 6	Gestures 3 and 5 are used to excite harmonics from silently sustained strings (gesture 4). These harmonics act as sustained chords over which gesture 6 is played. This time the gesture 6 counterpoint is made explicit by embellishing the upper voices with wide leaps in register derived from gesture 2.
	185 – 187	8 & 4	The first demonstration of gesture 8, the polymetric Necker cube. These also stimulate harmonics from sustained strings.
	188 – 193	2, 3, 4, 5	An alternation between illusory gestures ensues.
	194 – 198	8 & 4	As in bars 185 – 187
	199 - 204	2, 3, 4, 5	As in bars 188 – 193
	105 – 215	8 & 1	More and more notes are added to each chord in gesture 8. This transforms the chords into clusters reminiscent of gesture 1.
H	216 – 249	3 & 7 (inverse)	Gestures 3 & 7 are combined. One might understand an aspect of gesture 3 as alternating high and low chords. Here those alternating chords are connected with upwards Shepard tone scales (an inverse gesture 7). The Risset acceleration. At bar 229, slower layers are rapidly faded in so that even though the music continues to feel as if it is continuing to accelerate, the speed has paradoxically been dramatically reduced.
I	250 – 256 (end)	3 & 4	Leaping figuration from gesture 3 draws the piece to a close. These excite sostenuto resonance (gesture 4).

Fig. 37 The above table details where each gesture in *Jab* is used.

Fig. 38 Gesture 1, similar gestures are present in the third of Nielsen's *3 Klaverstykke Op. 59* (1928), and the second of Dutilleux's *Figures de Resonance* (1970 - 76).

Fig. 39 Gesture 2, based on Bregman's psychoacoustic demonstration, *Loss of rhythmic information as a result of stream segregation.*(Bregman, 2010)

Fig. 40 Gesture 3

Fig. 41 Gestures 3, 4, and 5 acting complimentarily.

Fig. 42a First appearance of gesture 6

Fig. 42b The second iteration of gesture 6 analysed

The sixth gesture, complex in its construction, is a long melodic line which gradually separates in register. This separation causes the single melody, or single auditory stream, to morph into two melodies in counterpoint, or two segregated auditory streams. The melodic line results from the superimposition and synthesis of two voices in inversion and mensuration canon (see figure 42b).

The two voices are polymetrically related by the ratio 10:11. The figure below details the way in which the second iteration of gesture 6 results from the mensuration canon.[226]

The staves which are labelled "10:11 inversion canon" show the rhythmic and pitch content of each canonic voice. The top voice's sequence of durations is produced by taking the lower voice's sequence of durations from the second bar of E (the bottom voice's point of entry) and multiplying them by 11/10. Note that in this figure, for the sake of clarity, the top and bottom voice's bar lengths differ. This makes it easier to show which bars in the upper voice are magnified inversions of which bars in the lower voice. The diagonal thick lines link bars in the upper and lower voice which are related by this augmentation process.[227]

Vertical dotted lines show that any pitch introduced by either canonic voice is absorbed into the 'Resultant Melody'.[228] Through this process of condensation, each pitch introduced in the inversion canon retains its temporal position of attack, apart from when simultaneities occur between the canonic voices. In these instances, one pitch will be made to precede the other in the resultant melody as a grace note. This is the case in bar 90 for instance.[229] In order for these combined attacks to be temporally accommodated for in the 'Resultant Melody', the decays of many pitches must be eroded. This act of decay negation renders the resultant percept as a melody rather than two voices in canon. In addition, since at first the voices occupy a similar register, the pitches produced by the canon initially form a sequence of largely conjunct intervals.[230] As such, at the start of the gesture, this sequence of intervals is perceived as a single melody because the pitches are mostly so proximate.

This manner of constructing melody affords one the option of playing with textural and temporal ambiguities, which I attempted to do through letters E to G. Figure 42c shows the passage as it appears in the score.

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[226] The second iteration of gesture 4, rather than first, has been deconstructed as it provides more insight into how and why the gesture is constructed the way that it is. Figure 4c shows the actual passage as represented in the score.

[227] One may note that the rhythms in the upper voice aren't an exact 11/10 multiplication of the lower voice rhythms. This is because 10:11 is an incredibly close polymetric ratio and therefore it was impossible to both multiply the rhythms exactly and keep the upper voice's tempo and metre the same as the lower voice's.

[228] The term 'Resultant melody' is a nod to Reich's 'resulting patterns' (described and explained in 2.2.6) which are products of phase-shifting. One may note that the use of 10:11 polymetre to gradually bring the canonic voices in phase is notionally similar to phase-shifting.

[229] In this figure, bar numbers refer to those that correspond with the 'Resultant melody' stave.

[230] One may note that, from a technical standpoint, gesture 6 is constructed in such a way that is similar to the manner in which Nørgård's infinity series is. The techniques are similar in that they both require two voices which overlap in register to be pitted against each other in inversion canon. The synthesis of the canonic voices enables a new melody to be produced.

Fig. 42c Letters E – G as written in the score

From letters E to F, one might observe the pedal markings and the voicings. The passage starts with the pedal fully down which gives each pitch a uniform sustain. As such, it is perceived as a monophonic line with added reverberation. At the second bar of E, the pedal lifts to half sustain

towards the end of the bar. Simultaneously, the notation changes to imply two-part counterpoint rather than monophony. By lifting the pedal at this point, and in doing so changing the uniformity of decay length, one can hint that there may be more voices in play than a listener might have initially thought. Furthermore, re-notating the pitches in two voices instead of one encourages the pianist to emphasise the voicings in a way that aids the perception of counterpoint. The passage between letters E and F fluctuates between being notated in one or two voices and the pedal is lifted periodically with the same intent of making the listener question their perception of texture.

The voices separate out in register across the passage and the same material from letter E is restated at letter F. This time, however, the voices are kept at a registral distance. This makes the canonic relationship explicit. I hoped that the listener might hear the distantly spaced canon; notice the similarities in rhythm and pitch interval; realise that letters E to F and F to G are made from the same materials; have their perception of the material transformed; and in doing so experience an illusion.

Between letters F – G, one's sense of time is disoriented by the close 10:11 polymetric canon. Since the ratio is so close, the note-lengths in the upper voice are not judged to be that much longer than the note-lengths in the lower voice, if there is any discrepancy sensed at all. Yet somehow the dux gets gradually closer and closer to the comes. If the note-lengths in both canonic voices are judged to be of the same length and the comes starts after dux, how can the dux catch up to the comes? Arguably, a temporal paradox is produced.[231]

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[231] The idea to create a canon where the dux imperceptibly gains on the comes was inspired by Zeno's Achilles and the Tortoise, and in a way one might regard the above canon as a reverse Achilles and the Tortoise. The paradox imagines a race between Achilles and a Tortoise. According to the paradox, if the Tortoise has a head-start, Achilles will never be able to catch up. The paradox is explained by Hofstadter in an imagined conversation between Achilles and the Tortoise (Hofstadter, 1979) p. 37 – 40. Nørgård has written a piece which tributes this paradox in its title, *Achilles and the Tortoise* (1983). One might note also that the ploy of imperceptibly moving two layers closer and closer together is reminiscent of Reich's phase-shifting.

Fig. 43a Gesture 7 – the above gesture was informed by sections of Łukawski's *Hypnogogia* (2020).[232]

Fig. 43b Scale used in the above passage.

Fig. 43c Chord stacks based on the above scale moving in parallel.

The seventh gesture is a Shepard tone, which first appears at letter C. In *Jab,* this illusion is interpreted as an expressive device with which one can make destructive gestures, as in Stockhausen's *Hymnen* (1966-67). The gesture and its ensuing variants would not exist in their current forms without Adam Łukawski, the dedicatee of *Jab*. During the period in which *Jab* was being extensively redrafted, Łukawski began using Shepard tone rationale to construct pitch sets and chord progressions, as is documented in his masters thesis.[233] Łukawski changed my preconceptions of how

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[232] In *Jab*, I return the dedication that Łukawski affords me in his *Hypnogogia*.

[233] I understand that this masters thesis, entitled 'Periodic Fractal of Shepard-Risset Frequency sets', forms the basis of Adam's PhD research, throughout which he will use Artificial Intelligence as a tool to navigate and select chords and progressions from his vast array of Shepard-Risset Frequency sets. The AI will allow him to produce material and construct pieces extremely quickly and the music which he composes will result from the dialogue between himself and the AI. (Łukawski, 2021)

I thought Shepard tones needed to be constructed with two key pieces of information. Firstly, he pointed out that, as was discovered by Burns in 1981, it is not necessary for Shepard tone scales to be related by the octave. As Burns describes, 'the illusion can be produced using (inharmonic) complex tones whose partials are separated by equal ratios other than octaves', as is evidenced by the fourth region of Stockhausen's *Hymnen*, Risset's *Mutations,* and Tenney's *For Ann Rising*. The same volume fades only need be applied.(Burns, 1981)

For this reason, much of the Shepard tone material in *Jab* makes use of chords, sometimes constructed with stacks of similar intervals, which move in parallel motion. The first iteration of gesture 7, shown in figure 43a, is constructed using the scale shown in figure 43b. Pitches in the scale, which are spaced six scale pitches apart, are stacked on top of each other (taking the first chord stack, if D flat is counted, A flat is six pitches above D flat and D natural is six tones above A flat). Each pitch in the chord stack is then made to conjunctly descend four times through the figure 43b scale. One can see that if each pitch in the last chord stack were to descend a tone in the figure 43b scale, the first chord stack would be produced, except there would be an extra G flat on the bottom which has not been included in the figure. Thus, what Łukawski would call a 'circularity space', a selected portion of the infinite pitch-register continuum within which Shepard tones descend or ascend, is defined.[234]

In addition to pitch circularity spaces, Łukawski has created rhythmic circularity spaces.[235] Just as one can define a pitch register range, one can define a range of rhythmic durations. In the example shown in figure 44, the range is set between a lower limit of crotchet and upper limit of semibreve. One can see that in the top voice, between the D semibreve and B flat crotchet, the rhythmic values of each scalic step decrease by a dotted quaver at a time. These intermittent rhythmic values are points along the durational continuum between crotchet and semibreve, just as a chromatic downward scale is a series of points along the pitch register continuum.

Łukawski pairs the rhythmic circularity space with the 'gravity line', shown in figure 44 by the dotted line. This is a temporal point which rhythmic values decrease toward along the durational continuum.[236] Upon meeting the 'gravity line', the scalic steps reach a minimum rhythmic value (in this instance the crotchet) and then expand back to the initial size of rhythmic value (semibreve). As the 'gravity line' is diagonal, these temporal points of maximum gravity are staggered at regular durational intervals between the voices. The effect is striking because Shepard tone illusions often are

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[234] Since the Shepard illusion does not actually encapsulate but only evokes the infinite pitch continuum, the illusionist must give the illusion upper and lower register limits. As Łukawski points out, this is especially so if writing for an acoustic ensemble which can only produce tones in a limited register range. Łukawski explains further that circularity spaces are defined in part by the intervallic content of each vertical sonority. Indeed, much of Łukawski's fractal is organised according to vertical intervallic content. A circularity space with chords of stacked major seconds might only be comprised of two alternating chords, whereas a circularity space with stacked perfect fifths might have seven or so (Łukawski, 2021) p. 11.
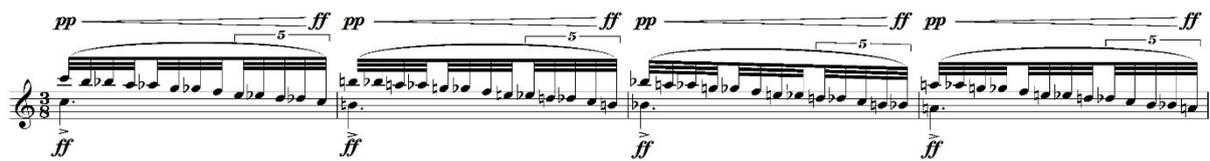
[235] (Łukawski, 2021) p. 21.

[236] Though he doesn't seem to refer to this line as a 'gravity line' in his thesis he has described it to me as such in person (Łukawski, 2021) p. 21.

made with parallel scales which descend or ascend at the same time. Here, the scales seem to accelerate and decelerate independently and yet somehow are still synchronised enough for a Shepard tone descent to be perceived.

Fig. 44 Example of Łukawski's gravity lines. The dotted line represents the gravity line.[237]

After being shown Łukawski's 'gravity lines', I realised that one can simultaneously trigger multiple Shepard tone descents across multiple timescales and that this only serves to emphasise the infinite character of the resultant texture. This can be achieved by simultaneously striking a lower pitch loudly and an upper pitch quietly. If one then plays a rapid scalic descent from the upper pitch which increases in volume and lands with an accent on the next tone downward from the initial loudly struck pitch, one joins this second accented pitch to the first in the beginning of a scale. One can take repetitions of the above-described passage and transpose them down a step on each repetition. In making such a sequence, one sets scales which descend at differing rates in motion, as is demonstrated by figure 45. This tactic is used copiously whenever gesture 7 appears, as is exemplified by the gesture's first appearance at bar 33, shown in figure 43a. One can see that the first G flat triggers two scales descending in two timescales, one at the semiquaver rate and the other at the quaver rate. This multiplying effect increases the number of simultaneous scales in motion and makes the illusion seem even more infinite.


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[237] The example is derived from a set of durations provided by Łukawski which he uses to describe a certain rhythmic circularity space (Łukawski, 2021) p. 21.

Fig. 45 Two examples of scales descending in different timescales.

The Shepard tones of gesture 7 are always paired with Risset rhythms. At bar 33, for instance, *ritardandi* slow the tactus considerably and metric modulations double the tactus once a minimum metronome mark has been reached. As figure 43a shows, in bar 33 the crotchet beat slows from 150 to 52 across 6 beats, doubles to 104 immediately after and slows to 60 across 4 beats, and finally doubles again to 120 and slows to 60 across another 4 beats. Whilst scalic layers slow, faster and faster subdivisions of the crotchet beat fade in but begin slowing as well. Where the subdivisions of the beat cannot get any faster, glissandi are used (see bar 36). These coupled illusions grant gesture 7 a characteristic sense of intensification.

I describe the eighth and final gesture as a polymetric Necker Cube. The Necker Cube is a visually ambiguous percept.[238] As figure 46 shows, the cube may be perceived from two contrasting and conflicting perspectives. Possible aural analogues might be found in complex polymetric music. Matheus de Perusio's *Le Greygnour Bien* (1406 – 1408), a typical *Ars Subtilior* piece, is one such example. One can hear multiple meters coexisting in a single auditory percept but, without specialist knowledge, one is unsure as to exactly how the polyphonic lines stays together and adjourn at the cadence points. Passages of Xenakis's *Pithoprakta* (1955 – 56) also point to ways in which polymeter can be used to create illusion. In the passage bar 175 – 185, dense polymetric layers of pizzicatos, notated as triplet crotchets, quintuplet quavers, and quavers are overlaid.[239] All sense of pulse is destroyed. Then, the triplet crotchet and quaver layer fade out and the quintuplet quaver layer remains: periodicity illusorily emerges from aperiodicity and an appearance illusion is created with polymeter.
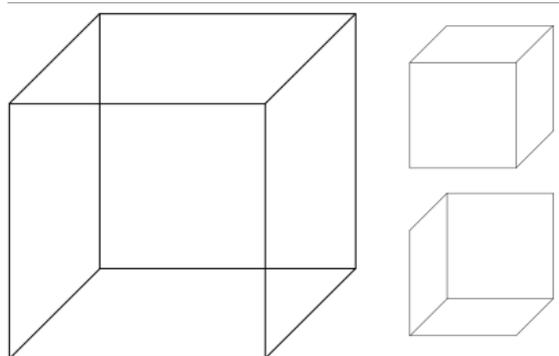

Fig. 46 The two ways in which a Necker Cube may be viewed.[240]

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[238] The phenomenon was first documented in 1832 by Louis Albert Necker (Necker, 1832).
[239] (Xenakis, 1956) Pp. 28 – 29.
[240] (*Necker's Cube*, n.d.)

