OPEN DOORS AND PARALLEL WINDOWS: TIMBRE, GESTURE, AND AFFECTIVE RESPONSE IN ELECTROACOUSTIC MUSIC

Jon Martin
Bachelor of Music, University of Lethbridge, 2013

A Thesis
Submitted to the School of Graduate Studies
of the University of Lethbridge
in Partial Fulfilment of the
Requirements for the Degree

MASTER OF MUSIC

Department of Music
University of Lethbridge
LETHBRIDGE, ALBERTA, CANADA

OPEN DOORS AND PARALLEL WINDOWS: TIMBRE, GESTURE, AND AFFECTIVE RESPONSE IN ELECTROACOUSTIC MUSIC

JON MARTIN

Date of Defence: August 8, 2017

Dr. D. Andrew Stewart Supervisor	Assistant Professor	D.Mus.
Dr. Paul Sanden Thesis Examination Committee Member	Assistant Professor	Ph.D.
Dr. Louise Barrett Thesis Examination Committee Member	Professor	Ph.D.
Dr. Josh Davies Chair, Thesis Examination Committee	Associate Professor	D.M.A.

Abstract

The ability to evoke meaning and emotion through sound is a powerful feature of electroacoustic music. Research in the areas of music psychology and cognition suggest that timbre, the elicitation of physical gestures, and familiarity may influence how a listener comprehends sound and draws meaning from music. By synthesizing research in the areas of electroacoustic music and music cognition, I formulated two propositions. The first suggests that timbre characteristics may be leveraged to elicit emotional response and past experiences. The second suggests that sound can be used to reference physical gestures and activate empathic responses in a listener. I composed a new three-movement work, entitled *Open Doors and Parallel Windows,* exploring how my two propositions can function as tools to assist the composer to increase affective response and be the conceptual basis for new works.

Table of Contents

1 Introduction

1.1 Electroacoustic Composition and Barriers to Audience Reception

Modern advances in technology have enabled new tools and methods for both artistic creation and human understanding. Composers of electroacoustic music have been increasingly enabled by the new sound generation and processing tools afforded by such technologies, as the electroacoustic genre essentially requires sound to be produced or altered by electrical means (Schrader & Battier, 2013). The expanded possibilities offered allow the electroacoustic composer to explore boundaries of musical expression in ways that can challenge or alienate the audience.

Electroacoustic music can draw on a palette of sound containing atypical, synthesized, unnatural, and otherwise foreign materials that may not be part of the audience's auditory lexicon or exist in other forms of music. The expressive and modifiable nature of this palette is an attractive feature of the genre; in some cases, the barriers or alienation caused by the use of unfamiliar materials may be desired by the composer and even be the main catalyst behind choosing electroacoustic composition over another artistic outlet. The ability to utilize sound materials that lack direct cognitive connections to specific objects, actions, or techniques is profound and substantial in terms of artistic expression. However, the use of unfamiliar materials can also create barriers between the audience and the composer that are a direct result of the audience's inability to comprehend what they are experiencing, as the lack of contextual relations with a particular sound event or sound gesture leaves a limited basis on which the sound information can be reconciled (Emmerson, 1986).

When hearing a sound, a listener draws on their past experiences to provide the context needed to interpret and comprehend the event. A listener is biased to favour a sound that is known or recognizable, over one that is not (Ward, Goodman, & Irwin, 2014). Familiar sounds also have the ability to reference and depict known actions, trigger empathic responses, carry extra-musical information, and elicit emotions (Chau, Wu, & Horner, 2015; Emmerson, 1986; Freedberg & Gallese, 2007; Huron, 2006; Martin, in press; Sahin & Erdogan, 2009). Furthermore, Juslin and Västfjäll (2008) suggest that the primary reason people listen to music is for the emotion that it evokes, while Kendall (2014) proposes that the blend of our individual emotional experiences influences the ways in which we interpret sound and find meaning in music.

It is, therefore, in the interest of the contemporary electroacoustic composer to gain an understanding of how affective response and the use of familiar or unfamiliar sound materials influences their work.

1.2 Electroacoustic Music and Music Psychology Research

Music psychology focuses on the "perceptual, cognitive, and affective nature of musical learning, and research-based pedagogy concerning music listening, performance, and creativity" (Fiske & Heller, 2014). The field has progressed rapidly and has been enriched through the use of new research technologies, new discoveries and concepts in neuroscience, and a growing interest in the role of music and sound in human development. Given that the aforementioned barriers existing for the audience of electroacoustic music are cognitive in nature, it is logical to look for solutions in the area of psychology.

How can research in music cognition help address barriers in electroacoustic music and increase the affective response of a composition? By synthesizing findings in the areas of music psychology and cognition on expectancy, affective response, timbral recognition, and mirror/canonical neurons (see Chapter 3), with established concepts from within electroacoustic music (see Chapter 2), I have formed two propositions that address the barriers created through the use of unfamiliar sound material.

The first proposition suggests that by applying traits of familiar sounds to unfamiliar sounds, we can link past experiences and new experiences, and subsequently provide a context for the listener to comprehend an aural event through emotional elicitation. The second proposition suggests that sound can be used to activate areas of the brain that process previously experienced physical gestures, and that through this activation, extra-musical information and emotional stimulation can be accessed.

Both propositions provide a conceptual basis to address familiarity barriers in electroacoustic music. If successful, they offer clear and transferable methods to enhance the emotional potency of a work and allow for the composer to employ sound materials that may otherwise be too alienating for an audience.

1.3 A Description of *Open Doors and Parallel Windows*

Open Doors and Parallel Windows (35:03) is a three-movement electroacoustic composition consisting entirely of environmental and soundscape recordings made between 2013 and 2016 while travelling in Canada, the United States, France, Germany, and Japan. The work explores the ways in which my two propositions can be practically applied to enhance a new piece of music based fully on recorded sound and the manipulation of those recordings. By exploring my propositions in a new work, I seek to

determine whether or not explicit inclusion of ideas from psychology and music cognition research is beneficial to the electroacoustic composer by increasing artistic agency when using potentially alienating sound materials.

1.4 Structure of Thesis

This thesis is arranged in seven chapters. In Chapter 1, I introduce the research question and scope of *Open Doors and Parallel Windows*. Chapter 2 contains relevant background materials in the areas of electroacoustic music, soundscape composition, spectromorphology, and mimetic space. Chapter 3 includes relevant background material in the areas of psychology, cognition, canonical and mirror neurons, timbre and emotion, expectation, and familiarity. In Chapter 4, I present my propositions of timbre and gesture. The application of these theories in the electroacoustic composition *Open Doors and Parallel Windows* is discussed in Chapter 5. The thesis concludes with a discussion of implications for my future research in Chapter 6.

1.5 Summary

The electroacoustic music composer faces many challenges inherent in the technological nature of the genre and use of a diverse, and often unfamiliar, palette of sound materials. When a listener is unable to comprehend what they are hearing, they are deterred, and potentially prevented, from deriving meaning from the experience of a musical work. Research in sound cognition and music psychology shows potential for addressing the barrier created between the listener and unfamiliar sound materials. The two propositions presented combine ideas from psychology, music cognition, and electroacoustic music research, and suggest that the explicit use of known timbres and

gestures can address these barriers. These propositions are explored and applied in a new electroacoustic work, *Open Doors and Parallel Windows*.

2 Electroacoustic Music

Electroacoustic music refers to a broad category of music that is either produced or modified by electronic means. *Open Doors and Parallel Windows* draws from several research areas in electroacoustic music and psychology. This chapter provides background information and concepts from electroacoustic music that support the propositions presented in Chapter 4 and inform the composition of *Open Doors and Parallel Windows*.