Though the passage from Xenakis differs in effect from the Necker Cube, it provided clues as to how one might use polymeter to create aural analogues of the Necker Cube. The passage from *Pithoprakta* uses volume fades as a means of eliminating the triplet crotchet and quaver impulses and focussing the listener's aural attention on the quintuplet quaver. It is also possible to use the opposite, increasing the volume of a polymetric voice, to yield illusion. Where gesture 8 first appears, the pianist's hands are put in close polymetric relation. By increasing the chord density in one hand whilst reducing the chord density of the other, one can force the ear into hearing a change of polymetric perspective. In bar 195, where the left hand increases in chord density, the slower pulse becomes heard as more dominant. Then, through bars 196 – 198, the left hand thins and the right hand increases in chord density, so the faster pulse is heard as more dominant. Here, and in other appearances of gesture 8, the listener's perception of meter is illusorily transformed.
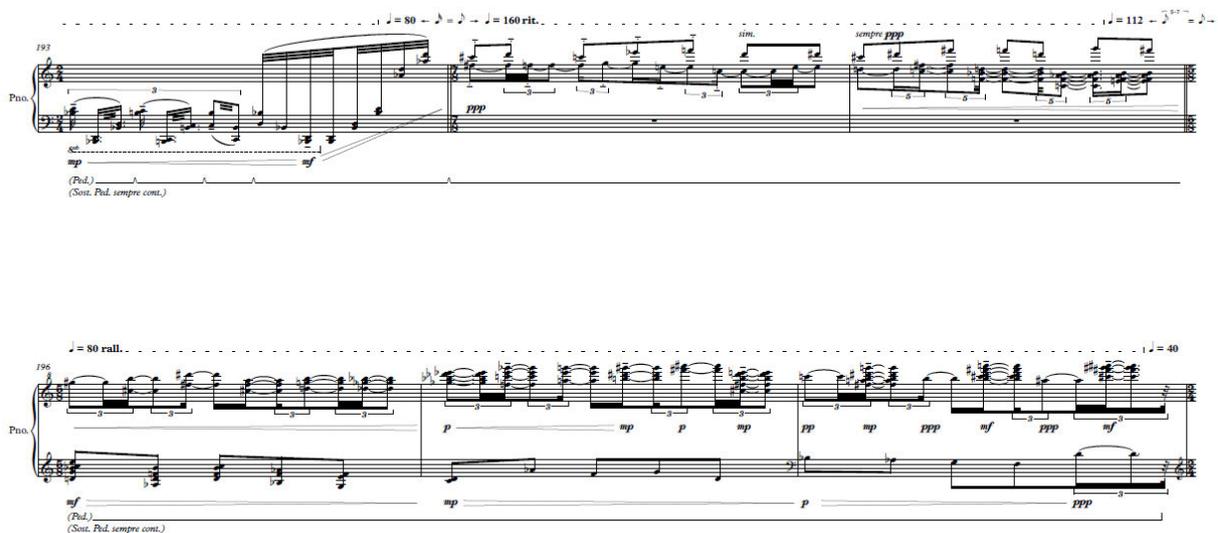
Fig. 47 First appearance of gesture 8, the polymetric Necker Cube, in bars 194 – 198.

3.5.2 TWO VERSIONS

When composing music which is intended to sound as if it is impossible, one risks composing music that *is* impossible. In this instance, I have, in the pursuit of making seemingly impossible music, composed passages in *Jab* which are literally impossible. As such, two versions of the piece exist: one for pianist and another for player piano.[241] In the version for solo pianist, the score foreword acknowledges that the fastest tempi marked are merely ideal tempi. The pianist should decide their own maximum tempi and then scale the other tempi in the piece accordingly, just as Stockhausen requests in each *Klavierstück* (1952 – 1984). Following Xenakis in the score of *Evryali* (1973), I also allow the performer to edit or omit details of passages which are literally impossible, as long as the

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[241] Ligeti's *Vertige* (1990) is a precedent to *Jab* in this respect. Interestingly both *Jab* and *Vertige* aim to create Shepard tone scales and it is the Shepard tone passages which are the most unrealistic in *Jab*.

performer aims still to convey the intent of that moment to the best of their ability. An example of how a performer might manage this is provided as a separate score in the portfolio. Markings are made in this score by the pianist playing in the recording, Ben Smith, who adjusted the relevant tempi and made deletions or edits to certain passages. Somehow, the recording sounds phenomenally fast and still as detailed as the player piano recording provided. On hearing the recording, one is reminded that, in a certain sense, all composers interested in speed and/or virtuosity are interested in illusion, or at least perception. As there is an upper limit to a human's virtuosity/playing speed, Liszts and Rachmaninovs have constantly danced the line between writing that which is beyond a performer's means and that which allows a performer to convey what should lie beyond human limits. Such is the dazzling and astonishing effect of virtuosity.

3.5.3 CONCLUSION

Jab represents a significant departure in the formal aspect of my research practice. Though I had worked previously with multiple illusions in a single piece, they would previously have had to be rigidly bound together with some sort of scheme or technique in order to conform to my research framework. In *Jab*, multiple seemingly unrelated illusions are combined together. The interaction between illusions and their development through the harmonic framework creates narrative. The illusions gain significance through interplay.

The arc of each idea's development is not as linear as that found in Reich's *It's Gonna Rain* (1965) or *Drumming* (1971) or even a Bach fugue. Nor is each statement of every gesture purely illusive in effect. Each gesture is treated somewhat traditionally, as a raw musical material. Every aspect of each gesture that I found to be musically developable was inspected and made use of. One might make the following description of the piece's *modus operandi*:

1. Multiple illusory gestures are presented.
2. The gestures interact and weather each other.
3. The materials which result from the interaction of gestures are driven into differing situations, some of which are more illusory than others.

This piece's structure differs from the formal models advocated in my research framework. Nevertheless, *Jab* is a vital part of my research. The act of composing *Jab* has encouraged me to reconceptualise my definition of musical illusion once more. One might think of a musical illusion not as an idea, texture, or gesture, though it may appear as all three, but instead a musical *behaviour* which any piece of musical material may be manipulated to exhibit when the right criteria are met.

3.6 GEORGIMORPHOSIS

    Partway through my studies, I was invited by a baroque flautist to create a piece for her. She introduced me to the Telemann solo fantasias for "transverse flute", which extensively use stream segregation illusions to imply polyphony.[242] The drafts that I originally produced were too chromatic for the instrument, and so I thought it best to start with the diatonic materials found in the Telemann fantasias themselves. Telemann's first name is Georg and the prospect of composing a piece built on quotations by other composers named George seemed an amusing concept. The piece which resulted, *Georgimorphosis*, is a collage of the quotations, which have been excerpted in figures 48 – 58. They are: Ligeti's *Six Bagatelles for Wind Quintet* (1953), Ligeti's *Violin Concerto* (1990, rev. 1992), Benjamin's *Into the Little Hill* (1996), Enescu's *Symphony 5* (1941 – 46), Haas's *Finale* (2004), Telemann's *Fantasias* 2, 3 and 5 (1727 – 1728), Handel's *Messiah* (1741), Handel's *Music for the Royal Fireworks* (1749) and Gershwin's *Rhapsody in Blue* (1924).[243] The quotations are transformed into each other, in the same way that frogs, birds, lizards and fish are metamorphosed between in Escher's *Verbum (Earth, Sky and Water)* (1942).[244] Much of the material was composed for the baroque flute but, before the piece's completion, the flautist found that she was unable to continue engaging with the project. On inspection, I fortuitously found that much of the material suited the clarinet, which has a greater capacity for chromaticism than the baroque flute and a great range of extended techniques on which one can draw. So, the piece was reworked for solo clarinet.

    Musical transformations, in themselves, are not considered illusory. In much western repertoire, particularly that of the romantic and late romantic periods, transformation through development has become synonymous with many a work's *raison d'être* and has seldom become associated with illusion.[245] Indeed, even Escher's metamorphoses in *Verbum* would not be considered illusory if the subjects of transformation were not distinct objects (frogs, birds, lizards and fish). Here lies the key to illusory transformation: in order to be considered illusory, transformation must occur between objects. With acoustic instruments, sonic analogues of Escher's metamorphoses are only achievable with quotations, because quotations have been objectified and rendered as ontologically autonomous entities by the reifying properties of canon and history.[246] I decided, therefore, to treat the compiled

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[242] Bregman notes in Bach's solo cello and violin sonatas a similar use of register-dependent stream segregation illusions. (Bregman & Campbell, 1971) p. 244

[243] In the same way that Finnissy credits his source materials in a score like *The History of Photography in Sound* (1995 – 2001), I have marked the appearance of each quotation in *Georgimorphosis* (C. Miller & Finnissy, 2017) p. 61.

[244] (*Transformation Prints*, n.d.)

[245] Nowhere in Schoenberg's *Style and Idea* (1950) is there any mention of illusion, at least in connection to developing variation (Schoenberg, 2010).

[246] In electroacoustic music it is possible, with the powers of cross-synthesis, to metamorphose distinct timbre objects into each other, such as a scream into birdsong at the start of Wishart's *Red Bird* (1973 – 77) (Wishart, 2015).

quotations as *objets trouvés*, in the manner of Finnissy, Adès or Kurtág, and compose illusory metamorphoses between the found objects. [247]

**Fig. 48** Melody from Ligeti's *Six Bagatelles* (1953).[248]

Fig. 49 Melody from Ligeti's *Violin Concerto* (1990, rev. 1992).[249]

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[247] *Objets trouvés*, a term which originates from the visual arts, are 'existing objects, manufactured or of natural origin, used in, or as, works of art… [T]he *objet trouvé* is most often used as raw material in an Assemblage, with juxtaposition as a guiding principle.' (Gale, 2009). An example might be Kurt Schwitter's *Construction for Noble Ladies* (1919), which uses wood, metal, leather, cork, paper, oil, gouache on paper on wood, and a tin funnel to make the piece. *Musique concrète* pieces such as Schaeffer's *Cinq études de bruits* (1948), which uses sounds of trains, toys, canal boats and sauce pans, or Cage's *Williams Mix* (1952 – 53), a tape collage of city, country, electronic, manually produced, wind and amplified 'small' sounds, might be considered direct musical analogues to the above described art pieces (Ross, 2008) p. 402. Composers such as Kurtág, Adès and Finnissy have afterwards expanded the definition of *objets trouvés* to include sounds found in existing art music and frequently treat quotations as raw materials that are to be composed with. Kurtág's *Stele* (1994) bursts forth from the first sonority of Beethoven's *Third Leonora Overture* (1806) (Kurtág & Varga, 2009) p. 50. His *Officium Breve* (1988 – 1989) uses both Webern's *Kantate no. 2 op. 31* (1941 – 43) and a quotation from his teacher Szervánsky's *Serenade for String Orchestra* (1947 – 48) (Frandzel, 2002). Adès's *Arcadiana* (1994) is peppered with references to Mozart's *Die Zauberflöte* (1791), Schubert's *Auf dem Wasser zu singen* (1823), Debussy's *L'Isle Joyeuse* (1904), and genres such as tango (*Arcadiana / Faber Music*, n.d.). In his *English Country Tunes* (1977/82 – 85) and *Verdi Transcriptions* (1972 – 2005), Finnissy uses the materials referenced in his titles. He describes the act of composing with materials in such a way as acts of musical photography or portraiture and compares his compositional practice to that of folklorists such as Granger and Bartók (C. Miller & Finnissy, 2017).
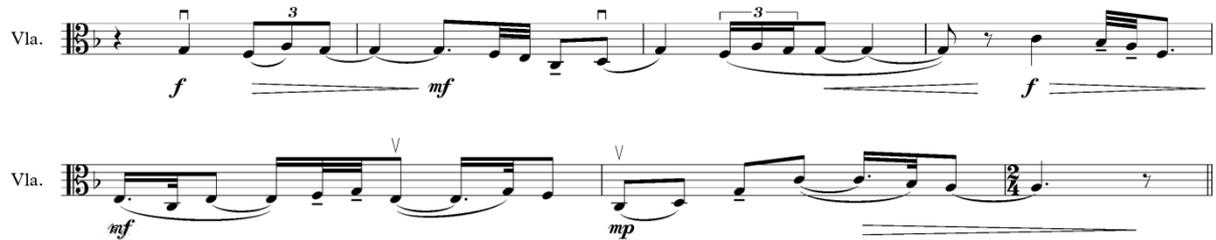[248] (Ligeti, 1973) pp. 13 – 15
[249] (Ligeti, 2002) p. 26
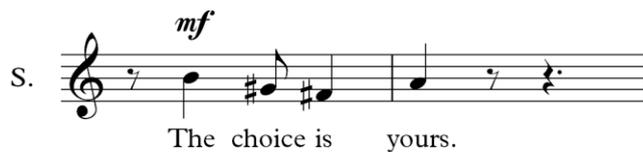
The choice is yours.

Fig. 50 Motive from Benjamin's *Into the Little Hill* (1996).[250]

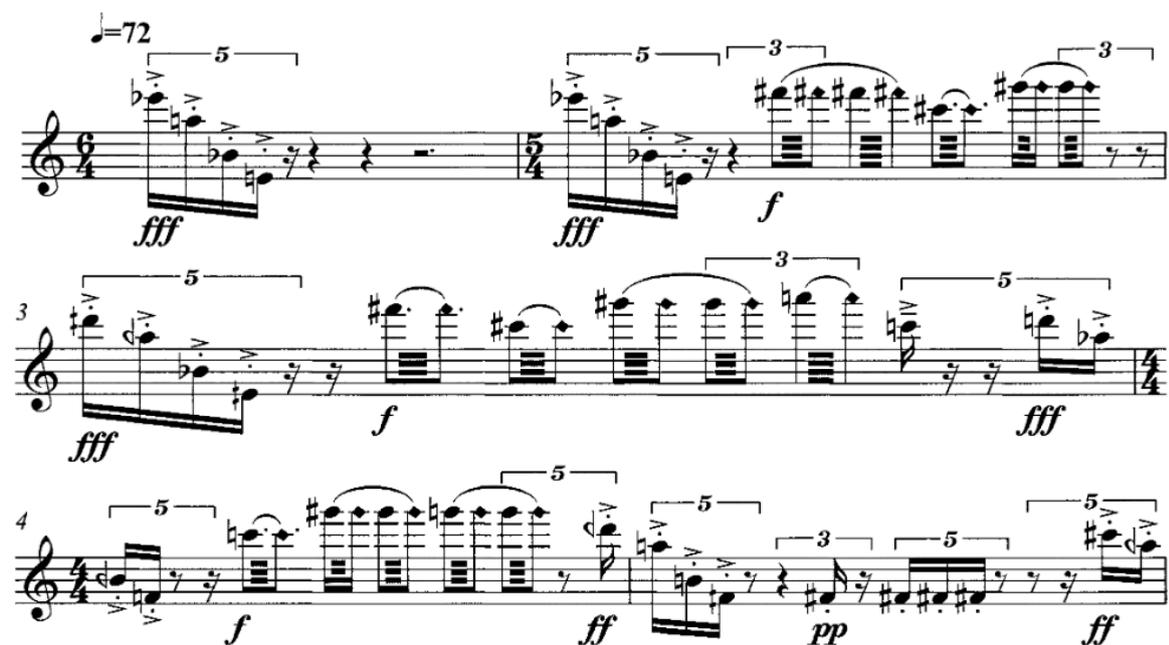
Fig. 51 Melody from Enescu's *Symphony no. 5* (1941 – 46).[251]

Fig. 52 Opening of Haas's *Finale* (2004).[252]

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[250] The reference is to a four-note motif first sung by The Stranger in bar 207 of *Into the Little Hill* to the words "the choice is yours". (Benjamin & Crimp, 2008) pp. 29 – 30.
[251] (Bauer & Kerékfy, 2017) p. 70
[252] (Haas, 2004) p. 1

Fig. 53 Opening of Telemann's *Fantasia 2* (1727 -28).[253]

Fig. 54 Opening of Telemann's *Fantasia 3* (1727 - 28).[254]

[253] (Telemann, 1987b) p. 4
[254] Ibid. p. 6

Fig. 55 Opening of Telemann's *Fantasia 5* (1727 - 28).[255]

Fig. 56 From the *Hallelujah* of Handel's *Messiah* (1741).[256]

Fig. 57 Overture to Handel's *Music for the Royal Fireworks* (1749).[257]

Fig. 58 Clarinet solo from Gershwin's *Rhapsody in Blue* (1924).[258]

One may note that this group of quotations exhibits a high degree of stylistic variance. Baroque, jazz, folk modalities, and 21st century works are referred to. On closer inspection, however, clusters emerge from the pool of objects. For instance, both melodies from Ligeti's *Six Bagatelles* and his

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[255] (Telemann, 1987b) p. 10
[256] (Handel, 2018) pp. 176 – 177
[257] (Handel, 1962) pp. 1 – 2
[258] (Gershwin, 1988) p. 1

Violin Concerto are incredibly similar (see figures 48 and 49), as are they both to the quotation from Enescu's *Symphony no. 5*, excerpted in figure 51.[259] The Telemann and Handel pieces form another cluster, linked by a common audible baroque-ness. The outliers, Gershwin, Benjamin and Haas have little in common with the other quotations, although Benjamin's 4 note motive is easy to relate to the Ligeti melodies because of its modal flavour, and the Haas makes extensive use of timbral trills, which baroque flute players commonly use to ornament the Telemann fantasias.[260] These collected *objets trouvés* lie on a spectrum of difference and similarity. This spectrum is used to grade the transformations and pace the piece. As such, the metamorphosis between Ligeti and Enescu melodies takes place near the beginning of *Georgimorphosis*, because the degree of change between these three melodies is much less than would be required for the transformation between Ligeti and Handel or Gershwin, which all appear towards the end of the piece (*Rhapsody in Blue* at bar 300, *Messiah* at bar 303, and *Fireworks Music* at bar 310).[261] As *Georgimorphosis* progresses, objects which are more markedly different in terms of style, modality/tonality, and pitch/rhythmic content emerge. The appearance of Handel, Gershwin, Telemann and Haas sustains one's interest in the piece and exacerbates each transformation's illusory effect. One is left wondering how such distinct objects can be produced from the same point of origin, Ligeti's *Six Bagatelles* melody.

These stylistically diverse quotations range from the recognisable to the obscure and so they lie on another spectrum of recognisability. Compared to the Telemann, Handel and Gershwin quotations, the Enescu (being from a posthumous work), Haas, Ligeti and Benjamin are relatively obscure, although the Ligeti might arguably be more well-known. Recognition is another important factor in the perception of transformation illusions. In Escher's *Verbum*, it is the recognition that frogs, birds, lizards and fish are distinct objects which allows one to perceive the tessellating shapes in between to be the interim states of metamorphosis. Why then, choose such obscure quotations, if selecting more recognisable objects could make the effect of illusion more obvious? I believe that it is not entirely necessary for one to know these objects intimately for these illusions to work. One only need recognise that they are distinct objects, that a frog is something different to a fish. Their distinction is made apparent by the stylistic contrasts presented by the objects. The solidification of A minor, arpeggiating figures and semblance of melodic sequence at bar 181 age the material enough for a

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[259] Julian Anderson brought the similarities between these melodies from Ligeti and Enescu to Richard Steinitz's attention in August 2014, suggesting that both melodies were derived from the same folk source. Steinitz, crediting Anderson, gives a detailed analytical comparison of the melodies in a book curated by Bauer and Kerékfy (Bauer & Kerékfy, 2017). Steinitz shows the melodies from Ligeti's *Violin Concerto* and Enescu's *Symphony no. 5* are similar in modality and are assemblages of incredibly similar motivic cells, thought those cells appear in varying orders and contrasting rhythmic guises. The melody is also used in Ligeti's *Musica Ricercata* (1951 – 53) (Ligeti, 1995), which his *Six Bagatelles* are essentially arrangements of. His *Viola Sonata* (1991 – 94) uses motives from the same melody (Ligeti, 2001) p. 12.

[260] Baroque flautists say finger vibrato instead of timbral trills, the method of which is detailed in Hottetterre's treatise on flute playing (Hotteterre, 1983).

[261] The *Bagatelles* melody transforms into the *Violin Concerto* first, at bar 37. Not long after, in bar 72, the material has morphed into the Enescu quotation.

listener to be aware that a baroque object has been metamorphosed into. At bar 105, the Haas quotation is arrived at, and although the listener may not know Haas's *Finale* even exists, they may be aware that the previous folk modalities of the Ligeti and Enescu have been departed from and that the timbral/microtonal trills and sequence of fourths, fifths and sixths are the components of *some quotation*. One might argue then collecting objects in varying styles and with differing degrees of recognisability enhances the palpability of these transformation illusions by providing contrast and so emphasising each object's distinctness.

3.6.1 METHODS

To audibly render these transformation illusions, one requires the appropriate compositional methods. It is important that listeners are not immediately made aware that transformation processes have already been set in motion. Such methods are found in the work of Donatoni. The methods which proved useful are excerpted below:

> "(1) the general principle of *rilettura* whereby the previous section of music is reread and varied either through new articulation, a new element added, an existing element taken away, or multiplied; (2) manipulation of duration through a mixture of symmetry and asymmetry (e.g. in the opening section [of *Nidi* for piccolo (1979)] the main notes are always in groupings of quavers, thus, 2-1-1-2-1-1 etc., while the intervening rests are irregular, in semiquavers, 6-2-5-2-4-7-2-8-3-1-3-6-5-1-7-2-8-3-1-1;[…] (4) the specific extension of interval groups to new pitches e.g.: (5) the grace-notes which deflect sense of pulse, regularity and accent; […] and (7) the new characters created by pitch re-articulation, e.g. the grace-notes of section 4 [of *Nidi*] transformed into the 'real' notes of section 5."[262]

The concept of *rilettura* has minimalist potentials. It requires one to repeat passages so that they may be varied. Out of context, and minus the element of multiplication, one might think the point on *rilettura* could be describing Reich's gradually transforming cells in *Music for 18 Musicians* (1974 – 76). The difference is a matter of change rate: Donatoni transforms faster than Reich. Both figures' ideas regarding metamorphosis influenced the development of *Georgimorphosis*.

Loosely, the other transformative techniques could even be described as ways of ornamenting material, or at least it is possible to apply them ornamentally. Here is an important aspect of deception in *Georgimorphosis*. In much music from many traditions, one expects to hear the ornamentation of melodies. This might especially be the case in pieces for solo instruments, which typically showcase

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[262] (Gorodecki, 1993) p. 249.

an instrumentalist's artistry. Since ornamentation is par for the course, and typically only fulfils a function of decoration, one does not expect ornamentation to be a force of illusory transformation. Ornamentation therefore fulfils the requisite double function of being both an agent of and a disguise for the illusive transformations between *objets trouvé*. It allows these magical metamorphoses to hide in plain sight.

The form of Georgimorphosis, shown in figure 59, is built on interplay between 2 types of material. The first, exemplified by section A, is slow, generally aperiodic and has plenty of rests which temporally space out the material. The use of trills between harmonics, multiphonics and slap-tongues is stylistically indebted to Sciarrino's *Let me die before I wake* (1982). The second kind of material, seen in section B, starts as Ligeti's *Six Bagatelles* melody and is generally pulsed (though the pulses are not always periodic), melodic and faster. Originally, the B sections formed one flow of material and were composed as such. This first draft was too relentless and didn't allow the clarinettist adequate time to breathe. When revising the piece for solo clarinet, I composed the A sections as inserts which would explore more of the clarinet's range, capacity for extended techniques and give the clarinettist more time to breathe. The A sections also give the piece contrast and variety.

Section/*Rilettura*	Bars	Quotations
A	1 – 18	N/A
B	19 – 27	Ligeti *Bagatelles*
Bi (expansion)	28 – 60	Ligeti *Bagatelles*, Ligeti *Violin Concerto*
Bii	61 – 108	Benjamin *Into the Little Hill*, Enescu *Symphony 5*, Haas *Finale*
Ai	109 – 137	N/A
Biii	138 – 212	Telemann *Fantasia 5*, Telemann *Fantasia 2*
Aii	213 – 231	Handel *Messiah*
Biv	232 – 240, 264 – 309, 313 – 315 (end)	Telemann *Fantasia 3,* Telemann *Fantasia 5,* Handel *Messiah,* Gershwin *Rhapsody in Blue*
Aiii	241 – 263, 310 - 312	Handel *Messiah,* Handel *Fireworks Music*

Fig. 59 Formal structure of *Georgimorphosis*.

Sections A and B are read and reread according to the *rilettura* principle, which produces variations on each type of material, as is shown in figure 59. *Riletture* occur across broader scales than are typically found in Donatoni's work and function so that, on each rereading, different portions of

material are successively transformed to increasingly resemble the next quotation. These *riletture* facilitate the transformation of materials in the same way in which tessellations in Escher's *Verbum (Earth, Sky and Water)* (1942) allow one to see gradations of transformations between objects.

One such graded metamorphosis is shown across figures 60 – 64. Figure 60 shows section B and figures 61 – 64 show its varied repetitions. These figures describe the ways in which Donatoni's methods are illusorily applied through these repeated passages and generally throughout the piece. For clarity, the terms "target object" and "origin object" are introduced here. The former describes quotations that materials have transformed into, and the latter refers to quotations/materials which other quotations have transformed out of. This use of terminology shows a fundamental difference between mine and Donatoni's use of *riletture*. My *riletture* are directed by the transformation of one quotation into another, whereas Donatoni's transformations are non-teleological, and he has 'no predetermined idea of form, the form emerges'.[263] Due to this contrast in compositional intentions, some modifications to Donatoni's methods needed to be made. The modifications are as follows:

(1) The same general principle of *rilettura* as Donatoni's but, in this piece, the transformation of origin objects into target objects directs the manner in which the material is read and reread.

(2) Manipulation of duration but according to the set of durations included in the target object, instead of symmetry or asymmetry. By this, I mean that if a tone lasts a dotted quaver in Telemann's *Fantasia 3* and the tone from which this tone originates in previous *riletture* is either shorter or longer than a dotted quaver, then the tone of origin must be successively elongated or truncated so that when Telemann's *Fantasia 3* is arrived at, the target tone is the correct/a more similar length. If a tone need be eliminated, then its duration may progressively be diminished until it is the length of a grace-note, after which it will be removed.

(3) Derived from Donatoni's methods (4) the specific extension of interval groups to new pitches and (6) the progressive replacement of one pitch with another. In order for one quotation to transform into another, often one must quite drastically change the intervallic content. As Escher and Reich show, in order for illusions to be experienced, gradations of change are required. In order to show these gradations, *glissandi*, microtones and microtonal trills are used to, as Donatoni might describe, extend the intervals/progressively replace the pitches of one quotation to/with another. Similarly,

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[263] (Ford, 1993) p. 120

between successive *riletture*, pitches are moved steps upwards or downwards so that
the intervallic content of a target object can be progressed towards.

(4) Derived from Donatoni's (5) and (7). If a target object possesses a pitched impulse
that the origin object does not, these missing pitched impulses are added to the origin
object over successive *riletture* in either grace-note form or as very small durations. In
succeeding *riletture*, in the fashion of Donatoni, the grace-notes are transformed into
'real' notes. Often these newly transformed notes will have their durations
manipulated in the manner described in method (2).

In the figures that follow, underlined and bracketed numbers will show where any of the above
listed techniques are being used.

Fig. 60 *Rilettura* B begins with the quotation from Ligeti's *Six Bagatelles*. Method 4 is used and grace
notes begin adding pitches which are needed to form the target object while resembling standard
melodic ornamentations.

Fig. 61 *Rilettura* B is reread as *rilettura* Bi. This *rilettura* begins with a re-reading of the figure 60
passage. In this second incarnation, the rhythmic values are progressively augmented or diminished,
as per method 2, so that the quotation begins to resemble Ligeti's use of the same melody in his *Violin
Concerto*. By bar 37 the rhythmic re-adjustments have been adequately made so that the melody can

continue in its *Violin Concerto* form and as such the *rilettura* is lengthened. The lengthening of the *rilettura* area allows for a greater selection of materials to be transformed and so a greater variety of quotations can be produced.

Fig. 62 This third incarnation of the same section from *rilettura* Bii is rhythmically transformed further. Although every successive *rilettura* is transformed in accordance to method 2, here one may draw particular attention to bars 61 – 62, which have been transformed into a reference from Benjamin's *Into the Little Hill*.[264] In this rilettura, the transformation towards Telemann's *Fantasia 3* begins to become more evident, particularly in bars 64 – 65. One may note the processes of transformation by comparing bars 20 – 22 from figure 60, bars 29 – 32 from figure 61 and bars 64 – 67 in this figure. Grace-notes are made real and short note values added, as per method 4, and the pitch content incrementally changed to resemble bar 2 of *Fantasia 3*, as per method 3.[265]

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[264] (Benjamin & Crimp, 2008) pp. 29 – 30.
[265] (Telemann, 1987b) p. 6.

Fig. 63 In the fourth incarnation of the same passage, from Biii, the first bar of the *rilettura*, starts to shrink in duration and the materials which will become the *Fantasia 3* quotation, bars 140 – 144, begin to grow in duration. In bars 145 – 152, the durations have been manipulated to make additive rhythms. These have not yet featured so prominently and renew interest in the piece. These additive rhythms are transformed in bar 264, shown in figure 64, where the *Vivace* material from *Fantasia 3* is referred to.[266] Though the transformation in this case is less gradual, certain shared characteristics, such as the upward semitone *glissandi*, link the passages. One can also read the dotted-semiquaver-demisemiquaver-semiquaver figure in bar 264 as a shrunken, distorted version of the quaver-semiquaver-quaver figure in bar 145.

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[266] Ibid. p. 6 bar 3.

Fig. 64 In the fifth and final incarnation of the passage, from Biv, the transformation to Teleman's *Fantasia 3* is completed. Though the Ligeti *Six Bagatelles* melody is no longer audible, traces of the previous *riletture* remain. The grace-notes in bar 232, G flat and E flat leading to F, are a shrunken version of the Benjamin four-note motive in bars 61 – 62 (see figure 62), though the third of four tones has been removed. The Benjamin reference is in itself a rhythmically altered version of the first three tones in the Ligeti melody with an added G flat, and this G flat had been planted as an *appoggiatura* in bar 28 (see figure 61). These remaining traces of previous materials remind one of the transformative processes that have taken place in order for these transformed materials to exist in their present state.

There are three additional ways in which materials are transformed in *Georgimorphosis* and these are used primarily in the A *riletture*. The first method plays on what one typically associates with certain categories of instrumental sound. Figure 65 shows the quotation from Handel's *Fireworks Music*, the climax of *Georgimorphosis*. In this passage, the quotation is created by joining the fundamental tone of each multiphonic together. Prior to this passage, multiphonics, including those in the passage below, have been used frequently in the A *riletture* but have either been reordered or interspersed with other materials. I intended the effect of restating these multiphonics in varying

orders to mirror the effect of Jonty Hurwitz's anamorphic sculptures. When viewed from a specific vantage point, his *Vanquished Co-founder* (2010) forms a clown face and yet the image disintegrates when one moves from this vantage point.[267] Similarly, the multiphonics do not resemble anything in their initially disordered state, and yet, when shuffled into the right order, they form the Handel quotation.

Fig. 65 The assembled *Fireworks Music* quotation.

In this circumstance, style is used to misdirect.[268] The use of multiphonics in conjunction with other extended techniques, including harmonic tremolos, slap-tongues and keyclicks evokes Sciarrino's *Let me die before I wake* (1982)*,* as previously mentioned. The allusion is deceitful because *Let me die before I wake* does not use quotations and to do so would be apparently anachronistic. As such, when the Ligeti quotation enters at bar 19, the listener's expectations are subverted and the scope of *Georgimorphosis,* its purpose and signification, is widened and changed. Furthermore, one does not typically associate Handel with multiphonics and the use of multiphonics to form the *Fireworks Music* quotation is unexpected. One may direct and subsequently shatter a listener's expectations by alluding to certain styles.

The second additional method is the use of the Wessel illusion to transform material into quotations.[269] As is shown in figure 66, passages of *Georgimorphosis* work with three-note repeated

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[267] (Hurwitz, 2010)
[268] See 2.4 for an explanation of misdirection.
[269] See 2.2.1 for an explanation of the Wessel illusion and auditory stream segregation.

cells. These relate to the tremolo harmonics that begin the piece, as the tremolos are typically between three repeated tones. The figure below shows how certain tones are isolated from the repeating sequence with accents, key clicks, slap-tongues and transpositions up or down octaves. The isolated tones form the Hallelujah from Handel's *Messiah* in two separate voices, and, at the same time, one auditory stream is split into three in counterpoint.

Fig. 66 Handel's *Hallelujah*, formed from the Wessel illusion.

Finally, there is the formation of the penultimate Handel quotation at bar 303, where accented octave leaps form another motive from Handel's Hallelujah chorus. Similar to the above Wessel-inspired illusion, these accented octaves are distinctive enough to separate the figuration into two streams in counterpoint: the octave leaps are grouped into one stream and the rest of the figuration into another. The seeds of this quotation are sewn at bar 19, the beginning of section B, where an accented high E flat grace-note leaps down an octave and begins the Ligeti melody (see figure 13). Just as the multiphonics which form the *Fireworks Music* quotation permeate the A *riletture,* these accented octave leaps are scattered through the B *riletture*. At first, they appear between lengthier periods. After the first at bar 19, the next appears at bar 42. Increasingly, through the B *riletture*, they appear at shorter and shorter periods until bar 303, where the Handel quotation is formed for them. As seen from figure 21, as well as dwindling in distance between each utterance, up until bar 303, the octave leaps spell out, at least in approximate contour "we shall live for" from the quoted motive. The manner in which this device is introduced provides a deceitful context to this illusion. The first accented octave leap at bar 19 is an interruption to the preceding Sciarrino-esque material and as such the listener assigns a function of "interruption" to the sonority. Then, through the gradual increase in frequency of reiteration and after a statement of the quotation proper at bar 303, the true function of the interjections is revealed. One might consider this method of illusorily assembling a quotation to be an amalgamation of the two previous. The quotation is communicated with the aid of auditory stream segregation and brought into focus by bringing each accented octave leap closer and closer together. The effect is similar to stepping into the sweet spot of an anamorphic sculpture.

Fig. 67 Handel, Messiah quotation created by accented octave leaps. Speech in quotation marks has been added to the figure to show where the quotation is and is not an instruction to the performer.

Fig. 68 The accented octave leaps are shown to spell out, at least in contour, "We shall live for" from the *Messiah* quotation.