2.1 Electroacoustic Music: Origins and Genre

The origins of electroacoustic music date back to the 19th century when the exploration of electromagnetism led to the first production of electrically produced sound, the development of the telephone, and early electronic instruments like Elisha Grey's musical telegraph and Thaddeus Cahill's Telharmonium (Davies, 2017). The early 20th century saw the advent of more complex electronic instruments and sound-related technologies. These developments include instruments like the capacitance-controlled Theremin in 1920, the Warbo Formant-Orgel synthesizer in 1937, and the Sakbut synthesizer in 1945, and sound production tools like capacitor microphones and magnetic tape recording devices. In the late 1940s and early 1950s, sound recording and electronic music production technology had matured to the point where it could be an effective outlet for composers.

Electroacoustic music is categorized according to the source of sound material and compositional approach. Generally speaking, there are presently two main categories

of electroacoustic music: *acousmatic* and *live-electronic*. Acousmatic music[1,2] refers to music and sound existing on a fixed medium intended for playback over loudspeakers (e.g. Jean Risset's (1969/1978) *Mutations,* Paul Lansky's (1979/1994) *Six Fantasies on a Poem by Thomas Campion*). Acousmatic music is typically composed in a studio environment, and can contain sound materials from virtually any source, including traditional and electronic musical instruments, environmental recordings, and synthesized or computer-generated sound. In this environment, the composer has access to specialized sound processing tools that enable exploration of recorded sound in ways that would not otherwise be possible (some of these techniques are discussed in section 5.2). Acousmatic music is also referred to as "music for tape" (Battier, 2007).

An experimental predecessor of acousmatic music, *musique concrète*, was developed by Pierre Schaeffer in Paris at the end of the 1940s. It is differentiated from traditional acousmatic music by virtue of using recordings of real-world sounds as the raw material for a musical work (e.g. Hugh Le Caine's (1955/1997) *Dripsody,* Schaeffer and Henry's (1950/1973) *Symphonie pour un homme seul*). The materials are abstracted from their natural context and presented in a new form as a composition. Through the creation of musique concrète, Schaeffer designated conceptual status to the sound object[3]—essentially a unique recording of a sound—and provided a framework for the

[1] The term "acousmatique" was first used by poet Jerome Peignot to describe "a sound that one hears without seeing what causes it". He introduced it to Pierre Schaeffer to describe musique concrète. It is an extension of the term acousmate, which stems from the Greek word *akousma* (Kane, 2012).
[2] Smalley states that "Acousmatic music is the only sonic medium that concentrates on space and spatial experience as aesthetically central" (2007, p. 12).
[3] Schaeffer described a sound object as an "object for human perception and not a mathematical or electroacoustic object for synthesis," specifying that it should not be confused with the object that is producing the sound (Schaeffer, 1966, p. 271-275).

development of new concepts in acousmatic music and sound studies, including soundscape composition (discussed in detail in the next section) (Schrader & Battier, 2013).

Live-electronic music is music performed live containing electronically produced sound, live performance in combination with pre-recorded elements, electronically-augmented instruments, or electronic processing of live acoustic sounds (e.g. John Cage's (1939/1995) *Imaginary Landscape no.1,* Mario Davidovsky's (1970/2005) *Synchronisms No.6*). A broad category, live-electronic music may feature: (1) real-time performance with pre-recorded sound; (2) real-time production or performance of electronic, or electronic and acoustic sound; or a combination of the two. Live-electronic music employing live and pre-recorded elements is sometimes referred to "music for (instrument) and tape" (Schrader & Battier, 2013).

The broad definition of electroacoustic music only requires music to be produced or modified by electronic means. Consequently, it is suggested that additional sub-genres will continue to emerge in tandem with developing technologies.

2.2 Soundscape Composition

Soundscape composition uses environmental recordings as the source material for musical works (e.g. Hildegard Westerkamp's (1989/1996) *Kits Beach Soundwalk,* Barry Truax's (2001) *Islands*). The concepts underpinning soundscape composition were created by R. Murray Schafer in the late 1960s with the World Soundscape project at Simon Fraser University in British Columbia, Canada to establish an awareness of, and provide commentary on, the deteriorating acoustic environment in urbanized areas. The

notable focus on the environment helps differentiate it from musique concrète as presented by Schaeffer[4].

Soundscape composition addresses various musical and sociological aspects of acoustic ecology, and was initially realized through the creation of the World Soundscape Project (Truax, 2008). A soundscape composition typically consists of audio materials recorded or captured from a specific acoustic environment or physical location, which are then arranged, edited, or otherwise manipulated by the composer to create a new work. In addition to the use of environmental recordings, Truax states that a soundscape composition must adhere to four principles:

1. Listener recognizability of the source material is maintained, even if it subsequently undergoes transformation;
2. The listener's knowledge of the environmental and psychological context of the soundscape material is invoked and encouraged to complete the network of meanings ascribed to the music;
3. The composer's knowledge of the environmental and psychological context of the soundscape material is allowed to influence the shape of the composition at every level, and ultimately the composition is inseparable from some or all of those aspects of reality; and
4. The work enhances our understanding of the world, and its influence carries over into everyday perceptual habits. (1996, p. 63)

These principles have laid the foundation and conceptual framework for modern soundscape composition. Furthermore, they highlight the importance of the composer's knowledge of the specific sound materials being used (principle 3) and their cognizant awareness of an audience's experience and knowledge (principles 1, 2, and 4).

A soundscape composition can range from a simple, neutral reframing, or "found sound" work, that consists of a small set of materials (e.g. R. Murray Schafer's (1973)

[4] Westerkamp suggests that soundscape and electroacoustic music are related, but different genres of music. She argues that labeling the former as a type of musique concrète removes aspects of explicit environmental listening and engagement critical to the genre (Westerkamp, 2002).

Entrance to The Harbour), to a processed and layered work consisting of several different sources (e.g. Barry Truax's (2001) *Island)*. Truax (2002) suggests that a composition adhering to these principles can be realized through three different types of perspective, which exist along a continuum from natural to abstract.

The first, most natural type, a fixed perspective, emphasizes the flow of time and events in a natural way through a discrete series of non-changing perspectives (Truax, 2002). In a fixed perspective piece, the composer employs a limited amount of processing and basic editing, which may include time compression or expansion, or a vocal or event-based narrative and oral history of the recording, with transitions that move naturally between stationary perspectives.

The second type, the moving perspective, depicts smoothly connected time and space relations that suggest movement, motion, or a journey (Truax, 2002). Pieces employing a moving perspective feature more pronounced processing techniques, which may include artificial or simulated reverberation, elaborate fading and crossfading of individual sounds or audio selections, partial or complete layering of materials, and sequential or parallel (layered) use of transformed and untransformed materials (Truax, 2002). The perspective may shift between real and existing locations, and include those that are simulated, imaginary, or invoked (Truax, 2002). As the perspective moves and transforms, connections are maintained between past and future events.

The third type is the variable perspective. As the most surreal and abstract type of soundscape composition, it prominently exhibits a discontinuous flow between temporal and spatial events (Truax, 2002). As its name suggests, a variable perspective soundscape work is characterized by the use of multiple perspectives. A variable perspective piece

can contain highly processed sound materials, including time manipulation, and timbral and spatial processing. Audio materials may be abstracted from their original perspective, juxtaposed against other perspectives, or subject to complex multitrack editing that breaks in the perceived time/space continuum of the piece.