3.6.2 CONCLUSION

Georgimorphosis is perhaps one of the most illusive pieces in the submitted portfolio. The reliance on *objets trouvés* and single-minded pursuit of one illusory effect imbues the piece with a

communicative clarity. In this sense, it is more similar to *After Images* than *Jab*.[270] Like *After Images*, *Georgimorphosis* uses a variety of transformative methods which obscure each other and counter theories which a listener might make regarding the methods of illusory transformation.[271] With these mixed methods, derived mainly from the work of Donatoni, the piece aims to evoke the state of belief-discordant alief in the listener.[272]

Just as Donatoni's non-illusory methods of transformation have been taken and reinterpreted so that they yield illusion, the above methods of illusory transformation may provide fresh tools for melodic development. If one observes figures 60 – 64, particularly 62 – 64, one can observe creative and unexpected contours and gestures in the interim states between origin and target objects. The use of one found object to distort another results in a process which is not unlike Boulez's process of chord multiplication; though in this case the product is not so much the superimposition of transposed pitch sets but a cross-fertilised mutation of two melodies which retains characteristic of both.[273] One might potentially use these by-products of multiplicative distortion to relate all kinds of composed materials to each other.

Yet, in *Georgimorphosis*, where these methods are illusorily applied to found objects, one is encouraged to consider and question the moment of recognition in the musical experience. What is it as a cognitive experience? How does such an experience change one's investment in a piece? Is the recognition of style, quotation, device or illusion necessary for a work to be engaged with? These are all questions which the piece posits.

Lastly, *Georgimorphosis* becomes ontologically interesting in the light of previously drawn conclusions. If one considers that illusions are not so much sounds but behaviours which can be performed by sounds, then what happens when these behaviours are performed by distinct, autonomous objects?[274] Perhaps the composition of illusory metamorphoses between these *objets trouvés* triggers one last transfiguration in the piece. In imbuing these quotations with illusory behaviours and therefore actions, objects become subjects. The sound materials become performative in their nature and, in doing so, mimic the living. This conceptualisation of sound and process as action has personally opened new compositional fields and different ways of understanding material. The work becomes a situation in which materials operate as characters. The composer's role then becomes the actualisation of these characters' actions within the context of the work. This idea of sound as subject crystallises in *Georgimorphosis*.

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[270] Georgimorphosis was sketched in its baroque flute incarnation after *Ghoulish Airs* was completed but then recomposed for clarinet after the completion of *Jab.* As can be seen in 3.5, I realised the advantages of contrast through the composition of *Jab*, which encouraged me to add A sections/*riletture* to the piece.

[271] See 2.4 for discussions on the importance of neutralising suspicion in a magical performance.

[272] See 2.4 for an explanation of belief-discordant alief.

[273] An explanation of chord multiplication can be found in Tom Coult's article on Boulez's *Sur Incises* (Coult, 2013).

[274] I describe illusion as a sound behaviour first in subsection 3.5.3 in the conclusion of the *Jab commentary*.

3.7 WITHERBUD

> 'For what is the shadow of the going in which we come, this shadow of the coming
>
> in which we go, this shadow of the coming and going in which we wait, if not the
>
> shadow of purpose, of the purpose that budding withers, that withering buds,
>
> whose purpose is a budding withering.' (Beckett, *Watt*)[275]

I was selected for the 2020 – 2021 London Philharmonic Orchestra scheme led by Brett Dean. He tasked us to compositionally respond to coronavirus-induced periods of lockdown that we and the wider population experienced with an 8-minute quasi-orchestral piece (double winds and brass but 3. 2. 2. 2 strings), entitling the concert at the Southbank Centre "Bunker Music". The above quotation, in which Beckett ties the concepts of coming, going, waiting, withering and budding into a linguistic Möbius strip, inspired introspection into the exhaustive cycles of lockdown and release that society collectively underwent.

From *Ghoulish Airs*, and other pieces in this portfolio which utilise such illusions, the expressive potential of the infinity series, Shepard tone scale and Risset rhythm became increasingly evident. In the context of *Witherbud,* I thought these illusions might fittingly portray the seemingly endless cycles of lockdown and release and the exhaustive nature of our collective situation at the time. We asked, "when and how will this end?", a question which arises on hearing the infinity series, Shepard tone scale and Risset rhythm.

These illusions are treated differently in *Witherbud* than in *Ghoulish Airs*. In *Witherbud*, rather than using the ShMInfinity series which was developed so that scales could be laced into the series, a faithful Nørgård-ian infinity series is manipulated to produce Shepard tones.[276] The approach to composing Risset rhythms is a blend of those found in *After Images* and *Ghoulish Airs*, the former being characterised by the discontinuous-dynamic use of metric modulations and the latter by continuous-dynamic accelerations.[277] The accelerations in *Witherbud* are mostly the former but from bar 98 until the end, more complex metric modulations are employed in conjunction with continuous-dynamic accelerations. At times the Risset rhythms are more palpable than others and more rhythmically adventurous counterpoint obscures the sense of pulse that is so necessary for Risset Rhythms to be perceived.[278] Still, *Witherbud* provides alternative ways of using these familiar illusions.

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[275] (Beckett, 2009)

[276] See 3.4.2. for comparisons and explanations of the Infinity and ShMInfinity.

[277] The terminology 'discontinuous-dynamic', which describes 'acceleration or deceleration by stages or by elision' and 'continuous-dynamic', which describes 'continuous acceleration' or 'continuous deceleration' is taken from Grisey's article *Tempus ex machina* (Grisey, 1987) p. 244.

[278] See 3.7.2 for more details

These alternative uses will be detailed in 3.7.1, which will describe methods of combining the above illusions with found objects. Additionally, the attempts at mimetic speech synthesis illusions, which also feature in *Witherbud*, will be detailed.[279] In 3.7.2, using my own and other people's reactions to the workshop and subsequent final performance of the piece, the effectiveness of my illusory intentions will be evaluated.

3.7.1 ILLUSIONS

The following table shows the overall structure of *Witherbud* and which illusions are employed where:

Section		Bar numbers	Illusions/Devices
A (Introduction)	Tempo loop 1	1 – 4	Infinity series, Shepard tones, Risset rhythm
	Tempo loop 2	5 – 8	
B (Exposition)	Tempo loop 1	9 – 26	Infinity series, Shepard tones, Risset rhythm, Metamorphosis of found objects
	Tempo loop 2	27 – 30	
	Tempo loop 3	31 – 34	
	Tempo loop 4	35 – 36	
	Tempo loop 5	37 – 39	
	Tempo loop 6	40 – 43	
	Tempo loop 2	44	
C (Transition 1)		45 – 58	Infinity series
D (Transition 2)	Tempo loop 1	59 – 64	Infinity series, Metamorphosis of found objects
	Tempo loop 2	64 – 67	
	Tempo loop 3	68 – 69	
E (Secondary Exposition)		72 – 97	Mimesis/Speech synthesis
F (Development)	Tempo loop 1	98 – 117	Mimesis, Found objects, Shepard tones, Risset rhythms
	Tempo loop 2	118 – 123	
	Tempo loop 3	123 – 125	
	Tempo loop 4	126 – 128	
	Tempo loop 5	129 – 131	
	Deceleration	132 – 139	
G (Coda)		140 – 159 (end)	Picket fence effect with found objects[280]

Fig. 69 Form scheme of *Witherbud*.

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[279] See 2.2.2 and 2.2.6 for descriptions of Mimetic and picket fence illusions.

[280] See 2.2.6 for descriptions of picket fence effects. In *Witherbud* they are briefly used as a device to bring the piece to a close. From bar 140, incredibly dense textures are cut away from for longer and longer periods, revealing layers of Bach quotations underneath.

The form scheme shows that the infinity series is used in substantial portions of the piece. As previously mentioned, the series used in *Witherbud* is an infinity series constructed with Nørgård's methods. The series is derived from the Royal Theme of Bach's *Das Musikalische Opfer* BWV 1079 (1747), shown in figure 70. The theme was chosen as a found object as I associate the florid and fluent counterpoint that Bach derives from such a difficult theme with propagation and growth, a metaphor for Beckett's buddings.
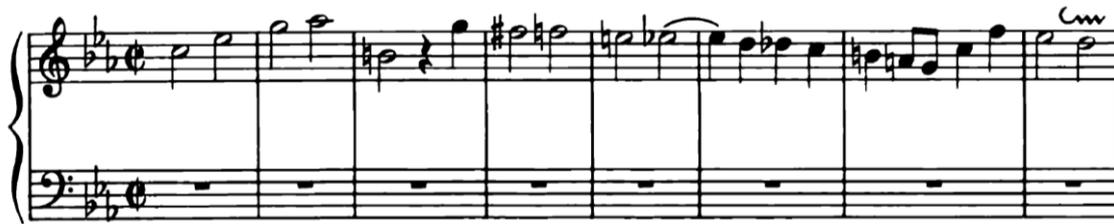
Fig. 70 The royal theme from Bach's *Das Musikalisches Opfer* BWV 1079 (1747).[281]

The first compositionally used infinity series, which features in Nørgård's *Voyage into the Golden Screen* (1968) and *Symphony no. 2* (1970), is generated from only two tones.[282] However, it is possible to generate a series from more than two tones and one is free to designate any tone as a generator of augmentation or inverted augmentation.[283] The figure shown below is one such example of this.

Fig. 71 Excerpt from the Bach-derived Infinity series. Plus signs show original augmentations and minus signs show inverted augmentations. Dotted lines show which augmentations stem from which generating tone.

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[281] (Bach, 1747) p. 1

[282] See 2.3 for an explanation of how the infinity series works and Kullberg's article on the Infinity Series for reference (Kullberg, 1996).

[283] Nørgård demonstrates a series generated from three tones and another from four tones (Nørgård, 1974) p. 6. See 2.3 for an explanation of the infinity series. Anderson has also experimented with the infinity series. He anecdotally related the process of projecting only normal augmentations of the series from each generating tone. He subsequently used the resulting series in his *Imagin'd Corners* (2002).

To link this series with Bach's royal theme, the infinity series used in *Witherbud* takes the first five pitches of the royal theme and implements them as generating tones, as is partly shown in figure 71. The first pitch produces inverted augmentations (shown by the boxed minus sign that it is annotated with), the next three produce augmentations (shown by the boxed plus sign), and the final generating tone produces inverted augmentations. Note that if one takes the filled noteheads, a largely descending scale results. This links this generated infinity series to the original Royal Theme: roughly half of the theme is comprised of a descending chromatic scale. If one reads the hollow noteheads, then one can see a three-note motive, derived from the Bach, moving largely in an upwards trajectory. It is largely the manipulation of the ascending motive and descending scale which creates Shepard tones in *Witherbud*. This can be seen for instance in the strings between bars 37 – 44 (shown in figure 72), which play ascending scales (at this point of *Witherbud*, an inverted version of the series is implemented and so the descending filled noteheads of figure 71 are inverted also in trajectory). What results is a multiplication of the original source material: the descending scales from the original Royal Theme are extended and the first five notes of the original quotation repeat but undergo processes of intervallic stretching and compression. Such a multiplication of the source material also felt like a natural allegory for Beckett's buddings.

Fig. 72 Strings isolating ascending Shepard tones from the Bach-derived infinity series.

Fig. 73 The modulating, and therefore endlessly rising canon, from *Das Musikalisches Opfer*.[284]

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[284] (Bach, 1747) p. 49

Due to the motivic similarities between the Royal Theme and this Infinity series which derives from it, metamorphosis between the series and the royal theme is made easier. Such transformations are facilitated by the Risset Rhythm in *Witherbud*. Figures 74 – 76 describe this metamorphosis. Section A begins not with the royal theme or the infinity series but with the melody from *Canon 5 a 2 per Tonos* (also from *Das Musikalisches Opfer*), the canon mentioned by Hofstadter in *Gödel, Escher Bach* (1979).[285] This canon (shown in figure 73), which modulates a tone higher over the course of 8 bars and thus has the potential to rise endlessly, was combined by Hofstadter and Scott Kim with the Shepard tone scale so that it truly rises eternally.[286] Given my choice of found materials and research subject, one would be remiss not to attempt such a combination in *Witherbud* as well.

As figure 74 shows, the theme from the endlessly rising canon enters in bar 9 and begins to both rise and accelerate until bar 27, where a version of the theme played at double speed is reached (figure 75).[287] Note the added glissandi, which accelerate the rate of pitch height increase and mimic the sound of a tape being fast-forwarded. Also, pitches 2, 4 – 6 and 9 – 11 of the rising canon melody are rhythmically shrunken and pitches 1, 3, 7 and 8 are elongated.[288] The acceleration continues until bar 31, shown in figure 76, where pitches 2, 5, 6 and 11 have been shrunken further and pitches 4, 9 and 10 have been removed. What results is an embellished royal theme played in octaves by the trumpets. Continued acceleration forces the royal theme to be compressed until the infinity series becomes the only logical continuation possible, as is seen at the last beat of bar 35 where the piccolo begins to play a transposed version. Across this passage, the Risset rhythm is used to durationally compress the rising canon quotation so that pitches must be shortened or jettisoned in order for the material to still be playable. This modification of duration is reminiscent of the transformative methods used in *Georgimorphosis*. In fact, because the rising canon melody modulates a tone upward on each iteration, repetitions are necessary for the modulation to be perceived and so each tempo loop functions as a transposed, durationally compressed *rilettura*. In this sense, Risset Rhythm and Shepard tone principles are combined with methods from *Georgimorphosis* to illusorily metamorphose found objects into each other.[289]

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[285] See 1.2 for an initial discussion of *Gödel, Escher, Bach*.

[286] (Hofstadter, 1979) pp. 712 - 714.

[287] While most notated Risset accelerations would accelerate from double speed and drop to half again after the double bar and in previous drafts the accelerations until F were designed in this manner. However, after observing the speeds at which players were being asked to perform difficult figurations, supervisors advised that the accelerations until letter F accelerate only to crotchet = 88 and drop back to 60 again. In fact, the effect of such accelerations is not unlike a standard Risset rhythm.

[288] In this instance, the terms "shrunken" and "elongated" are meant proportionally, in that the quotation in figure 7 is already shrunken to half size as it is at double speed. Still, even taking this shrinkage into account, pitches 1, 3 and 7 have been made longer than they should be at half speed and pitches 2, 4 – 6 and 9 – 11 are shorter than they should be at half speed.

[289] From letters J to L this entire process of morphing Bach quotations into the infinite series is reversed. A Risset deceleration causes pitches of the infinity series to be durationally spaced wider and wider, which allows fragments from Bach's *Das Musikalische Opfer* to grow in those durational spaces.

Fig. 74 Trumpet (non-transposed) playing the melody from the *Canon 5 a 2 Per Tonos* in bars 9 – 26 (first tempo loop of section A) of *Witherbud*.

Fig. 75 Horns in bars 27 – 30 (second tempo loop of section A) of *Witherbud*.

Fig. 76 Trumpets and upper winds in bars 31 – 36 (Tempo loops 3 and 4 of section A) of *Witherbud*.

Towards the middle of the piece in section E (marked in figure 69 as Secondary Exposition), the mimesis of human speech is attempted. As Barlow attempts in *Im Januar am Nil* (1981 - 1984) with his 'synthrumentation' technique, the synthesis of the word "Wither", in keeping with the piece's concept, is attempted.[290] SPEAR was used to analyse recordings of the vowel sounds "i" and "er" at various pitches.[291] Figure 77 shows the transcribed SPEAR analyses for "i" on E flat 4 and "er" on E natural 3. These analyses were then orchestrated in the manner shown in figure 78.

Fig. 77 Transcribed SPEAR analyses vowels "i" and "er". The partials of each vowel were assigned an approximate dynamic and approximated to the closest quarter tone.

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[290] Poller describes 'synthrumentation' as a 'technique for the resynthesis of speech with acoustic instruments developed by the composer Clarence Barlow' (Poller, 2015) p. 7. Poller describes the exact manner in which Barlow analyses the partials of speech recordings and attempted to resynthesise them with an acoustic ensemble.

[291] See 3.4.1 for a description of the programme SPEAR and its workings.

Fig. 78 Attempted speech synthesis in Witherbud.

My own listening experience of *Im Januar am Nil* is of mixed admiration. While the timbre-harmonies generated by Barlow's 'sythrumentation' are miraculous, I am unable to hear any of the texts which are purportedly being synthesised, other than the odd vowel sound.[292] With the idea that the speech synthesis might be made more effective with the addition of sounds which approximate consonants, I drew a scale of phonetic sounds, shown in appendix B. The table matches instrumental sounds with the spoken phonetics that I subjectively felt sounded most similar.[293] Sounds from this table are used to approximate the sounds of consonants in *Witherbud*. For instance, in bar 90 (see figure 78) double-bassists are instructed to bow their bridges, horns blow air through reversed mouthpieces and flutes simultaneously sing and play. These instrumental sounds all used with the aim of simulating the fricative "th" from "Wither". The scale of sounds is not restricted to consonants either. In bar 91, the bass clarinet plays the fundamental tone of the vowel spectrum because my phonetic scale determines that the tone of a bass clarinet is similar to the "er" from "Wither". These attempts to orchestrally simulate speech are combined with real speech, as the instrumentalists are instructed to whisper the words "Wither" themselves. The intent was to have the real speech blend with the orchestrally synthesised speech and, in doing so, strengthen the illusion.