The perspective adopted is a considered decision made by the composer of a soundscape composition. In conjunction with the four principles of soundscape composition, each of these three types serve to emphasize different aspects of a work and influence how the musical materials are interpreted by a listener.

2.3 Spectromorphology

Denis Smalley's 1997 landmark article *Spectromorphology: Explaining sound-shapes*, consolidated important ideas and vocabulary in the field of electroacoustic music. In this article and its 1986 predecessor, Smalley advanced the groundwork laid by Pierre Schaeffer (1966). In doing so, he established the conceptual framework for spectromorphology, which can be defined as the perceived interaction between the sonic footprint of a sound and how it is shaped through the passing of time (Smalley, 1997).

Contained within spectromorphology is the concept of *source bonding*. Smalley (1997) describes source bonding as the natural tendency to relate sounds to supposed sources and causes, and to relate sounds to each other because they appear to have shared or associated origins. For example, when hearing a human voice speak, a listener associates the sound of speaking with the physical action of a person moving his or her mouth in a manner that would produce speech, and not an action or object thought to be unrelated, like an automobile or a washing machine. Hence, the sound of speaking is bonded to the action of speaking. By virtue of new recording technologies and audio

processing tools, sound can be created or captured that is not bound to any specific action or object. This includes synthetic and computer-generated audio that does not occur in the natural world, as well as sound existing in the natural world that would not be perceivable with the human ear alone.

Smalley (1997) also provides the concept of gestural surrogacy, where the inherent relationship between a sound and gesture is emphasized, transformed, or otherwise disrupted in an intentional manner for the purposes of electroacoustic music. Gestural surrogacy suggests two-way communication, where a spectromorphology provides information about the humanity that caused the sound gesture—a mechanism that Smalley calls the spectromorphological referral process (1997).

2.4 Mimetic Space

Emmerson (1986) provides similar ideas regarding sound materials that imitate those of the natural world or human culture not typically associated with music. He discusses the importance of the set of rules used for the analysis of an event, which in this case is an event relating to sound. Emmerson suggests that such an event can be examined and presented as both abstract and abstracted. An event is considered abstract when it consists of "real but unconscious relations which are able to function without being known or correctly interpreted," and considered abstracted in the absence of contextual relationships (Emmerson, 1986, p. 20-21). He states that the compositional decision to keep or remove relationships of sound-objects cannot be made in isolation, and must be viewed holistically (Emmerson, 1986). Choosing to maintain or deliberately create new relationships that are not possible in the natural world are methods by which a narrative or story line may be established. Emmerson's resulting concept, the Language

Grid, suggests that we can hear electroacoustic music as having both aural *and* mimetic discourse[5], or as having aural *or* mimetic discourse that is "organized on ideas of syntax either abstracted from the materials or constructed independently from them in an abstract way" (Emmerson, 1986, p. 24).

Fischman (2008) uses Smalley's concept of spectromorphology and Emmerson's Language Grid as a point of departure to provide the concept of mimetic space. Mimetic space is the venue in which source-bonded sounds and spectromorphologies move between abstract and abstracted contexts, aural and mimetic function, and real or constructed relationships, ultimately in new perspectives and virtual spaces (Fischman, 2008). In doing so, Fischman provides a conceptual framework for the electroacoustic composer where perspective and musical meaning may be more effectively translated.

2.5 Summary

The capacity of electroacoustic music to facilitate sound exploration is inherent in its technological nature. Acousmatic music, requiring fixed-media musical works to be performed over loudspeakers, and soundscape composition, a type of acousmatic music that uses environmental recordings as its source material, offer a stable conceptual basis and platform from which a listener's cognition of sound can be explored. Spectromorphology and mimetic space provide the composer a perspective that considers the connection between sound and an action or object, its context, and its relationship with other sounds.

[5] Aural discourse refers to the "conventional and familiar structuring and discursive musical attributes such as relationships and patterns of pitches and rhythms," while mimetic discourse refers to the "signifying potential of referential or extrinsic attributes of sound, being particularly pertinent to electroacoustic music which uses recorded sound as material" (Weale, 2007).

3 Music Psychology and Cognition

In addition to changing the ways in which we are able to produce and experience music, modern technologies have facilitated the understanding of sound cognition. This chapter provides background information and concepts from music psychology and cognition that support the propositions presented in Chapter 4.

3.1 Psychology in Music

Music displaying a composer's awareness of cognition is not new. Beethoven's challenge of audience expectation with the "false entrance" at the beginning of his Symphony No.3 (1803/1976), Chopin's surprise fortissimo and rubato during the final presentation of the melody in Opus 9 No. 2 (1832/2006), Luc Ferrari's use of layered environmental and abstract sound materials to draw on a listener's experience and suggest dramatic narrative in *Hétérozygote* (1969), and Denis Smalley's use of fluid sound gestures to imply physical motion in *Valley Flow* (1991), all indicate the composer's consideration for how the music would be understood by the audience. While these are only a few of many examples, the historical precedent of a composer's attention to audience cognition is significant, as it highlights the musical and artistic effectiveness and importance of the technique. As discussed in the ensuing sections, recent research in the area of music cognition suggest that the affective potential of a piece of music can be explicitly enhanced through attention to aspects of timbre, familiarity, and expectation.

3.2 Timbre and Emotion

Timbre refers to the specific set of harmonic and inharmonic relationships that make up the character of a sound. Every sound, both naturally and artificially created, inherently contains such a set of relationships. Timbre is a critical musical element that

influences a listener's affective response and perception of a piece of music (Chau, et al., 2015), has the capacity to carry extra-musical information (Giordano & McAdams, 2010), and serves as a primary indicator of a sound's source (McAdams & Giordano, 2009). In recorded sound, timbre is influenced by many factors: microphone; preamp; dynamics processing; the room or space the sound was recorded in; and the type of instrument or object creating the sound.

Chau, et al. (2015), using non-sustaining string instruments, demonstrated that the timbral properties and amplitude envelope[6] of a sound can influence the emotional perception of a sound, linking timbre and emotion. Their 2015 study consisted of three listening tests where participants compared pairs of instrument sounds over emotional categories. They found that timbral features, specifically harmonic density and decay slope[7], were significantly correlated with most emotional categories tested. While the number of participants in the test group was small, the implications of this study are substantial, suggesting that the cognition of timbre can contribute to the elicitation of emotion in recorded sound.

Deacon (2006) discussed the intrinsic relationship between cognition and emotion caused by symbolic associations in humans. Considered in the context of recorded sound and timbre, Deacon's comments suggest a conceptual connection linking timbre and emotion. He stated:

> Emotion is not distinct from cognition. Emotion cannot be dissociated from cognition. It is the attached index of attention relevance in every percept, memory, or stored motor subroutine. Emotional tone is the prioritizing marker attached to every cognitive object that enables an independent sorting of it with

[6] An amplitude envelope refers to the attack, decay, sustain, and release of a sound.
[7] Decay slope is the rate at which a sound moves from its initial peak amplitude to its sustained amplitude.

> respect to other competing cognitive objects, irrespective of pattern-matching processes. One acquires not only patterns of perception, categorization, and norms of action but also information about the set of attached prioritizing markers. This information can often be far more important, because of the precognitive role it can play in organizing interpretations and activities according to a largely hidden and sometimes orthogonal matrix of emotional associations. (Deacon, 2006, p. 37)

The link suggested between emotion and cognition is inherently inseparable, as the cognition of any sound would require a check against one's experience-based set of prioritizing markers, therefore becoming connected to past experience and related emotions. Using this logic, cognition of the sound of a piano, for example, is intrinsically attached to past experiences of hearing a piano.

Deacon proposed that the human aesthetic experience is the result of our motivational structure being influenced by an adapted preference for combinatorial associations that "ease the mnemonic difficulties of symbolization" (2006, p. 38), with the preferential function extending to the correlating emotional representations. In doing so, he suggests that processing a singular symbolic representation containing several elements, will be preferred when compared to processing each of the elements individually. The resulting preference allows for a reduced cognitive burden, and promotes the capacity to explore complex and subtle relationships between combinatorial associations (and their related emotions) when experiencing a work of art (Deacon, 2006).

Expanding on the ideas provided by Deacon (2006), Kendall (2014) discussed how blending, layering, and combining multiple emotions may be implemented to elicit new, emergent emotional responses. Kendall employed a model adapted from Brandt's (2005, 2006) five mental layers to explain how a listener's perception and interpretation

of meaning in an electroacoustic work is derived. He proposed that meaning is derived through both comprehension and emotional response. Kendall (2014), agreeing with Deacon (2006), suggested that emotive states function like symbolic tokens that can be occupied simultaneously. He believes that we are able to explore "uncharted and extraordinary blends of feeling without getting mired in practicalities" through the use of shared cultural symbols and patterns in individually unique and combinatory presentations (2014, p. 201).

The link between Chau, et al.'s (2015) timbre and emotion association, Deacon's (2006) connection of cognition and emotion, and Kendall's (2014) blending emotive states to foster the emergence of new emotions, suggests that there is potential in exploring timbre as a device to explicitly elicit emotions and attach meaning to the cognition of sound. The connection of timbre, emotion, and cognition is central to the propositions presented in Chapter 4.

3.3 Expectation

The fulfillment or subversion of expectation is one of the key elements that allow for music to be pleasurable (Huron, 2006; Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011). In his book, *Sweet Anticipation: Music and the Psychology of Expectation,* Huron (2006) proposes his ITPRA Theory of Expectation, that employs five distinct psychological stages to explain how events are observed, anticipated, and assessed. His theory begins with two pre-outcome stages, followed by three stages after the outcome is known.

The first, imagination response, is where a prediction of potential future events is made. Predicting future outcomes can motivate changes in our behavior and allow for a

greater chance of achieving a favourable result (Huron, 2006). The second stage, tension response, is where the perceptual and motor systems prepare for the expected result (Huron, 2006). If the outcome of an event is unknown, more preparation time, mental effort, and energy is required. The following three stages occur after the outcome of the event is known. The third stage, prediction response, psychologically rewards a successful prediction and punishes an incorrect prediction. Even if a result is negative, a successful prediction yields a positive emotional response, as quick and efficient preparation of motor and perceptual systems allows for a greater chance of a better outcome (Huron, 2006). The fourth stage, reaction response, functions like a reflex, where a previously learned action is triggered in response to the outcome of an event (Huron, 2006). The final stage, appraisal response, is where the outcome of an event is assessed and transformed by further thought (Huron, 2006).

While a detailed description of the inner workings of Huron's ITPRA Theory of Expectation is beyond the scope of this document, he argues that, generally speaking, a positive outcome for a predicted result—when expectations are fully met—is less desirable than a positive outcome for an unexpected, or unpredicted, result, and vice-versa. He states that this is due to low expectations amplifying an emotional state when a person is faced with unexpected fortune or misfortune, as is predicted by Kahneman and Miller's (1986) norm theory.

In the context of listening to music, Huron (2006) proposes that if an unpleasant sound is unexpected, it will be more unpleasant, while if a pleasant sound is unexpected, it will be more pleasant. He suggests that this phenomenon is caused by unused endorphins, pain-blocking chemicals secreted in the brain, which activate our opiate

receptors. When endorphins are released in anticipation of potential pain, but go unused, a feeling of euphoria is created. Salimpoor, et al. (2011) demonstrated that the pleasure associated with listening to music is directly associated with dopamine activity in the mesolimbic reward system[8] by observing areas of dopamine release in members of a test group using magnetic resonance imaging. Salimpoor, et al. also agree with Huron (2006; Huron & Margulis, 1993) in that familiarity with musical conventions and structure can provide the basis for the predictions, expectations, and anticipation that may be subverted to release dopamine and heighten the emotional experience of a piece of music.

Huron's (2006) ITPRA Theory of Expectation suggests that active attention to the preparation and resolution of auditory events and characteristics, such as timbre, may yield gains for the composer in the form of inducing pleasure in an audience through the release of dopamine.

3.4 Familiarity and Preference

A primary challenge for electroacoustic composers is the barrier created when a listener lacks the ability or knowledge to comprehend unfamiliar musical materials (Smalley, 1997; Truax, 2008). The resulting loss of a listener's attention and focus greatly reduces the composer's ability to communicate ideas and emotions (Deacon, 2006; Huron, 2006). Emmerson (1986) states that a fundamental problem—the barrier

[8] The mesolimbic system is a natural behavioral reinforcement mechanism. Salimpoor, et al. (2011) state "Humans experience intense pleasure to certain stimuli, such as food, psychoactive drugs and money; these rewards are largely mediated by dopaminergic activity in the mesolimbic system, which has been implicated in reinforcement and motivation. These rewarding stimuli are either biological reinforcers that are necessary for survival, synthetic chemicals that directly promote dopaminergic neurotransmission, or tangible items that are secondary rewards" (p.257).

identified in Section 1.1—is created for types of electroacoustic music when the group of relationships, both conscious and unconscious, surrounding a sound event is removed or unknown to a listener.

A listener's familiarity with music has been shown to be a strong indicator of choice. Ward, et al. (2014) performed a series of choice studies examining the influence of familiarity on choice of contemporary music. Each of three studies showed strong correlation between a listener's familiarity of a song and their choice of music - even when there was an expressed desire for new or novel music from participants.

A similar study was performed by Peery and Peery (1986) that examined the effects of exposure to classical music on the musical preferences of preschool children. Forty-eight children between the ages of four and seven were split into two groups: one operated as a control group, while the other was regularly exposed to classical music over the period of one year. In comparing the results of tests for musical preference performed before and after the one-year listening period, they found that musical preference can be influenced through repetitive exposure to music.

The findings of Peery and Peery (1986) and Ward, et al. (2014) indicate that familiarity with music contributes to listener preference. Similarly, Wapnick (1980), tested ninety-eight undergraduate music students for music preference based on timbre, pitch, tempo, and familiarity in excerpts of popular and uncommon pieces of recorded piano music. He found that, in addition familiarity, timbre and tempo are indicators of musical preference. The preference for familiar materials indicated by these three studies suggests that a possible solution to the barriers discussed in Chapter 1 may exist through the application of familiar traits to unfamiliar materials (see Section 4.1).

While an in-depth examination of why familiarity is an indicator of preference is beyond the scope of this thesis, it may partially be explained by certain neural pathways operating more efficiently due to an increased level of myelin. Myelin is a fatty substance that wraps around neural circuits and provides insulation from outside electrical interference. Neural circuits that are activated frequently are subject to increased levels of myelination. With reduced interference, neural circuits are able to operate more accurately and efficiently. Neural pathways, containing many neural circuits, activated more frequently become more efficient than those activated less often (Gopnik, Meltzoff, & Kuhl, 2001; Hartline, 2008).

As a result, a person gets "better" at any physical or cognitive action repeated frequently, including processing sound. Familiar musical materials, including timbre, are inherently those that a listener has experienced before and that, due to an increased level of myelin on the corresponding neural pathway, are processed faster and more efficiently. This suggests that the reduced burden of processing the familiar experience yields a preference or positive bias when compared to a less familiar experience.