3.7.2 IN PERFORMANCE

After hearing the piece, my evaluation is that only some of the illusions are perceptible in *Witherbud*. Sometimes miscalculations of balance obscure the intended effect of these illusions. At the opening in bars 1 - 8 for instance, the initial Risset deceleration does not come across, as the regular pulsation in the string layer is not powerful enough to be perceived in the foreground of the texture against dense tuplet figuration.[294] The Risset decelerations between letters J and L are not audible for similar reasons, although regular pulsations in this passage are assigned to the harp and pizzicato violins. Due to coronavirus restrictions, string section sizes could not exceed 3. 2. 2. 2. 2. and so perhaps larger string sections and extra doublings of these regularly pulsed layers could correct the above imbalances, as the strings were contending against double winds and brass sections in the recorded performance.

To expect the attempts at speech synthesis to translate as well was perhaps a sign of hubris. To expect my own speech synthesis to succeed where Barlow's rigorous synthrumentation fails

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[292] One struggles to hear any resemblance of 'Ohne Ahnung nahm ein Oma im Innern einer Emailleurne einleimen', which translates to 'Glue my Grandmother's earliest ancestors onto the inside of an enamel urn' (Poller, 2015) p. 12.

[293] One might think of this table as an expanded version of the musicalized alphabet from Messiaen's *Méditations sur le mystère de la sainte Trinité* (1969) for organ. Pitches in the score itself are annotated with the phonetic sounds which each pitch is supposed to correspond in the third movement, *La relation réelle en Dieu est réellement identique à l'essence* (Messiaen, 1969) p. 26.

[294] Although, in a previous workshop of the piece, for which I had composed exactly the same opening, the strings layer comes through well and the deceleration is perceived.

(perceptually but not artistically) was also foolish. Some pragmatic issues arose in practice. When showing drafted materials to Brett Dean, orchestrated partials of varying dynamic strengths were assigned differing dynamics. For the sake of ensemble, he suggested that they all be marked with the same dynamics. While this makes sense in the context of rehearsal and performance, such a decision naturally affected the appropriate perception of vowel sounds.[295]

With respect to the speech, one regret that I have from the rehearsal process is the decision to allow the whispering in section E (figure 78) to be voiced. The whispering would have allowed the speech to colour the orchestration. Instead, the voiced text is more audible, and sounds segregated from the instrumental timbres.[296] Perhaps whispering would have achieved a better timbral blend.

From audience members I received interesting reactions. One found my use of metre changes disorienting and felt that the speed illusions would have been more perceivable if the time signatures had stayed the same. Still, he felt the visual aspect of seeing the conductor beating time did help his perception of speed. Another was surprised when she saw the double basses bowing their bridges with force and yet heard no standard double bass sound produced. Here, the use of an extended technique caused a miscorrelation of sight and sound, or ventriloquism, to occur.[297]

3.7.3 CONCLUSION

Though not all of the illusions in *Witherbud* are immediately perceptible, the illusions are braided into a form with continuity, direction, variation and goal. The evolution of Bach quotations into the infinity series and back again acts as metaphor for Beckett's withering and budding. These processes and their consequences communicate that the events of the piece have significance. The combination of the Risset rhythm, infinity series and Shepard tone scales with found objects from *Das Musikalische Opfer* demonstrates fresh ways of composing with these illusions. Manipulations of speed are shown to have the power to distort and metamorphose quotations in an illusory manner. Perhaps a weakness of the form is that attempts to synthesise speech are suddenly introduced in section E without reason. The introduction of such a section was in part a result of composing *Jab*. After contrasting illusions in a manner that I found satisfactory, I attempted to similarly enact contrasts again. In this piece I attempted to paradoxically both use and depart from the models

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[295] Although, whether the vowels would have been perceived with the original dynamic markings is also questionable.

[296] At bar 102, the shouting was omitted, as coronavirus restrictions did not permit the musicians to shout at the time. Although, in one run-through, I did hear a version of the passage with the shouting and the musicians who committed to the action made it sound rather good. I later learned that the musicians who had carried out the performance instruction effectively had experience performing in punk bands as adolescents.

[297] See 2.2.5 for a description of ventriloquism and 3.8 for other compositional explorations of ventriloquism included in this portfolio.

advocated in performance magic literature. In this instance, I find this compromised intermediary between approaches to structure less convincing.[298]

It is interesting to note where *Witherbud* occurs in the research timeline of this project, especially where the speed illusions occur. The piece was written after *After Images* and *Ghoulish Airs*, two pieces where the speed illusions are relatively successful. This is perhaps endemic of a developing approach to composing with illusion. The first of my research questions seems relevant: *How can illusion be integrated into an organic, sophisticated and imaginative musical language? Can I achieve this whilst my illusions are heard?* This question points to a contradiction in my compositional self. While I am fascinated by psychoacoustic illusions and stimulated by the potential of such phenomena to deceive listeners, there are aspects of my developing compositional persona which do not make me the most natural composer of illusions. The use of complex tuplets while trying to create Risset decelerations is an example of this. In trying to express the absurdity and mania of lockdown, mistakes in balance were made which result in intended illusions not being perceived. This conflict between my research and compositional objectives is one of the greatest emerging tensions present in this submitted portfolio of works and research project in general.

3.8 AN INTERVIEW WITH A "PUPPET" AND HIS "MAKER"

This final piece in my portfolio is a culmination of my research. As well as including a ShMInfinity series, Shepard tone scales, Risset Rhythms, found objects and mimesis, the piece also features attempts at phase-shifting and, crucially, ventriloquism.[299] The incorporation of ventriloquisms seemed especially pertinent, as it is a multimodal illusion: perceptual deception occurs when two perceptual modes, sight and sound, struggle to process contrasting information. Since *An Interview* is the only work in the portfolio which includes such illusions, it singularly responds to the second of my research questions posed at the outset of this project: *how can conflicting aural and visual information be exploited to create illusion and adapted into performance contexts?*[300]
The piece's focus on ventriloquism necessitated a genre that would allow the incorporation of voices and theatrical elements. As such, I asked Gareth Mattey to compose a libretto and they conceived a text for this cantata in thrown voices. Through collaboration, we decided on a setting and plot which would allow our ventriloquisms to describe the power dynamics between two puppets locked in an abusive relationship and a sinister, unseen Interviewer, who is represented by the instrumental ensemble. One puppet is called "Maker" and the other is called "Puppet". At the beginning of the

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[298] See 3.5 for discussions on the structures that I have interpreted performance magic literature as advocating and 3.8.4 for an instance of where I feel that I have successfully blended the above-described contrasting formal approaches.
[299] See 2.2 for explanations of Shepard tones, Risset Rhythms, mimesis, phase-shifting and ventriloquism; 3.4 for the ShMInfinity series and 3.6 for descriptions of found objects.
[300] See 1.2 for said research question.

piece, "Maker" and the audience believe that "Maker" is indeed the maker of, and therefore in control of, "Puppet". However, through the piece, the audience discovers that the relationship is more complex. The piece documents their struggle for dominance. In the end, faced with his imminent loss of control over the relationship to "Puppet", "Maker" violently destroys "Puppet" and himself. The pair are discarded onto a pile of other defunct puppets by the interviewer. The piece is about how one asserts power, how one can be manipulated into believing one has power, and the hypocritical willingness to inflict the same power hierarchies that one has been a victim of onto others.

By way of theatrically depicting these power structures, Mattey stitched their own textual illusions into the libretto:

> "Does the ant **look up** and **say why**? Does the vole **ask who pulls the strings**? Does the sea urchin **rise** from the ocean floor and **demand to know** its maker's mind?
>
> *?*
>
> If not for me, this little guy, well **he** just **talks and talks and talks** when no one else is around – **he never lets me speak**! **I** would **have to hide in his words**, try to **find a way out**!"

The text in bold is sung by the "Puppet" and the rest by the "Maker". If the above excerpt is observed as a whole, ignoring the bold, one sees "Maker" boasting of his dominion over "Puppet". If one takes the bold text, one sees "Puppet" crying for help. These two meanings simultaneously coexist in Mattey's Necker Cube-like paradoxical text. The excerpt is reminiscent of the famous "Dear John" punctuation exercise.[301] Furthermore, Mattey's textual illusions are designed to be sung by ventriloquising singers. As "Maker" ventriloquises the text in bold as "Puppet", the listener is made aware that the text contains a second hidden meaning. Mattey's employment of ventriloquism creates a textual auditory stream segregation.

The centred question mark from the above excerpt, which one might observe pervades most of the libretto, is a provocation to me, the composer. With these question marks, Mattey challenged me to musicalize the interviewer's questions. These question marks were also nods from Mattey to Maxwell-Davies's *The Lighthouse* (1979), which similarly features an unseen musicalized voice who poses questions to the court. In *The Lighthouse,* the voice is represented by a French Horn, and one

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[301] A letter punctuated in two contrasting ways shows that contrasting punctuation can produce opposite meanings. The first version begins, 'Dear John: I want a man who knows what love is all about. You are kind, generous and thoughtful. People who are not like you admit to being useless and inferior.' The second begins, 'Dear John, I want a man who knows what love is. All about you are kind, generous and thoughtful people, who are not like you. Admit to being useless and inferior.' (Crossley, 2015)

may note that the trumpet and trombone are employed with similar intentions in my own score, although in *An Interview* the opening and closing of plunger or Harmon mutes is used to mimic speech vowels (see figure 79). [302] The effect is taken from the children's television cartoon called *Peanuts*, in which the speech of teachers is represented with a Harmon muted trombone.[303] These musicalized questions heighten the interrogatory character of the interviewer.

This shows parallels with two of Deutsch's illusions: her Phantom Words illusion and its ability to facilitate multiple subjective interpretations of an ambiguous sound stimulus so that individuals hear different words in the stimulus to each other; and her Speech-to-Song illusion, which isolates a recorded speech phrase and repeats it until the listener hears a clearly identifiable melodic pattern.[304] Since one is unaware as to the precise words spoken by the interviewer, one is left to retrospectively piece together what has been asked from the puppet's answers. This ambiguity allows different listeners to contrastingly interpret the musicalized questions, hence the parallel to Deutsch's Phantom Words. The parallel to Deutsch's Speech-to-Song illusions, on the other hand, lies in the "vocal setting" of the Interviewer's questions, the text of which I wrote and "set" for trombone and trumpet.[305] In order for the questions to be perceived as such, the melodic contours and rhythms of the trombone and trumpet melodies were designed to imitate natural speech, as can be seen from figure 79. Though most, if not all bar Stravinsky, composers of opera imitate natural speech with their vocal setting, not all do so for trombone and trumpet, and it is this aspect which is illusory. In fact, it is this practice of setting vocal lines to follow the natural speech rhythms and contours which makes this mimesis convincing, as the setting of the Interviewer's questions follows standard operatic conventions.[306]

Fig. 79 Bars 50 – 53, an example where mutes are used to simulate speech vowels. The trombonist and trumpeter are given texts in the score which the interviewer is supposedly conveying at the given

[302] (Maxwell-Davies, 1979) pp. 4 – 5.

[303] (*Peanuts' Teacher Calls Out Charlie Brown & Linus - 'Wah Wa Wa Wah Wa Wa' - 1969*, 2016) The idea to represent the teachers accordingly came from Vince Guaraldi, the composer of the show's famous tune *Linus & Lucy* (1964), and was executed by trombonist Dean Hubbard (M. Johnson, 2020).

[304] See 2.2.6 for a description of Deutsch's phantom words. The Speech-to-Song Illusion, described on Deutsch's website (Deutsch, n.d.), is a feature of Reich's work. For example, in the first movement of *City Life* (1995), the repetition of "Check it out" within a C minor environment, musicalizes the sample (Reich, 1995).

[305] It gave me no pleasure at all to write such condescending, homophobically-charged vitriol for the Interviewer.

[306] Janáček talked extensively about the impact of "speech-melody" on his work (Janáček, 1907).

moment. These texts, along with hairpins and articulations, show the players what phrasing to imbue their melodies with, as the texts produce spoken cadences that the performers are instructed to emulate with their playing.

Though a wide range of illusions and devices are used in conjunction with ventriloquism and mimesis throughout *An Interview*, each serves a narrative function, as in *Ghoulish Airs*, and responds to Mattey's imaginative libretto.[307] Below, in 3.8.1, the ways in which each illusion conveys events within the plot and/or describes the power dynamics between characters at pivotal moments will be explained. After, in 3.8.2 the ventriloquisms in *An Interview* will be subject to more in-depth explorations.

3.8.1 OTHER THAN VENTRILOQUISM

However, first for the sake of geography, the formal structures which underpin *An Interview* will be elucidated. Below is a formal scheme of the piece:

Section		Bars	Illusions/Devices	Plot/Comments on structure
Overture		1 – 28	ShMInfinity series, phase-shifting, mimesis, Risset rhythm	"Puppet" and "Maker" are dragged into the office and set up/prepared for interview.
Session 1	Questioning	29 – 93	Mimesis, found objects, ventriloquism	Interviewer asks "Maker" a series of questions. Each section of questioning functions as recitative. "Maker" answers sometimes in these periods of recitative and sometimes in short, formulated arias. He is eager to perform for the interviewer and show off his use of a hand-puppet to control "Puppet", who largely bends to his will. Overall, session 1 is characterised by a high degree of contrast, as would be consistent with a number opera.
	'From just a single finger...'	94 – 109	Found objects	
	Questioning	109 – 114	Mimesis	
	'Are you happy...'	115 – 143	Found objects	
	Questioning	144 – 160	Mimesis	
	'Blooms...'	161 – 194	Risset rhythm, ShMInfinity series	
	Questioning	195 – 209	Mimesis, ShMInfinity series	
	Theme	210 – 226	Found objects	

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[307] See 3.4.1

Session 2	Variation 1	227 – 242	Ventriloquism, found objects	"Maker", responding to a question which he finds particularly insulting and patronises "Puppet" with lyrical poeticisms. His rantings leave him susceptible to a covert coup from "Puppet" who begins to take control of "Maker" with his own hand-puppet. "Maker" gradually becomes aware of this and grows more and more panicked. The two wrestle mentally for control with "Maker" only just able to supress "Puppet" by the end of the session. The Interviewer watches, laughing. The Session takes the form of a loose theme and variations, with each variation showing the gradual shift in power dynamic between "Puppet" and "Maker".
	Variation 2	243 – 275	Ventriloquism, found objects, Shepard tones, Risset rhythms,	
	Variation 3	275 – 296	Ventriloquism, found objects, Shepard tones, Risset rhythms	
	Coda	297 – 316	Mimesis, ventriloquism, found objects, Shepard tones, Risset rhythms	
Respite		317 – 380	Found objects, ventriloquism, mimesis	The interviewer resumes his questioning, and more explicitly derides the pair. "Maker" protests while "Puppet" manages to finally seize power, stripping "Maker" of his voice. The section functions as a transition between sections.
Session 3	Module A	381 – 411	Found objects, ventriloquism, large-scale Risset rhythm	The Interviewer watches as "Puppet" takes control of "Maker", putting words in his mouth and mocking him with his own poeticisms. Voiceless, "Maker" is forced to comply but strains to be free. He briefly regains his voice
	Module B	412 – 420		
	Module C	421 – 431		
	Module D	432 – 439	Found objects, ventriloquism, large-scale Risset rhythm, Shepard tones	

	Module E	440 – 461	Found objects, ventriloquism, large-scale Risset rhythm	and the two mentally wrestle again. Eventually, "Maker" is suppressed.
	Module F	462 – 500	Found objects, ventriloquism, shorter-scale Risset rhythm, Shepard tones	
Coda		501 – 525	Mimesis, found objects Risset Rhythm	"Maker", having lost power to puppet, resorts to physical violence. After beating "Puppet" to death, he destroys the hand-puppet of himself and therefore himself. The Interviewer reacting with mild annoyance, orders that "Puppet" and "Maker" be thrown onto the mound of puppet corpses behind them.

Fig. 80 Form scheme of *An Interview.*

Fig. 81 Drumkit and trombone in bar 224 of *An Interview*.

Certain devices typify the portrayal of specific characters and their behaviours. As previously described above, mimesis is used to portray the interviewer's questions. Though the mimesis is mostly carried out with trombone and trumpet mutes, occasionally the speech synthesis and the phonetic scale (appendix B) used in *Witherbud* are implemented in conjunction with the muted trombone or trumpet.[308] In bar 224, for example, the drum kit is used to embellish the trombone line with consonantal sounds. As figure 81 shows, the rimshots of the snare produce the necessary "k" sound for the word "could"; the hi-hat is used to produce the sibilance for "say" and "once"; and the woodblock produces the "o" sound of "more". In bar 242 (see figure 82), the flute, oboe, piano and

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[308] See 3.7.1 for the mimetic uses of speech synthesis in *Witherbud*.

viola embellish the trombone line with partials of "o" vowel spectra.[309] In these instances, embellishment of the muted trombone writing heightens the mimetic illusion and imbues the Interviewer's questions with a more threatening edge.

Fig. 82 Bars 242 – 243 of *An Interview*.