3.5 Gesture and Neurons

Examination of research in the areas of mirror and canonical neurons and empathic response provides additional insight into how composers may increase artistic agency when using unfamiliar sound materials.

The study of mirror neurons is a recent area of research that suggests cells in the pre-motor cortex—the area of the brain associated with the planning and control of movement—are activated when sensory information depicting the actions of another animal is observed (Gallese, Keysers, & Rizzolatti, 2004; Rizzolatti, Fadiga, Gallese, &

Fogassi, 1996). The existence of a mirror neuron system in humans, however, is a topic of contention and debate. While several studies have demonstrated mirror neuron-like empathic responses in humans while observing the expressions and actions of others (Botvinick, Jha, Bylsma, Fabian, Solomon, & Prkachin, 2005; Cheng, Yang, Lin, Lee, & Decety, 2008; Jabbi, Swart, & Keysers, 2007; Morrison, Lloyd, Pellegrino, & Roberts, 2004; Wall, 2008), the existing research primarily employs non-human animals as test subjects. For example, Matyja (2015) argues that, while data suggests mirror-neuron like empathic functions exist in a musical context, mirror neurons in humans can only be an assumption until a mechanical explanation of how the neurons are actually functioning is produced.

Whether it is actually motor neurons responding directly to sensory information (as is suggested by a mirror neuron system) or similar empathic response, the link between observing an action and the elicitation of a neural response is a compelling concept for the electroacoustic composer. Rey, Roche, Versace, and Chainay (2015) performed a perceptual and motor task study comparing response times to visual and auditory representations of objects. They found that an auditory presentation of a gesture initiated the same kind of motor preparation in a listener as its visual counterpart. Their findings suggest that observing the sound of a physical action may yield the same response as observing the physical action itself. With consideration to the empathic response offered by mirror neurons, it would follow that hearing an action may induce the same motor activity, and possibly the associated emotions, of performing the action one's self.

In a similar study, Lemaitre, Heller, Navolio, and Zúñiga-Peñaranda (2015) showed that a link exists between auditory cues and physical gestures. They found that priming a participant with a sound linked to a specific and expected gesture increased the speed at which they were able to identify the gesture. While their research does not attempt to detect empathic response, it does suggest an additional link between sound and physical gesture.

Canonical neurons function in a manner similar to that of mirror neurons. Unlike mirror neurons' activation of the pre-motor cortex upon observing an action, canonical neurons activate regions of the brain upon perceiving of the potential actions or affordances offered by an object (Sahin & Erdogan, 2009). The study provided by Rey, et al. (2015), in this context, suggests that both the visual and auditory representation of an object may lead to neural stimulation.

The ability to use sound to imply or reference a physical gesture is an interesting prospect for the electroacoustic composer. It becomes particularly compelling when considering potential connections between gesture and emotion. Overy and Molnar-Szakacs (2009) suggest that the cognition of auditory events and the understanding of their underlying motor gestures is linked with what they call the shared affective motion experience (SAME). Their work suggests that the human mirror neuron system allows for a shared experience between the producer of the music and the listener.

Similarly, Freedberg and Gallese (2007) suggest that aesthetic response to a work of art is a result of the activation of embodied mechanisms that simulate actions, emotions, and corporeal sensations. They suggest that a response occurs in an observer when a physical or emotional state or gesture is witnessed or implied, stating that "even

the artist's gestures in producing the art work induce the empathetic engagement of the observer, by activating simulation of the motor program that corresponds to the gesture implied by the trace" (Freedberg & Gallese, 2007, p. 202). Freedberg and Gallese claim that empathic response supports a basic level of comprehension and causes a "direct experiential understanding of the intentional and emotional contents" of a work (2007, p. 198). Their work suggests that the physical actions and emotions that are both depicted and used to create a work are perceptible by its audience.

While there is still significant work to be done in the areas of mirror and canonical neural activity, the link between visual and auditory sensory information, and empathic response, the existing research supports—at least conceptually—the notion that the auditory presentation of a physical action may be capable of eliciting emotional and referential responses. One application of these concepts is explored in Section 4.2.

3.6 Summary

Studies in the area of music cognition provide insight into how listeners understand auditory experience. The cognitive links between timbre and emotion are pertinent to electroacoustic music, in that they suggest timbre may be used to elicit emotion or attach meaning to sound. Furthermore, attention to elements of expectation, as presented in Huron's (2006) ITPRA Theory of Expectation, may provide a composer the ability to induce the feeling of pleasure, while aspects of familiarity, as they have been shown as a predictor of musical preference, may be able to influence a listener's experience of a new work. Using sound to reference physical gesture shows potential as a creative technique to induce empathic response.

4 Compositional Propositions: Timbre and Gesture

The electroacoustic concepts presented in Chapter 2 and the discussion of timbre, gesture, and cognition in Chapter 3 suggest that potential solutions may exist to address the barriers in electroacoustic composition created from the use of unfamiliar or alienating materials, as discussed in Chapter 1. Furthermore, the research presented suggests that timbral characteristics and the empathic response induced by sound can enhance affective response in a work. I have synthesized the concepts and ideas previously discussed and developed two new propositions that seek to address barriers potentially present in electroacoustic music.

4.1 Timbre

I have discussed a connection between timbre and emotion (see Section 3.2) that suggests that a property of a sound—timbre—can influence the elicitation of emotion when experiencing music. Drawing connections between the ideas presented in Chapters 2 and 3 will help form my first proposition. I have also presented studies by Ward, et al. (2014), Peery and Peery (1986), and Wapnick (1980) that confirm the existence of preference for, or bias favouring, familiar recorded music (see Section 3.4).

Furthering these ideas, Poulin-Charronnat, Bigand, Lalitte, Madurell, Vieillard, and McAdams (2004) examined the effect of a change in instrumentation on the recognition of known musical works. They found that timbre, in addition to pitch and rhythm, is a recognizable trait that contributes to a listener's identification of music. Combining the results of Poulin-Charronnat, et al. (2004) with the aspects of familiarity and emotion presented in Chapter 3, I suggest that, in addition to being able to elicit

emotion responses (Chau, et al., 2015), timbre can influence or bias a listener's preferences through a familiarity bias.

Ali and Peynircioğlu (2010) build on the associations between timbre, familiarity, and emotion. They found that familiarity with musical materials enhanced the emotional intensity of the listening experience. Incorporating their findings suggests that hearing known timbres may elicit a more intense emotional response than those that are less familiar.

I suggest that the effectiveness of a timbre, in its capacity to influence preference or elicit emotion, increases in correlation with the listener's experience and familiarity with the referenced sound. Examining the connections between Poulin-Charronnat, et al.'s (2004) link between timbre and familiarity, the preference displayed for familiar music (see Section 3.4), and the benefits of heavily-myelinated neural circuits discussed in Section 3.4, suggest that timbres experienced more frequently create a preferential bias.

Finally, combining the ideas of Smalley (1997) and Fischman (2008) as presented in Chapter 2, Chau, et al. (2015), Deacon (2006), and Rey, et al., (2015), which were presented in Chapter 3, I suggest that timbre can present extra-musical meaning via gesture reference, cognitive and emotional association, and emotional elicitation.

4.1.1 Proposition. I propose that, through the mindful application of familiar timbral characteristics to unfamiliar recorded sound material, the extra-musical information, referential connections, and emotional associations inherently existing within the established timbre can be accessed, and subsequently leveraged by the electroacoustic music composer. In integrating a familiar timbre with a new or unfamiliar

sound, the latter can exist as its own entity, access existing referential and emotional associations, and also benefit from the preferential bias and amplified emotional response caused by the presence of familiar sound materials.

In applying this proposition, the barriers created through the use of alienating or unfamiliar sound materials, as discussed in Chapter 1, can be addressed. The familiar timbre provides a basis for the comprehension of the unfamiliar sound, and offers the composer the ability to increase affective response through timbral elicitation of emotion.

4.1.2 Application. While determining a listener's general experience may be possible at a broad level, it would be impossible to predict the detailed and unique experiential makeup of an individual. For example, one could assume that a person has had the experience of speaking to another person, but not the specific details of the conversation. Effective use of my proposition reflects the composer's understanding of the cognitive and experiential knowledge of the intended audience. Conversely, using a timbre unknown to the listener will have no effect. In *Open Doors and Parallel Windows,* for instance, consideration of broad level listener knowledge is represented through the use of the sound materials typically found in a train or train station environment. The details residing within the general sound environment, like the particular buzzer sound of the Paris Metro in *I – Open* Doors (see Section 5.6), are directed at the specific knowledge and experience of the listener.

Determining what timbre to employ is a decision that must be considered carefully. Teo, Hargreaves, and Lee (2008) provide insight into how a composer may consider the experience and preferences of an audience. Through an examination of music preference in post-secondary students from Singapore and the United Kingdom,

they demonstrated that cultural background influenced musical preference and predicted musical familiarity. As presented in Section 3.2, Chau, Wu, and Horner (2015) demonstrated that it is possible for similarities to exist in regards to emotional response to a timbre. For example, the timbre of a harpsicord was shown to induce a feeling of heroism in the majority of participants, while the harp was commonly associated with depression.

The results of Teo, et al. (2008) and Chau, et al. (2015) both suggest that making suppositions and considered predictions about experience could be useful when selecting timbres for use in electroacoustic music. If the composer knows that an audience is familiar with or enjoys a particular type of music, he or she could extract timbral elements from the music and apply them in their own piece. For example, the timbre of a piano, which is broadly familiar, anchors *Open Doors and Parallel Windows* (see Chapter 5).

4.2 Gesture

Discussed in Chapter 3 is how empathic responses may be elicited through the auditory representation of, or allusion to, a physical gesture. The association between gesture and sound suggests that observing a gesture, whether presented as auditory or visual means (Rey, et al., 2015), can yield a neural response that is similar to that of actually performing the gesture one's self. The emotional, referential, and contextual associations linked to performing a physical gesture can, therefore, may also be induced using sound (Deacon, 2006). I suggest that the preference and bias caused by familiarity, which was discussed in Sections 3.4 and 4.1, would equally apply to physical gesture.

4.2.1 Proposition. I propose that through the use of auditory stimulus, a physical gesture can be referenced that results in the activation of the mirror/canonical neural systems and the induction of empathic-like motor response. Such gestures, in addition to their emotional and contextual associations, are recalled through the sound materials. This concept can be used by the composer to enhance narrative or structural elements, focus listener attention, induce emotional response, or contribute to a blend of emotions, as suggested by Kendall (2014). An example can be found in the sound of a door used prominently in the first movement *Open Doors and Parallel Windows* (see Section 5.4).

4.2.2 Application. The discussion of application and use of the first proposition (see Section 4.1.2), in regards to consideration of the audience's potential experience and knowledge, is equally applicable for the second proposition. In addition, the concepts provided by Smalley (1997), Emmerson, (1986), and Fischman (2008) in Chapter 2, which support the listener's capacity to observe the context and/or the human action behind sound materials, may provide additional insight into how physical gestures, objects, or actions behind sounds may be referenced.

4.3 Summary

By forming two propositions, I seek to increase affective response and address the barriers in electroacoustic music caused by the use of unfamiliar or alienating sound materials. The first proposition suggests that the mindful application of known timbral characteristics to unfamiliar recorded sound material can create a basis for the listener to comprehend unfamiliar sound, and allow the composer to leverage extra-musical information, referential connections, and emotional associations attached to the

established timbre. The second proposition suggests that sound can be used to evoke physical gestures and access the listener's emotional, contextual, and referential associations connected to the gesture.

5 Open Doors and Parallel Windows

This chapter discusses the electroacoustic work *Open Doors and Parallel Windows,* including the tools, processes, and materials used to create the piece. I applied the concepts underpinning the propositions presented in the previous chapter in each of the three movements contained in the work. Specific examples of each proposition's application are discussed in this chapter.

5.1 Description

Open Doors and Parallel Windows is a 35-minute long electroacoustic work in three movements. Adhering to Truax's principles of soundscape composition (see Section 2.2), the composition draws from the sound world of the modern train and focuses on a theme of movement and motion.

One of the main goals of this project was to apply music cognition research to enhance the affective response in a new electroacoustic work. The first two movements, *I – Open Doors* and *II – Parallel Windows*, establish the timbral and gestural elements that are used in the third movement, *III – Seven Vignettes*, to support an abstract narrative in a manner that is consistent with Kendall's concept of emotion blending (see Section 3.2). Due to the presence of multiple simultaneous perspectives in each movement, *Open Doors and Parallel Windows* fits in Truax's typology as a variable perspective work (see Section 2.2). The methods and techniques I identified in my preliminary studies, along with Truax's (1996) four principles of soundscape composition, were used as references while making creative decisions. In doing so, I ensured that each decision made during the compositional process supported the goals of the project.

5.2 Overview of Tools and Techniques

Several techniques and methods were explored that facilitated aspects of my two propositions including:

1. Dynamic filtering and equalization, which is equalization processing and filters that are only active when predetermined criteria, such as frequency amplitude and the duration of a signal exceeding a threshold, are met
2. Bandpass and narrowband filtering, which is when filtering or equalization is performed only on a specific range of the audio spectrum that rejects the signal outside of the specified range (Christiano & Fitzgerald, 1999)
3. Resonance filtering, which is a type of equalization that causes particular frequencies to be amplified while neighboring frequencies are removed
4. Synthesis and integration of timbral characteristics
5. Envelope filtering and modification
6. Convolution/impulse response capture and processing (see Section 5.4)
7. Dynamics processing
8. Transfer, exchange, and combination of sound envelopes
9. Transient removal, which is a technique where the attack and decay portion of a sound is removed
10. Noise reduction
11. Sound gesture extraction and recontextualization, which refers to the process of removing a portion of a sound from the context in which it is initially presented (Smalley, 1986)
12. Audio spatialization

13. Frequency-based spatial processing, which involves the manipulation of a sound in the stereo spectrum based on, or divided by, frequency
14. Manipulation of temporal elements
15. Layering, which is the simultaneous presentation of two or more sounds
16. Granular synthesis processing, which is a processing technique that breaks down sounds into smaller portions and reassembles them to create a new sound (Truax, n.d.)
17. Use of surrogate sounds and sound gestures, which is when a sound is used in place of another (Smalley, 1997)
18. Sound gesture priming, which is when sound is used to prepare the listener for, or contextualize, a subsequent sound (Lemaitre, et al., 2015)

Specialized pieces of audio processing software and hardware were identified and tested for the ability to accomplish the aforementioned tasks. Tools included the INA GRM Tools 3 suite, Altiverb 7, Waves Q-Clone, Soundtoys 5 suite, Pro Tools 12, Eventide Anthology X bundle, Universal Audio 1176, Solid State Logic X-Logic G-Series Compressor, and Neve 33609 J/D.