Found objects appear in the ensemble when the Interviewer mocks and undermines the pair of puppets. The interviewer is an opportunistic, uncaring appropriator who aims to collect experience at the expense of his interviewees. As such, his sadistic derisions are musicalized with items from his collection, found objects which have been taken out of context and used sardonically to satirise his victims. The allusions to Strauss's *Salome* (1903 - 1905) at bars 105 and 337 are examples of this (see figures 83a – c). In the former case, the allusion occurs as "Maker" sings:

> 'From just a single finger, to a friendly sock pal, from a fist, a mask or a glove, to the complex rigging of a strung up guy or gal, to the dainty shadows you help with love, I've done them all.'

In the latter case, the interviewer "sings" of the interviewees' "glorious perversion". Given the subject of Strauss's *Salome*, the employment of such an object at these points makes clear what the Interviewer thinks of his interviewees.

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[309] See 3.7.1 for examples of transcriptions of vowel spectra from SPEAR and their use in *Witherbud* and 3.4.2 for an introduction to SPEAR.

Fig. 83a Appearance of Strauss's *Salomé* at bar 105.

Fig. 83b Appearance of Strauss's *Salomé* at bar 337.

Fig. 83c The quoted excerpt of Strauss's *Salomé*.

One may observe from this example that the use of found objects in *An Interview* is less rigorous than in *Georgimorphosis*. The guises that these objects appear in are sometimes fleeting and distorted, the piccolo rendition of *Salome* being an example (see figure 83a). This lack of rigour points to a contrast in purpose between *Georgimorphosis* and *An Interview*. *Georgimorphosis* is an abstract piece written with the sole purpose of transforming objects into each other in an Escher-like manner. In *An Interview,* the transformation of materials into found objects is a device which allows the Interviewer to make musical asides and break the fourth wall, as these references are acknowledgements that music exists outside of the confines of the piece.[310] Furthermore, even where the objects are less recognisable, they still lend the Interviewer character, as even if the audience is unaware as to what is being quoted, they will, hopefully, be aware that they are hearing a distortion of something familiar. Take for instance, the reference to Stravinsky's *Petrushka* (1910 – 11, rev. 1946 – 47) at bar 280, which is compared with the original in figures 84a and b. The intervallic shapes are distorted, and ornamentation added, which obscures the source of the material. Yet, the distinctness of the triple octave spacing between clarinet and piccolo and similar melodic contour to Stravinsky's original object should be enough to make clear that the material is imported. The reinterpretation of the material shows that the Interviewer is handling his collection roughly, adding glissandi,

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[310] See 3.6 for the use of found objects in *Georgimorphosis.*

ornamentations and contorting his objects to denigrate his interviewees. He intends to do the same to the puppets once he has added them to his collection. Though the found objects in *An Interviewer* are not always handled in as an illusory manner as in *Georgimorphosis*, the fleeting metamorphoses of the musical material into these micro-quotations serves to reinforce the identity of the unseen Interviewer. In this instance, theatricality is chosen over illusion.

Fig. 84a Use of *Petrushka* in bar 280 of *An Interview*.

Fig. 84b Quoted motive from Stravinsky's *Petrushka* (1910 – 11, rev. 1946 – 47).[311]

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[311] (Stravinsky, 1965) p. 16

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Fig. 85 Risset rhythms and Shepard tone scales which characterise "Puppet".

Where found objects and mimesis characterise the Interviewer, Risset rhythms and Shepard tone scales are associated with "Puppet". Throughout *Session 2*, the periods where "Maker" is conscious and where he falls under the influence of "Puppet" are contrasted. Where "Maker" is in control of himself, the pitch environment is equal temperament and quasi-serially organised. As "Puppet" gradually gains influence over "Maker", glockenspiel, scordatura classical guitar, microtones, and Shepard tones are introduced. The tactus is also contrasted. When "Maker" is self-aware, the tactus is largely crotchet = 60 and subjected to varying subdivisions, though these are mostly triplets. When "Maker" falls into the possession of "Puppet", the tactus at first decelerates slightly, see bar 269 for instance, and then becomes quaver = 120 and the metre changes to 3/8, as shown in figure 85. Note that while the metre stays steady, rhythmic values elongate (see the string parts of bar 254) which creates the feeling of deceleration. Later, as "Maker" falls more deeply under "Puppet's" spell, Risset rhythms are introduced, as is shown in figure 85. Since *An Interview* was composed after *Jab*, the Shepard tones are relatively Łukawski-an in nature, as the Shepard tones don't make use of octaves, at least in these passages.[312] The characterisation of "Puppet" with Risset rhythms, Shepard tones, microtones, glockenspiel and classical guitar allows "Puppet" to be understood as a strange, fantastical, magical character with gifts that "Maker" does not possess himself but aims to possess through his initial possession of "Puppet".

Another notable use of Risset Rhythms and Shepard tones appears in Session 3, as "Puppet" ultimately takes control of "Maker" and the piece drives towards its climax. A large-scale Risset rhythm structures the tempi of the entire section which ensures the final section is imbued with an ever-increasing intensity. The tempo scheme of the section is laid out below:

Module	Bar numbers	Tempi
A	381 – 411	Crotchet = 120
B	412 – 420	After the metric modulation quaver = triplet quaver, crotchet = 80
C	421 – 431	After the metric modulation semiquaver = triplet, crotchet = 108
D	432 – 439	After the metric modulation triplet quaver = quintuplet semiquaver, crotchet = 66

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[312] See 3.5.1 for Łukawski's impact on my treatment of Shepard tone scales and his concept of 'circularity space'.

E		440 – 461	After the metric modulation semiquaver = triplet quaver, crotchet = 88
F	1	462 – 468	After the metric modulation triplet quaver = quaver, crotchet = 132
	2	469 – 478	After the metric modulation crotchet = quaver, an acceleration from crotchet = 66 to 120
	3	479 – 488	After the metric modulation crotchet = quaver, an acceleration from crotchet = 60 to 120
	4	489 – 500	After the metric modulation crotchet = quaver, an acceleration from crotchet = 60 to 144

Fig. 86 Details of large-scale Risset rhythm in Session 3.

The metric modulations into modules B and D appear to decrease the tempo. However, in the case of the former, the rhythmic values sung and played in the guitar are generally larger prior to the metric modulation (see figure 87), whereas the values post metric modulation are smaller. Thus, the change in tempo is not so much perceived as a decrease from 120 to 80 but rather an increase from 120 to 160. The metric modulation from module C into D functions in a largely similar manner (see figure 88). These staggered increases in tempo are similar to the discontinuous-dynamic accelerations of *After Images.*[313]

At module F however, smoother, continuous-dynamic accelerations are employed. The reasons for this blended approach are pragmatic and formal. To ask singers who must act, sing complex lines and, in this piece, ventriloquise to constantly be in a state of smooth acceleration or deceleration would be unreasonable. Therefore, the continuous-dynamic accelerations are saved for the end of the section so that *Session 3* can be paced with a greater sense of apotheosis. The staggered accelerations make the increases in tempo incremental at first and the singers can sing in a consistent tempo for longer periods at first. Then, as the intensity increases the rate of acceleration becomes

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[313] See 3.7 for explanations of the terms 'discontinuous-dynamic' and 'continuous-dynamic' in relation to these acceleration and Grisey's *Tempus ex machina* article (Grisey, 1987) p. 244.

constant as the smooth accelerations are employed. The sense of intensity is further increased with the use of Shepard tones in module F. See the rising stacked, staccatissimo octaves passed between the synth, violin, contrabassoon, saxophone, oboe, flute and piccolo shown by the arrows in figure 89.

Fig. 87 Metric modulation from modules A to B.

Fig. 88 Metric modulation from module C into D.

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Fig. 89 Shepard tone scales in module F of Session 3.

Fig. 90 ShMInfinity series used in *An Interview*. The arrows show where each augmentation has reached in the main series. One may note that the *Ghoulish Airs* and *An Interview* incarnations of the ShMInfinity series differ in three ways. Here, there is no underlying chord, scheme or descending point of symmetry and the positions of augmentation and inverted augmentation have been swapped.[314]

These stacked Shepard tones are part of a ShMInfinity series, which is shown in figure 90. In *An Interview* only a small section of the ShMInfinity series is used, because the prospect of composing extended sections with the series, as was the case in *Ghoulish Airs,* seemed unlikely due to

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[314] See 3.4.2 for the genesis of the ShMInfinity series and how/why it is used in *Ghoulish Airs*.

the variety of illusions being employed in the piece.[315] Łukawski's concept of 'circularity space' is applied by using the augmentation or inverted augmentation to jump back to where the augmentation or inverted augmentation has respectively reached in the series, as is shown by figure 90.[316] The caveat for using this inversion path, however, is that one must invert the continuation once one has jumped back to this previous point in the series. These paths enclose the series within an infinite pitch cycle, which prevents the series from continuing infinitely and ensured that I would not spend huge lengths of time pre-composing the series.

The use of the series in Session 3 is too diffuse to be identified due to octave re-transpositions and the metamorphosis of materials into found objects. A more discernible use of the series can be found in the overture, excerpted in figure 92. The series enters at bar 11. Here, the piano plays the series as quavers; the cross-marked augmentation is passed between the oboe, clarinet, saxophone, bassoon and trumpet (only the staccatissimo pitches with Hauptstimme markings); the circle marked Shepard tones are played by the glockenspiel; the hollow-headed inverted augmentation is played by the piccolo and flute; and a larger-scale augmentation derived from an augmentation of the cross-marked pitches is played by the trombone (again, only the staccatissimo pitches with Hauptstimme markings). This Wessel illusion-like isolation of wavelengths to create stream segregation illusions is reminiscent of *Ghoulish Airs*.[317]

Fig. 91 Excerpt from the duet *'Blooms…'* from Session 1.

[315] See 3.4.2 for the genesis of the ShMInfinity series and how/why it is used in *Ghoulish Airs*.
[316] See 3.5.1 for Łukawski's 'circularity space' concept.
[317] See 3.4.2 for discussions of the ShMInfinity series and its wavelengths and 2.2.1 for the Wessel illusion.

Fig. 92 Bars 9 – 15 of the overture.

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The ShMInfinity series is less associated with any one character but more an evocation of the abusive relationship's trappings: the infinite pitch cycle is inescapable, as is the relationship. The series is used notably in the duet *'Blooms…'*, excerpted in figure 91, alongside incredibly florid vocal writing and the Risset rhythm. The florid, medieval-inspired lines and decelerating Risset Rhythm show the influence of "Puppet" on the relationship, and this rare moment where the two aren't at odds shows intimacy and love between the two.[318] Despite the florid lines and Risset deceleration, the ShMInfinity series, played by the Celesta, is a constant in the background and tinges the scene with unease. Indeed, the Risset deceleration enhances the sense of feeling trapped, as the deceleration continues far longer than one feels should be possible.

Fig. 93 Phase-shifting in the *Overture*.

Lastly, aside from the ventriloquisms, there are the attempts at phase-shifting (see figures 93 and 94), which feature in the *Overture* and *Respite*. These uses of phase-shifting are less linear than those found in Reich's *Drumming* (1971), or any of his other phase-shifting works.[319] In both sections, repeating three note cells are overlaid in polyrhythmic relation. The notational deceleration that the layers undergo (note values are incrementally expanded) brings the repeating patterns in and out of phase. Note that the patterns are varied with more freedom and faster note values are introduced with more spontaneity than Reich would allow. The resulting textures are more similar to the opening burbling of Ligeti's *Chamber Concerto* (1969 – 1970). Furthermore, there are no instruments which

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[318] These florid lines were inspired by the work of Thomas Fournil, a doctorate candidate at the Guildhall who is researching compositional cross-fertilisations between Medievalism and Spectralism. In periods of creative sharing, he showed me melodies of Hildegard of Bingen and some of his own also.

[319] See 2.2.6 for explanations of phase-shifting and Reich's use of the technique in *Drumming* (1971).

pick out resulting patterns from the phase-shifting as the singers are instructed to in *Drumming*.[320] Without a recording of the piece, it is difficult to assess the illusory effect of such quasi-phase-shifting. Still, a personal variant on the effect was used out of admiration for the mysterious, 'impersonal, unintended, psychoacoustic by-products' of phase-shifted gestalts that Reich has composed.[321]

Fig. 94 Phase-shifting during *Respite*.

3.8.2 VENTRILOQUISM

Fig. 95 "Maker" ventriloquises through "Puppet" in bars 75 – 82.

While other illusions in *An Interview* are used largely as markers of characters, almost as *leitmotifs,* ventriloquism shows which of the puppets is dominant at any point in the drama. These illusory effects require both mezzo-sopranos to be amplified. Through Session 1, "Maker's" ventriloquism of "Puppet" shows that "Maker" is in control, as is demonstrated by the excerpt shown in figure 95.[322] The mezzo-soprano playing "Maker" is instructed to sing the text with bared teeth and

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[320] See 2.2.6 for an explanation of resulting patterns and Reich's use of singers to elucidate these patterns in *Drumming* (1971) (Reich, 1971) p. 19.

[321] (Reich, 2004) p. 305.

[322] See 2.2.5 for an understanding of what is understood as ventriloquism in the context of this research project.

minimal jaw movement, marked v.t. for "ventriloquist's teeth". At the same time, the hand-puppet's mouth must be opened and closed so that the words appear to be sung by the puppet. In this case, the mezzo-soprano playing "Puppet" is instructed to mouth the words at the same time, so as for the audience to see that the singer and hand-puppet that "Maker" is controlling are linked.

Fig. 96 Bars 229 – 234 of *An Interview*.

In *Session 2* this standard method of ventriloquising is modified, as through *Session 2* a transition of power takes place and changing ventriloquisms reflect this. Figure 96 shows an example of such a major change. Here, as "Maker" ventriloquises with his hand puppet, the mezzo playing "Puppet" creeps in. Note that where simultaneities occur, the voices are largely spaced in parallel intervals of fourths, fifths, tritones or thirds. Such parallel intervals bind the voices so that they are grouped into a stream, at least at these points where they coincide.[323] "Puppet" also begins to isolate

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[323] As Huron notes when explaining, from a psycho-acoustician's standpoint, the reason that parallel fifths are often avoided in Bach chorales, 'The perceptual independence of concurrent tones is weakened when

individual words from "Maker's" words and construct his own meanings together from them, as in the manner shown with the bold text at the beginning of this commentary. Then, "Puppet" starts his coup and begins using his hand-puppet to capture "Maker's" voice, shown in figure 97. Each time "Puppet" uses his hand-puppet, "Maker", singing through "ventriloquist's teeth", enters a trance-like state and causes him to drop his own "hand-puppet" in bar 248. This symbolises his loss of dominance. Every time, the trance is broken, "Maker" becomes more and more aware as to what is being done to him and panics. As figure 98 shows, "Puppet" possesses "Maker" for longer and longer spans, which is reflected by longer periods of purely parallel melodic motion. These are accompanied by more and more elaborate Shepard tones scales and Risset rhythms, which represent "Puppet's" growing influence.

their pitch relations promote tonal fusion. Intervals that promote tonal fusion include (in decreasing order): unisons, octaves, perfect fifths... Where the goal is the perceptual independence of concurrent sounds, intervals ought to be shunned in direct proportion to the degree to which they promote tonal fusion.

Fig. 97 Bars 242 – 252 of *An Interview*.

Fig. 98 Bars 273 – 279 of *An Interview*.

In Session 3, concepts of ventriloquism are further expanded. Here, "Maker's" voice has been captured in "Puppet's" hand-puppet. The mezzo who sings the part of "Maker" is instructed to sing

melodies with their tongue against the soft palate, which "closes" the throat and allows the mezzo to mouth words independently of their hummed melodies. This vocal technique was developed by Kate Soper and used in her piece *Only the Words Themselves Mean What They Say* (2011).[324] As figure 99 shows, in *An Interview*, the vocal technique is used in conjunction with extended flute techniques, as it is in Soper's piece. The words are mouthed at the same time as being played and spoken by the flautist. The hand-puppet which represents "Maker" and is controlled by "Puppet" mouths the words at the same time. The implication is that "Puppet" is putting words in "Maker's" mouth and inflicting dominance with the same violent tools of suppression that previously have been enacted by "Maker". Furthermore, in this the Interviewer's complicity in the suppression of "Maker" is implied, as the words are sounded by the flutes who are members of the ensemble: the Interviewer is putting words in "Maker's" mouth. This use of ventriloquism results in an additional illusory effect. As it could appear to the audience at first that "Maker" is actually saying the words spoken in the flute parts, one might experience the hummed melody as a disembodied hallucination.[325] Occasionally, "Maker" tries to break free from control, as is shown by the arrows which instruct the mezzo to lower the tongue from the soft palate and transition from a hummed tone to voicing the mouthed words. These moments break the effect of hallucination and, in doing so, allow the audience to recognise the above-described direction of ventriloquisms and, therefore, dynamics of power in play at this moment.[326] In this section, amplification becomes incredibly important for the perception of these illusions.

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[324] The piece is discussed in relationship to ventriloquism in 2.2.5 (Soper, 2011) p. 8. I was advised by a mezzo-soprano to write melodies which are centred in the vocal range between A4 – C5 and so one will note that whilst the hummed melodies exceed this pitch range, it is still frequently returned to.