5.3 Sound Recording

The sound materials used in *Open Doors and Parallel Windows* consist entirely of field recordings made between the summer of 2013 and the fall of 2016 in France, Germany, Japan, Canada, and the United States. I used a Sony PCM-M10 portable audio recorder to capture the raw sounds as WAV files at a resolution of 24-bits and a sample rate of 48khz. No filtering, limiting, compression, or other processing was applied at the time of the audio capture. None of the audio was captured specifically for *Open Doors*

and Parallel Windows, and no new audio recordings were made for the project. I chose to limit my materials to only recordings I had made prior to composition to help define the creative scope of the work.

Verbal and written notes were made about each recording. Photographs and GPS coordinates were taken from most sound capture locations to provide geographical context, and for future reference. All subsequent audio processing and the digital aspects of the composition process were performed in the Pro Tools (12.7.1) digital audio workstation.

The files were catalogued and sorted based on year, recording location, time/date, and activity/event. Each of the approximately two-thousand raw audio clips were reviewed to identify useful or interesting audio content. Materials were chosen based on a number of factors, including similarity, detail, general interest, and favourability. Recordings were also selected for their suitability to support the overall artistic intent of the composition, including the presence of: unique timbral qualities, a sound alluding to a physical gesture, a significant audio event, audible dialogue, accurate depiction of interesting acoustic space, a sense of motion or movement, and exceptional plainness. Approximately three hundred raw audio files of varying lengths—from approximately three seconds to over fifteen minutes—were selected for possible use. Following the review and selection of audio files, preliminary and exploratory processing was performed to assess the viability of applying the propositions formed during the research period (discussed in Chapter 4).

5.4 Preliminary Exploration of Impulse Response Processing

Prior to beginning the formal composition of *Open Doors and Parallel Windows*, I composed several etudes. These preliminary compositions ranged from three to five minutes in length and were used to explore my technical tools and ideas. During this process, I recognized impulse response processing and convolution as the best tool for accurately and effectively transferring timbral characteristics from one sound to another.

An impulse response functions as a sonic snapshot or image of an acoustic space or audio path at a specific time. The process requires a control signal to be passed through the audio equipment or played through neutral, reference-quality speakers into an acoustic space, and then subsequently recaptured with a neutral, reference-quality capture device, such as an analogue-to-digital signal converter or microphone. The difference between the control signal and the recaptured version of the control signal yields the acoustic influence and resulting impulse response of the space or device. An impulse response of the inside of an upright piano, which was taken during this period, played a prominent role in all three movements in *Open Doors and Parallel Windows*.

5.5 *Movement I – Open Doors*

5.5.1 Description. The first movement, *I – Open Doors,* is ten minutes and twenty-two seconds in length. It functions as an exposition for the entire work. Within the movement, aural gesture, implied physical gesture, timbre, and virtual acoustic space are established as the primary areas of focus. In addition to the aspects of music cognition presented in Chapter 3 and Truax's principles of soundscape composition, as discussed in Chapter 2, the goals of the movement are to: (a) explore the properties and components of a single sound gesture—a closing train door; and (b) establish the main timbres and

virtual spaces used throughout the rest of the work (see Section 5.7). The focal point of *I - Open Doors* is the sound of a train door opening and closing, and the soundscapes or environments presented as the door "opens" and "closes". The created sense of physical motion supports and facilitates the narrative and structure of the movement.

5.5.2 Materials. In this movement, the door sound is the primary carrier and representative example of the propositions presented in Chapter 4. First occurring in its original context at 0:02, and again at 1:12, the door sound is abstracted from its original context at 1:18 and gradually recontextualized (e.g. 2:14-2:24), deconstructed, granualized, and presented in different forms (e.g. 2:36, 4:12, 4:17, 5:21) throughout the first movement. The inner details of the door sound were explored using the processing methods discussed in Section 5.2.

The most prominent method used to transfer and combine timbral characteristics from one sound object to another was convolution processing with impulse responses. The technique was used to present the collection of virtual spaces and timbres used throughout *Open Doors and Parallel Windows.* Following a presentation in its basic abstracted form at 2:14, the door sound undergoes a series of six rapid timbral changes. Each discrete presentation of the door sound serves to highlight the unique timbres used in the remainder of the work.

The decision to use each space was based on either personal preference for the sound or on an assessment of the sound's potential for being familiar to a Western audience. These spaces include the interior of a Boeing 747, Hansa Studios Meistersaal[9],

[9] As heard on "*Heroes"* by David Bowie, *Lust for Life* by Iggy Pop, and *One* by U2.

SARM West Studio Two[10], the Sydney Opera House, the Utrecht Maliebaan Train Station waiting room[11], the Fox Scoring Stage, and an upright piano.[12] I chose to apply timbral characteristics of spaces that have housed well-known recordings as a means to increase the probability of the listener having existing experience with, and knowledge of, the sounds.

The impulse responses of the interior of the upright piano and the Utrecht Maliebaan Train Station waiting room were chosen for other reasons. Both sources were selected because they exhibit broadly familiar timbral characteristic (i.e. a piano and medium-sized room), yet still maintain unique sound properties that are likely unknown to the listener. The piano was chosen specifically for its general recognizably, while the waiting room was chosen for its contextual relation to the sound materials used in the piece (i.e. trains). Consequently, the train station timbre was treated as unfamiliar, and the piano timbre was used during musically important sections of *I – Open Doors* to help establish it as a timbre individually unique to *Open Doors and Parallel Windows.* As such, a generally familiar timbre could be used prominently in subsequent movements without the fear of specific external references.

In addition to the door sound having the structural function indicating the end or beginning of a section or idea, it is used to provide a baseline sound to facilitate and demonstrate developments of timbre. In providing both control and effected versions of the door sound between 2:14 and 2:30, the listener is introduced to each prominent

[10] Formerly Island Studios. As heard on *Stairway to Heaven* by Led Zeppelin and *We are the Champions* by Queen.
[11] Built in the 19th century and located in the Netherlands.
[12] Core acoustic space-type impulse responses were accessed through Altiverb 7, with the exception of the upright piano timbre, which was created by the author.

timbral profile individually, allowing the timbres to be learned, leveraged, and accessed in the manner described in Chapter 4. The recording of the specific door sound, which previously carried no, or limited, relationships or associations, is connected to a series of relationships based on timbre that may exhibit a preference bias (see Sections 3.2 and 3.4). The timbral profiles become uniquely connected to the door sound, eliciting potential emotions embedded in the timbres independently of the gestural activation function of the door.

By using certain timbres more frequently, especially at beginning or ending of a section, traditional tonic/dominant/subdominant relationships found in tonal music are established, - with the piano timbre functioning as the tonic (presented first at 2:24). After establishing relationships between the door and the individual timbres, the set of seven main timbres are applied to, and explored through, the creation of relationships between other sounds and sound gestures like that of steam-like whistling (first presented at 4:39) and various instances of the human voice throughout the movement. The auditory gesture elicitation incites a set of responses in accordance with the mirror and canonical neural response suggested in the Chapter 4 discussion, and reveals the humanity behind the gesture in accordance with the spectromorphological referral process provided by Smalley (1997).

5.5.3 Form and structure. *I – Open Doors* has four main sections in an ABCA′ form. Each section serves to facilitate a different aspect of the narrative, highlighting transformations in timbre, and exploring the door sound gesture. The structure was chosen to create the feeling of motion and movement. The listener begins the journey in

the first A section, is transported to two different scenes in B and C, and is returned to a surreal version of the first scene in A′.