[325] See 2.2.6 for a description of the term "hallucination" and its meaning in the context of this research project.

[326] One is reminded of a category of illusion described by Lamont and Wiseman as "Extraordinary feats" which can include 'the appearance of extraordinary strength or invulnerability to ostensibly harmful effects' (Lamont & Wiseman, 1999) p. 5. Even if one is aware of how a singer could hum and silently mouth at the same time, one would have to respect the skill of such a feat.

Fig. 99 Bars 426 – 432 of *An Interview*, an example of ventriloquisms in *Session 3*.

3.8.3 CONCLUSION

As already asserted, *An Interview* is undeniably an investigation into the expressive potentials of illusion. The work features phase-shifted passages, Risset rhythms, Shepard tone scales, mimetic illusions which simulate human speech, metamorphoses of found objects, passages with the ShMInfinity series, and ventriloquisms. These illusions provide characters with strong identity and function almost as plot devices in the drama. They provide commentary on the dynamics of power between characters and so gain narrative function. One is reminded of Steinmeyer's assertions regarding the importance of narrative when creating illusion in *Hiding the Elephant*.[327]

This also indicates an interesting approach to temporal aspects of the piece. During the composition of *Jab*, a new research question essentially arose: *Must compositional adaptations of illusion consist only of the presentation of an illusion's effect and the subsequent subjection of the illusion to variation with the aim of inducing belief-discordant alief in the mind of the listener?[328] Or can forms which allow for contrast also be used?* While the question implies that a dichotomy exists, in *An Interview* the two approaches are blended. *Session 1* takes the form of a mini-number opera built on contrasting pieces of music and illusion. *Session 2* contrasts two types of music which are demarcated by differing illusions and yet the contrast between the two strains forms the basis of the entire section. In *Session 3*, the ventriloquist ideas which have been sown in the first two sessions are

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[327] See 3.4.1 for discussions of *Hiding the Elephant* in relation to *Ghoulish Airs*.
[328] See 2.4 for an explanation of 'belief-discordant alief' (Leddington, 2016).

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taken and varied with the aim of inducing belief-discordant alief, a gambit which may be familiar from *After Images* or *Ghoulish Airs*. One can envision sections of the piece lying upon a spectrum with the poles "contrasted" and "un-contrasted" at either end.

The opera forms an essential part of the submitted portfolio, as it is the only submission of the portfolio which features the voice and asks what illusions can be perceived when conflicting visual and aural stimuli are simultaneously presented. I believe these miscorrelations of sight and sound will strengthen the drama of the piece, deceive and, hopefully, astonish.

CHAPTER 4 – THE ILLUSION OF CONCLUSION

'Musical illusions which I consider to be also so important are not a goal in itself
for me, but a foundation for my aesthetical attitude.' (Ligeti, programme note to the
Concerto for Piano and Orchestra (1985 - 1988))[329]

'Even when all the cards are on the table, and everyone hears what is gradually
happening in a musical process there are enough mysteries to satisfy all. These
mysteries are the impersonal, unintended, psychoacoustic by-products of the
intended processes. These might include sub-melodies heard within repeated
melodic patterns, stereophonic effects due to listener location, slight irregularities
in performance, harmonics, difference tones, and so on'. (Reich, *Music as a
Gradual Process*)[330]

My research project has ultimately been framed by these two contrasting approaches to illusion. To
generalise, the former prioritises traditionally European notions of invention, whereas the latter values
the intricacies and individuality of listeners' perceptions.[331] This frame highlights the prejudices
implicit in the first of my research questions and shows what I first prioritised as a composer when
embarking upon this research project. In asking whether illusions can be adapted into an 'organic,
sophisticated and imaginative language… whilst ensuring my illusions are heard', I asked whether I
could compose pieces in the manner of the former and yet achieve the results of the latter.[332] Indeed
the answer to this above research question and the rest outlined in subsection 1.2 is sometimes yes but
equally often no. These successes and failures are documented in the preceding third chapter. With
pleasure, I disprove Croft's assertion that composition is not research.[333]

As well as elucidating, with positive and negative examples, the conditions of creating
psychoacoustic illusion at a localised level, I have written much about the musical contextualisation of
illusion in time. The structures derived from performance magic literature proved to be fruitful. A
strength of these structures is that they are designed to focus one's attention on the effect of a
psychoacoustic illusion and successively increase the potency of the illusion's effect. Structure

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[329] (*Concerto*, n.d.)
[330] Reich explained this to Tenney, who responded: 'Then the composer isn't privy to anything'. (Reich, 2002)
p. 35
[331] See 2.3 for the differences in attitude between Tenney, Stockhausen and Radulescu.
[332] See 1.2.
[333] In order for one's research to constitute as such, Croft argues, there must exist the possibility that your
research questions might not be fulfilled after the research enquiry has been carried out. He then naively asserts
that a composer's investigations will only ever be positively answered and that, as such, composition is not
research (Croft, 2015).

becomes a form of communication (pun intended) rather than an imperceptible construct. *After Images* and *Georgimorphosis* are both rigorously shaped by such structures.

Through the lens of my research framework, it is these two pieces which I count as most successful in the submitted portfolio. In these works, the creation of just one illusory effect, albeit in a variety of different ways, is doggedly pursued. This conceptual focus primes the listener and allows them to attend to the present phenomena more closely. [334] In both pieces, so many of the phenomena which occur are so clearly concerned with either manipulations of speed or the transformation of quotation that the intention of each work is made obvious. In these pieces, the invocation of belief-discordant alief and neutralisation of suspicion were truly aimed at.[335] This was managed by using a variety of methods to create the same illusive effect. The basic conditions of illusion were generally complied with and so the illusions are more perceptible in these works. *Georgimorphosis* benefits also from its textural lightness. Since it is for solo clarinet, vertical density can only be increased to a certain limit and so nothing can obscure the linear transformations. The illusiveness of these pieces proves my research framework right with respect to form and communication.[336]

In this spirit of communication, narratives began to be included for their allegorical powers in pieces such as *Ghoulish Airs* and *An Interview with a "Puppet" and his "Maker"*.[337] As discussed, successful magic tricks have strong narrative arcs which imbue the consequences of the performed illusions with more significance, examples of which are discussed in subsections 2.3, 2.5 and 3.4.1. By similarly narrativizing musical illusions, the psychoacoustic illusions are prevented from becoming abstract phenomena and, in situations where the illusions are made less palpable by my interfering hand, the extra-musical allusions help to clarify my illusionistic intentions.

Departures from these performance magic modelled forms and narratives also yielded meaningful results. The more abstract focus on gesture and contrast in *Jab* for instance produced a rare work among illusionistic pieces, in that many, especially those by Reich and Tenney, work with gradual processes rather than juxtapositions. However, the counterpoint between illusory gestures in *Jab* creates another sort of narrative. Though similarly abstract, the metamorphoses of found objects in *Georgimorphosis* again produces a kind of drama. The process of composing these pieces provoked

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[334] 'Experience and memory of environmental stimuli that indicate future stress can prepare (prime) organismic stress responses even in species lacking a nervous system. The process through which such organisms prepare their phenotype for an improved response to future stress has been termed 'priming'. However, other terms are also used for this phenomenon, especially when considering priming in different types of organisms and when referring to different stressors.' (Hilker et al., 2016) In other words, organisms, such as humans, can be subconsciously prepared to expect certain outcomes from a situation from nonverbal cues present in their immediate environment. Priming is an especially useful tool used by magicians (Pailhès & Kuhn, 2020) (Mohr et al., 2015).

[335] See 2.4 for this terminology.

[336] See 2.3, 2.4 and 3.5

[337] It is difficult to discuss the success of *An Interview* without a recording, but I suspect that for reasons similar to those given for *After Images* and *Georgimorphosis* that the piece might also be successful for a research standpoint. The voices require a certain textural clarity in the ensemble to be heard and, despite the copious number of illusions in the ensemble, there is a staunch focus on ventriloquism in the vocal writing.

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the understanding that psychoacoustic illusions can ontologically be understood as actions or behaviours, which reifies them and imbues the sounds performing these illusive behaviours with subjective qualities. The following from Finnissy comes to mind:

> '…and he [Büchner, the playwright] makes [Jakob Michael Reinhold] Lenz say, "All I demand of art is that it has life". Isn't that fantastic? And that's what I demand too. And when I find that my pieces, to me, don't have life, I either burn them or I change them until they do. And what is life? Unpredictability, spontaneity, love, hate, everything.'[338]

I personally have found that the paradoxes and contradictions of illusive behaviour simulate liveness. In my work with illusion, new questions with which I can ask my materials surfaced. For instance, how should this material behave? Would the behaviour change in a separate context and if so, how? What is the antithesis of this behaviour and what would provoke its instigation? The treatment of material as a living being that is developed through "psychoanalysis" is a practice that I will carry beyond the bounds of my research.

The perceptual miscalculations present in the portfolio do not merely show my interest in deceiving listeners and engaging them with strange psychoacoustic phenomena, though many of the works certainly show a desire to do just so. The risks constantly taken which threaten each piece's illusionistic premises point to an interest in finding where listeners' perceptual limits lie. I found extra-musical resonances with this interest in the psychological aspects of music once more in the field of performance magic. In 2019, at an exhibition run by the Wellcome Collection entitled "Smoke and Mirrors: The Psychology of Magic",[339] I encountered a video description of a psychological experiment, which featured the magician and researcher Jay Olson.[340] In the documentary which covered the experiment, Olson describes magic as a folk psychology,[341] which is "a name traditionally used to denote our everyday way of understanding, or rationalizing, intentional actions in mentalistic

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[338] Finnissy is describing dialogue in a play by Büchner which features the writer Lenz as a character (C. Miller & Finnissy, 2017).

[339] The exhibition was curated by A.R. Hopwood (*Smoke and Mirrors*, n.d.).

[340] The experiment sought to find differences between participants' feelings of control over their decisions when they were inside a neuroimaging machine which could supposedly both influence and read their minds (it could not and in both cases performance magic techniques were used to mentally influence participants). The aim of the experiment was to use the '*simulated thought insertion paradigm*… [to] influence feelings of voluntary control and… help model symptoms of mental disorders.' (Olson et al., 2016)

[341] This description by Olson is used in his DPhil thesis, 'The magic of placebos' (Olson, 2020) and an article 'Applying insights in magic to improve deception in research: the Swiss cheese model', although in the latter the term is more alluded to with the phrase 'folkways of deception' (Olson & Raz, 2021). In an email correspondence with Olson, he expressed surprise that "magic as a folk psychology" is not more widely used in scholarly articles, as the term is common parlance in performance magic circles.

terms."[342] The term fittingly describes performance magic, a practice which deceives by intuitively understanding and finding the limits of human perception.

The understanding of music as a folk psychology is surprisingly non-existent, despite the aptness of the term for the field. What is Schenkerian, and indeed musical analysis in general, if not spurious theorising projected from one's musical training, which ultimately has been shaped by generations of accrued practical knowledge? Huron's article *Tone and Voice* (2001) elucidates that baroque musicians and composers instinctively constructed voice-leading principles that have real scientific bases, though they were unaware of these bases at the time.[343] Debasing as classical musicians may have at a time found the descriptor, I celebrate the term folk psychology for its accuracy, particularly within the context of this research project which aims to combine both disciplines of music and magic. With little understanding of "proper" psychology but some of psychoacoustic and musical theory, I have aimed in this compositional portfolio to create works which predict listeners' responses to sonic phenomena, modelled their consequent expectations, and, in confounding these expectations, attempted to deceive them. Folk psychology seems an appropriate description of the entire project.

Such aims have aided my compositional growth. In writing the literature review and categorising illusions according to effect, I set myself concrete goals. By taking individual illusions and compositionally adapting them, I tasked myself with the provocation of a particular psychological response in the mind of the listener when writing each piece, which often, where more successful, would lead me to compose materials with clear identities and trajectories, as the conditions of psychoacoustic illusion are often specific. This clarity of aim when composing is an uncommon luxury, as often the aim of a composition can be elusive and poignantly so.

Perhaps it is the specificity required to create illusion that lies at the heart of the constant struggle between my compositional persona and research aims. To be interested in illusion is to be interested in liminality, because these phenomena exist in the liminal cracks of audition. Shepard tones, for instance, lead the ear to confuse pitch and timbre (the higher scale which fades out is absorbed as a partial of the scale underneath[344]) and so sit on the knife-edge between musical parameters. So, when creating illusion, the margins for error are tiny. Barlow's synthrumentation and my attempts at speech synthesis in *Witherbud* are evidence of this.[345] Electronic syntheses of speech made with sine waves, which eschew the spectral baggage of instrumental overtone structures,

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[342] The article continues: 'There is great interest in folk psychology not only because of its status as a familiar way of making sense of our actions and those of others but also because it is thought to underwrite a range of moral, legal, educational, clinical, and therapeutic practices (Fodor 1987; Baker 1988). For this reason, a great deal of work in analytic philosophy has been devoted to better understanding folk psychology and its cognitive basis.' It should be noted that "Theory Theory", as often folk psychology is referred to as, is a fairly divisive theory with those who ardently oppose it on the basis of its perceived lacking rigour (Hutto & Ravenscroft, 2021).
[343] See chapter 2, 3.4 and 3.8 for references to the article (Huron, 2001).
[344] See 2.2.3 for an explanation of the illusion's mechanics.
[345] See 3.7.1 and 3.7.2 for discussions of Barlow's synthrumentation and my attempts at speech synthesis.

succeed where synthrumentation and orchestral speech synthesis fail because of the precision afforded by the computer with respect to dynamics and tuning.[346] Precision and clarity are required. It is odd that I, a composer with an aesthetic base founded on density and overwhelm, which decentre precision and clarity in the listening experience, would choose such a topic as illusion.

As such I have learned there are hard limits to the bounds of perception, even when working with phenomena which seem to confound these hard bounds. An ironic paradox emerges: to do something "impossible" is to defy rules of perception. But, after escaping these laws of perception, one is faced with a new set of rules. This isn't to say that these limits of human perception will stay the same forever. In his time, Stockhausen certainly felt humanity's capacity for perception change in response to stimuli such as Op Art and his own work:

> 'We are in a very important transition from the traditional way of perceiving art to a new way of making and perceiving art, and discovering new functions for art, that it is revelatory. It reveals our existence and ourselves, and thereby changes us as human beings. This change in perception will bring about incomparable changes in humanity in the next hundred years, spiritual and physiological. Don't imagine that we remain the same when our perception is changing so drastically, now that our musical perspectives have become relative instead of absolute.'[347]

Though the above provokes personal scepticisms towards Stockhausen's unilateral view of human perception and his idea of physiological evolution as a response to art, it seems logical that perceptions of the world would evolve according to its ever-changing environment. So too should conceptions of truth. The relation between illusion, perception and truth is complex: perception is regarded as an illusion and so is generally positioned in opposition to truth.[348] However, I argue, from the experience of routinely facing hard perceptual rules when composing with illusions, that perception is the beginning of truth rather than its opposite; an invitation to deeper understanding. I suspect this trifecta of concepts will evolve in ways that we cannot predict and present very differently in the future.

With the exception of *Jīng*, I knew the conditions required to compose the illusions I had chosen for each piece, and yet the portfolio shows a consistent will to deny those conditions from being fully met. My compositional aesthetic, characterised by this portfolio of fast, dense and overwhelming work, has played a puzzling and antagonistic role in my research. Though I knew and was advised that restraint would enhance the effectiveness of my illusions, I was unable to fully negate my hyperactive tendencies. Many have commented on this seeming unwillingness to yield to clarity with confusion, why write in

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[346] (Bregman, 2008)
[347] (Stockhausen, 1989)
[348] This topic is discussed in 1.1, see footnote 8.

this style and especially for this research project? My answer is that overwhelm is how I experience the world and a composer cannot shut themselves out of their work. If the portfolio is not exemplarily illusive, it is at least honest.

Overwhelm is what I seek both from my writing and listening. If the composer Holmgreen is 'invaded by pessimism' then I am by escapism.[349] To mentally escape is to have one's attention completely held or anchored in an experience, and I've found that sensory overwhelm holds my attention. Illusions too are phenomena which I find sensorily overwhelming, as they allow me to escape into or be suspended in sustained cognitive dissonance. This is my experience of Harris's "astonishment".[350] When composing this portfolio, perhaps my subconscious intention was to write music which cognitively overwhelms in these two contrasting ways. I sought not only to make music that is perceptually illusive, but also music that metaphorically evokes *my* experience of illusion: bewilderment, disorientation and delight.

Within this aesthetic context, the recurrence of certain illusions within this oeuvre make sense. Risset rhythms, Shepard tones, Infinity series (or derivatives of the technique) all encourage a composer to layer, and so I used these devices as excuses to fill the page with notes, which at times led each illusion's conditions to be contradicted and effect rendered imperceptible. This is sometimes the case in pieces such as *Jīng, Ghoulish Airs, Jab* and *Witherbud*. This recurring use of false infinities provoked an epiphany, prompted in part by Łukawski:[351] due to Shepard and Risset's research, any point on the pitch or speed continuum can be made an upper or lower limit. Discoveries such as these would allow me to continually recontextualise and renew a listener's attentional focus in my work. No matter what high or low point I had reached in the piece, and now we discuss climax, there would always be another along the continuum, as long as it was looped back round to via "invisible" Shepard/Risset pitch or tempo pathways.[352]

The aim to successively expand the bounds of a piece is present in the continual redefining of upper tempo limits in *After Images*;[353] the contrasting materials and techniques of *Ghoulish Airs* which weather each other, are counterpointed in contrasting A and B sections and then combined in the third section;[354] the multiplicities of objects in *Georgimorphosis* which frequently trigger a satisfying sense of recognition and distort the melody in such a variety of directions so that unique intermediates are created;[355] the variety of illusions in *Jab* which sustain an evolving drama through their interplay;[356] and the ventriloquisms in *An Interview with a "Puppet" and his "Maker"* which completely transform

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[349] (Beyer, 2019) p. 199
[350] See chapter 1.
[351] Łukawski's influence is discussed in 3.5.1
[352] Within reason. Naturally constraints of instrumentation and other practicalities will always affect how "big" or "small" a moment feels.
[353] See appendix A and 3.3.3.
[354] See 3.4.1
[355] See 3.6
[356] See 3.5.1 and 3.7.1

the theatrical context of what is being witnessed *in situ*.[357] All of the above create unique *teloi* which subvert and burst through the circumstances of their creation. In these moments I have aimed to cognitively flip the listener, to turn their inner worlds upside down: "look, the world is just a little bigger than you thought it was".[358] Perhaps the above explains the sheer quantity of material and ideas included in each piece. This need to pack so much material into my work (and often for those materials to undergo multiple processes at once), the density, and unwillingness to bend to the required conditions of illusion are all marks of the desire to flood the senses and escape boredom. The seed of tension between my composing and my research framework finally reveals itself.

However, it would be untruthful to say that no concessions to my research were made. My current compositional aesthetic has been completely remoulded by my experiences with illusion and during this research project many decisions were made in the name of illusion. Before researching illusion, I would never have used quotations or found objects as I did in *Georgimorphosis*, *Witherbud* and *An Interview* but the transformation illusions that I worked with in these pieces required the element of recognition that could only be afforded by known objects.[359] The satisfying process of melodic division that emerged from *Georgimorphosis* was a surprising and welcome discovery that I look forward to applying to materials both found and original in the future.[360] The use of found objects in *An Interview*, while less audible, also lend a playful cartoonish quality to the piece.[361] Ventriloquism was a fresh and enlivening challenge as I had no experience with the artform before writing *An Interview*. The work is imbued with a theatricality rare to my oeuvre. It would also not have been my choice to close *Jīng* with a unison melody doubled with contrasting timbres had the Wessel illusion not been in my mind.[362] A relationship with repetition has crept in, as is evidenced by the tempo loops of *After Images*, *Ghoulish Airs, Jab* and *Witherbud*. Though the *riletture* of *Georgimorphosis* and Session 2 of *An Interview* are the basis of transformation, they too are modified forms of repetition. Without coming to terms with the unique power of Steve Reich's phase-shifting when writing the literature review, I wouldn't have tried to similarly build textures of overlapping 3 or 4 note patterns in *An Interview*. Minimalism has made known its power to repeat and therefore communicate the significance of a sonic entity or collection of sounds. Minimalist pieces are microcosms of reification.[363]

Though they are rare, there *are* moments of clarity and simplicity in my portfolio. Thanks to the patient imploring of my supervisors, *After Images* opens with a simple repeating 5 note falling pattern in the wood block. *Ghoulish Airs* opens with a ShMInfinity series in crotchets which accelerate to quavers then semiquavers. The entire first section has a simple rhythmic profile and the counterpoint

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[357] See 3.8
[358] 井底之蛙 (jǐngdǐzhīwā) is tale of a frog who lives in well, considering himself a lord of paradise until a visiting turtle tells him how magnificent the ocean is. I'd like people to see the ocean.
[359] Although again my aesthetic would often prevent these found objects from being rendered fully recognisable.
[360] See 3.6.2
[361] See 3.8.1
[362] See 3.2.2.
[363] See 3.8.1.

between voices is of clear and simple relation. Perhaps for this reason it is one of the more illusive sections of *Ghoulish Airs*. From this quasi-heterophonic style of counterpoint and my attempts at Appearance illusions, I've learned to consider resonance in my orchestrations. While textures are dense, there is a conceptual simplicity and directness to the portfolio. The processes, though various and not immediately obvious in their direction, generally tend to go linearly from one end to the other. As a result of my research, I have become interested in different speeds of transformation, as is exemplified by *Georgimorphosis*.[364] There is an above mentioned interest in liminality that wasn't present in my work previously – an example of this might be bars 197 – 206 of *After Images* where the tubular bells accelerate from triplets to tremolo and, in doing so, traverse the gulf between rhythmic impulse and timbre.[365] The pieces have an intensity of form and intention that has arisen due to my work with illusion, not just because of the ever-rising Shepard tones and accelerating Risset rhythms. I credit this to setting out clear phenomenological goals when composing and trying to realise ideas from performance magic regarding the systemic neutralisation of suspicion and procurement of astonishment.[366] This has resulted in a portfolio of work with a direct sense of purpose, even if the works don't always succeed in their purpose. All these qualities in my recent work, both illusive and non-illusive, would not be present without having undergone this research project. These lessons will stay with me always.

This research project may help others who are interested in illusion to begin their own research enquiries. There are certainly gaps in the research to fill: the categories of Hallucination (although arguably Hallucinations have been well explored by the figures mentioned in 2.2.6) and Appearance and Vanish have been only lightly explored and many of the pieces included in the portfolio have been extremely False Infinity centric.[367] Meta-illusions have remained untouched, and mimesis has been limited to attempts at speech synthesis.[368] These are all effects that other composers might further explore.

The portfolio consists entirely of acoustic works and so, even though electroacoustic composers have composed extensively with illusions, contemporary electroacoustic composers may be able to derive fresh insights from my evaluations and reinvent electroacoustic aspects of illusion. This research project continues the dialogue between acoustic and electroacoustic genres. Though the invention of new psychoacoustic illusions has not been an aim of this research project, I have faith that new illusions will be discovered and that compositional adaptations will be made of them.[369]

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[364] By comparing the different ways in which the materials transform, as is shown in 3.6.1, one can see that some transformations occur over relatively short timeframes and others, such as the anamorphic transformations occur across the whole work.

[365] See 3.3.2.

[366] See chapter 1 for astonishment and 2.4 for the neutralisation of suspicion.

[367] Every piece aside from *Georgimorphosis* and *Jīng* has included Shepard tones and Risset rhythms.

[368] See chapter 2 for explanations of these categories.

[369] As recently as 2015, a teenager, Katy Hetzel, discovered that a low-quality recording which was supposed to show the proper pronunciation of the word "Laurel" sounded to herself like "Yanny". The sound clip "went

Lastly, a quote from Hofstadter explains my motivations for producing such a portfolio in the first place. In the following passage, Hofstadter talks of the seeming impossibility and initially unresolvable contradiction of programming intelligent behaviour:

> 'Isn't this the most blatant of contradictions in terms? One of the major theses of this book is that it is not a contradiction at all. One of the major purposes of this book is to urge each reader to confront the apparent contradiction head on, to savour it, to turn it over, to take it apart, to wallow in it, so that in the end the reader might emerge with new insights into the seemingly unbreachable gulf between the formal and the informal, the animate and the inanimate, the flexible and the inflexible.'[370]

I hope that my research has epitomised the savouring of contradiction. To wonder at art, magic or anything else is a beautiful, joyful experience. I have aimed to show the listener and reader some curiosities which exist in the nooks of our limited perception; to encourage the embrace of paradox; to be incredulous to absolutes.

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viral" and the internet was whipped into a fervour by the sharp split in public opinion which occurred (Pressnitzer et al., 2018).

[370] (Hofstadter, 1979) p. 34.

APPENDIX A – Chart of Tempi for *After Images*

Theme	72	90	108	144	216		
Variation 1		90	113	135	180	270	
Variation 2		108	135	162	216	324	
Variation 3			144	180	216	288	432
Variation 4			216	270	324	432	648

	43	54	65	87	130	
Variation 5		54	68	81	108	130
Variation 6		65	81	98	130	195
Variation 7			87	108	130	173	259
Variation 8			130	162	195	260	389

Variation 9	162	203	243	324	486
CODA (i)	162	203	243	324	486
CODA (ii)			122	152	183	243	732
CODA (iii)	92	114	183	274	343
CODA (iv)	85	103	124		
CODA (v)	74	93	112	149	224
CODA (vi)	68	84	101	135	
CODA (vii)	101	126	152	202	
CODA (viii)	76	95	113	151	
CODA (ix)	113	142	170	204	243

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APPENDIX B – Scale of Phonetic sounds

Phonetic	Instrumental equivalent
(b)-a-(th)	**Brass**: harmon mute (w-Ahhh) **Oboe** at swell peaks and mid-high range **Bassoon**: *forte* bassoon sustained sound, bassoon multiphonic **Trumpet** unmuted attack (p/b), straight mute changes trumpet from uh to in between uh and ah **Pno**: sustained tones soft attack ((D3(m*n)), E flat 3 – F3, B3 – F#4,) **Violin**: sustained tone (all octave harmonics) **Viola**: ord. (between uh and ah, espec. Open A and as go up A string), octave harmonics closer to ah, G4 (fifth harm. on C),
Ah-eee	**Oboe** trill
B	**Brass**: short staccatissimo (between buh and duh) **Bass drum**: (byoo-owm or dooooom), muffled is definitely boomboomboomboom **Oboe** staccato (between buh and puh) **Clarinet** accent (between b and p), clarinet step step up (buh-duh-loo) **Bassoon** staccato *piano* or just normal accent (between p and b),
Buah	**Trumpet** plunger mute short note closed to open
c	See "k"
d	**Clarinet** slap tongue **Vibraphone** accent **Snare** single staccato strike centre, snare flam: (t-Da) **Tubular bells** mid-high (ding or dong) **Harp**: harmonics, Xyl. (like handmuting) and ord. mid to low register (doh in mid register) as harmonics increase in height (dung), same with p.d.l.t. but more nasal, spread chords (d-d-loh), piano accents (doh) **Celeste** (Dow, as higher deow), pizzicato resonances (dunggg) **Strings** col leg battuto s.t. to s.p. (dohkohdihkee, deekihdohkoh) **Violin** pizz E string (ding) A: (deng) D: (dang) G: (dong) **Viola** pizz A string (deng) D (dang) G (dong) C (dung)
Doo	**Vibraphone** mid to low
Deow	**Tubular Bells** low
dihrrrrrRah	**Snare** roll-tie-strike,
(b)-ee	**Harp**: Very high gliss on p.d.ch. fast scrape (whEE) **Pno** sustained tones (D7 upward) **Violin** sustain D7 upward, nat. harmonic D6 upward except lower in between ih and eee, 3rd harm. on A and E, bowing pegs **Viola** art. harm. at 4th from B6 upward, nat. harm. at 4th D & A (D6 & A6), bowing pegs
(b)-e-(d)	**Pno** sustained tones (D5 – F#5) **Violin** sustain (E string: open string up to A#) **Viola**: fifth harm. on G (D5) between uh and eh, fifth harm. on D (A5) eh, third. harm. on C (E5)
f	**Flute** trill with aeolian sounds, breath tone accent **Clarinet** and **Bass Clarinet** breath tone accent

	Snare accent **Strings** hand-mute bow back and forth in between bridge and fingerboard (Lachenmann), handmute bow bridge (f/h sustain more f if *trem.*)
Fwear	**Flute** high & loud
Ft/f-(oo)-t	**Flute** tongue ram (7th down) **Oboe** slap tongue (without reed),
Fshiiioo	**Snare** brush circle
G	**Marimba** low (G/Kung), higher (D/Gung) **Snare**: throw-off (D/Gung) **Violin** & **Viola** staccatissimo low (k/gung, G and D string)
H	**Viola** trem. bow tailpiece
(b)-i-(n)	**Trumpet** plunger mute halfway between open and closed, also fully closed in higher register **Sus Cym** higher bowed **Vibraphone** bowed (straight tone) from G5-ish up, E flat 5 is (iooo) **Tubular bell** glockenspiel mallet **Triangle** (diiing) **Clave** (knick) **Harp**: slow scrape, slow whistle up and down, rub strings **Pno** sustained tones (G5 – C#7) **Celeste** mid high to high (espec with ped?) **Cello** (harmonics on A string from E up), sul pont. **Violin** E string B5 – C#7 nat. harm. 7ths, 5th & 3rd on D string **Viola**: fifth harm. on A (E6), art. harm. at 4th E6 – A#6, third. harm. on G, D and A (B5, F#6, C#7)
K	**Bassoon** (TK) **Trumpet** & **Trombone** triple/double tongue (tkt) **Snare** rimshot, only rim (Ka)
L	**Flute** fluttertongue, trill **Clarinet** trill **Bassoon** trill between dark and light fingerings **Snare** ruff (t-d-La/Ta) **Harp** bisbigliando (b-d-l-dl), tremelo multiple strings (d-d-l-d-l) **Viola** trills
Loo	**Flute** legato change of note
M	**Bass Drum**: quiet roll (mmm) **Flute** singing and humming (vvvv) **Marimba** low bowed (hmmm) **Cello** (mmm, even mid range harmonics) **Double bass** (even harmonics)
M*n	**Pno** sustained tones (F2 – G#2, D3, F#3 – A#3, G4 – C#5)
knock	**Temple block** (like Xhosa x (click))
(r)-o-(se)	**Sus Cym** lower bowed **Pno**: sustained tones soft attack (E flat 1 – E2, A2 – C#3) **Violin** D5 nat. harmonic
(r)-o-(ck)	**Temple block** **Violin** G5&B5 nat. harmonic

o to i and back	**Violin**: rattling from mid fingerboard to edge of fingerboard, handmute col leg bat from close to pegs to close to bridge
(h)-o-(wl)	**Trumpet & Trombone** plunger mute open to closed
o-(ar)	**Bassoon** quiet sustained sound **Horn** quiet **Sus Cym** quiet roll
P	**Flute** lip pizzicato **Oboe** staccato **Clarinet** accent (between b and p) **Bassoon** staccato *piano* or just normal accent (between p and b) **Horn** accents **Trumpet** unmuted attack (p/b) **Trombone** double tongue even sounds more like p **Tuba** articulation, except double-tongue in between p and tk **Snare** drum wire brush lateral stroke ruffs (between t and p) **Sus Cym** mallet (p/ksss between sss and shhh)
Rrr	**Flute** fluttertongue **Bassoon** fluttertongue **Snare** roll
S	**Flute** sound **Sus Cym** mallet (psss between sss and shhh), mallet roll at loud peak of cresc. **Harp** whistle down (whsss), leaving hand on string (wheeSooh)
t	**Flute** tongue pizzicato low register, plus key clicks **Oboe** attack (attack between t and d) **Clarinet** repeated note (between t and p) **Bassoon** fast staccatissimo *forte* repeated notes and TK **Trumpet** triple/double tongue (tkt) **Snare drum** single staccato strike edge, brush strike and damp (tp or chp) **Sys Cym** drumstick & dreadlock brush (tsss), drumstick tip similar but not as evident **Strings** col legno battuto
Th	**Flute** singing and humming (vvvv) **Sus Cym** triangle beater scrape (between sss and th)
(y)-ou	**Flute** quiet low sound, somehow C and G multiphonic **Piccolo** low **Alto flute** mid-range **Clarinet** quieter higher range **Trumpet** & **Trombone** plunger mute all the way closed **Vibraphone** bowed low to mid **Marimba** mid high bowed **Harp** slow whistle up and down **Celeste** low to low mid (espec with ped?)
Oohah, between ooh and ah	**Trumpet** and **Trombone** sustained sound
Ü	**Piccolo** mid-range (more extreme version of vowel higher)
Between ooh and uh	**Horn** and **Tuba** sustained tone

Ooah	**Oboe** mid range, like Aflat 4
Ooowhioo	**Flute** overblow harmonic, or jet whistle
Ooooohih (accent on ih)	**Flute** (play and sing gliss. up to any high note)
Ihoooooh	**Piccolo** high to low
u-(dder)	**Oboe** low **Alto flute** low **Clarinet**: whole range (between uh and ooh, gliss down goes from uh to ooh) **Bass clarinet** low (uhm) **Horn** loud **Trumpet** like "uh" but with mouth closed emphasised with harmon mute no stem **Vibraphone** sustain (but with small ee on the end, also harmonics) **Pno**: sustained tones soft attack (A0 – D1) **Viola**: ord. (between uh and ah, espec. Open A and as go up A string), art. harm. at 4th until D#6, all art. harm. at 5th
Uh(r)	**Violin** G string (all), D string (all), A string (all) but more open in lower positions, art. Harm below E7
V	**Flute** singing and humming (vvvv)
Woah/wuh	**Vibraphone** motor vibrato
Who	**Flute** low swell

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