5.6 *Movement II - Parallel Windows*

5.6.1 Description. *II – Parallel Windows* is nine minutes and twelve seconds in length. While the timbres established in *I – Open Doors* are present to specifically to elicit emotions and facilitate narrative, the goals of the second movement are to: (a) emphasize the application of the gesture as discussed in Chapter 4; (b) build a new sound gesture in an inverse fashion to how the door sound was deconstructed in *I – Open Doors*; and (c) allude to the prominent demarcating onset of gestures used in movement I through the absence of onset characteristics. Furthermore, I wanted to expand on the first movement's comparatively conservative approach to the sound processing and move towards an more abstract sound environment.

5.6.2 Materials. In *II – Parallel Windows,* one of the main sounds used to illustrate the aspects of gesture discussed in Chapter 4 is laughter. Beginning at 0:07, a series of five different instances of the same person laughing is presented in unaltered sections of their original context, mirroring the presentation of the door sound in movement I. Following the introduction, the laughing sound, referring to any and all sections of the initial five laughter instances, is repeated until 0:54 with variations in sequence and amplitude. The laughing sound, which has been extracted from its original context, reoccurs throughout the entire movement in new contexts (e.g. 3:04, 5:21, 8:49) in accordance with Huron's (2006) ITPRA Theory of Expectation and Kendall's (2014) theory of blended emotions, to induce a complex series of emotional responses that differ from the initial response caused by the first presentation of the auditory gesture.

During the second section of the piece, beginning at 0:55, a new sound gesture, the waterfall, is created through the sequential combination of fifteen different recordings made at varying distances from a waterfall in the Black Forest of Triberg, Germany. In an inverse fashion to the deconstruction of the door sound present in *I – Open Doors*, the interior details of the waterfall gesture are presented first, with a final presentation of the meta-waterfall occurring at approximately 2:30. The waterfall sound has a similar structural function to that of the door. However, instead of indicating the end or beginning of a section, the waterfall sound occurs once within each section to indicate that it is unique.

In addition to the waterfall sound object, each section in *II – Parallel Windows* contains an instance of the laughing sound, thunder, trickling water, and a train. The presence of all four elements in each section helps define the structure of the movement and emphasizes the lack of defining onset characteristics between sections of the piece, as found in the door sound in *I – Open Doors*. Moreover, the auditory gesture, is implied in its absence and accomplishes the same task as if it were present (e.g. 0:51). In accordance with Emmerson (1986), the laughing, thunder, and train sounds are used in a manner that deliberately creates new spectromorphological relationships and facilitates progression of the narrative. Furthermore, the referencing of the human action behind the sound relationship, a la Smalley (1997), the application of timbre discussed in Chapter 4, and the layering of simultaneous events as prescribed by Kendall's (2014) theory of blended emotions, allows for a unique experience to be felt, as well as heard, in each section.

5.6.3 Form and structure. *II - Parallel Windows* has a form of AA′ BA″. Each A section contains four sound elements: laughing, thunder, a train, and moving water.

The presentation and context of the sounds develops and changes in each A section. The varying relationships between the materials facilitate the narrative and feeling of movement. The dream-like B section, beginning approximately at 5:40, does not contain all four sound elements. as the laughing and moving water sounds are excluded.

5.7 III – Seven Vignettes

5.7.1 Description. The final fourteen-minute and twenty-second-long movement, *III - Seven Vignettes*, focuses on the development of the abstract narrative through the expansion of the materials presented in the first two movements. As the title suggests, the third movement contains seven smaller sections. In each, the timbres and virtual spaces established in *I – Open Doors* and *II – Parallel Windows*, are presented, in addition to newly introduced spectromorphologies and sound gestures that function in accordance the propositions discussed in Chapter 4. The materials are simultaneously combined, as suggested by Kendall (2014), in an effort to have each section feel different and elicit complex emotions. Furthermore, each vignette contains two or more concurrent elements that have been made familiar or given preferential "weight" by virtue of exposure in the first two movements. By doing so, the listener is presented with a situation where they must choose, consciously or subconsciously, where to focus their attention. Confronting the familiar sound materials in new contexts yields benefits in accordance with Huron's ITPRA theory.

5.7.2 Materials. An example sound material layering can be found in the third section of the piece. Beginning at 4:14, the sound of moving water, gunshots, birds, a modified traditional Japanese folk melody, and airplanes flying in the distance, are combined to create a scene. Each element was subjected to the timbral properties of one

of the core impulse responses (see Section 4.4) and remains in a single virtual space for the entirety of the vignette. The gunshot sound, however, changes timbral properties and the virtual space it occupies with each repetition, eventually entering all of the virtual spaces presented in the section. Consequently, the sound of the gunshot, and the associated gesture elicited in accordance with my second proposition, enters each space to deny the listener the an "escape" from the gunshot through focus on one of the other elements. Instead, the sound eventually becomes intertwined with each of the other elements present by virtue of timbre, requiring the listener to reconcile the newly created relationships.

Throughout *III – Seven Vignettes,* the combination of sounds and invoked gestures are carefully chosen for their distinction and for potential contextual relations. The natural and unnatural relationships in each vignette are made possible not only through the presentation of timbral and gestural elements, but also through a new awareness of interior sound detail promoted in the first two movements, in accordance with Truax (1994, 1996, 2008) and Westerkamp (2002).

5.7.3 Form and structure. As suggested by the title, *III – Seven Vignettes* is a movement in seven sections inspired by seven-act narrative structure. Each of the seven scenes contains a unique set of sound materials and presents a new environment or scenario. The connections between each section, established through timbre and contextual association, support the overarching narrative development within the movement. A specific or "correct" narrative is not intended, and it is left to the listener's experiential knowledge and comprehension of the sound materials to reconcile the events of each vignette.

5.8 Summary

Open Doors and Parallel Windows is a three-movement electroacoustic composition that applies the propositions of timbre and gesture provided in Chapter 4. Several tools and techniques were explored as viable means of applying the propositions, including filtering and equalization, dynamics processing, spatialization, temporal processing, impulse response processing, and convolution. The sound materials used in *Open Doors and Parallel Windows* are drawn from a catalogue of field recordings, which is comprised of audio material created in France, Germany, Japan, Canada, and the United States between 2013 and 2016. Through a series of preliminary compositions, convolution and impulse response processing was found as an effective method of transferring timbral characteristics from one source to another. Specific examples of how both propositions can be applied in an electroacoustic composition are discussed in each of the three movements contained in *Open Doors and Parallel Windows.*

6 Conclusions

If a listener cannot comprehend or connect with a piece of music—whether it is due to the musical materials used, preference, or any other barrier that may exist—the composer has lost his or her audience. When an experience cannot be understood, or is meaningless to a listener, music loses its powerful ability to change, release, and enhance emotions (Juslin and Västfjäll, 2008). In electroacoustic music, the composer must address specific comprehension-based challenges as a result of using unfamiliar or potentially alienating musical materials that are not typically present in more common types of music.

Music and sound have been explored in a great number of areas. Electroacoustic music composers have created concepts and theories to help make sense of the vast and often abstract aspects of the genre (see Chapter 2), while researchers in areas of psychology and cognition have sought to explain how we comprehend our experiences (see Chapter 3). Both electroacoustic music and music cognition are rich and diverse areas of study; offering theories, concepts, and hypotheses that attempt to better our understanding of human experience.

The links between timbre (Section 3.2), familiarity (Section 3.4), gesture (Section 3.5), and emotion (Section 3.2) provided the basis for two propositions that I derived to assist the composer to increase the affective response of their work (see Chapter 4). Through the application of these propositions, I hoped to gain a better understanding of the function of specific musical traits and the implications of using particular sound materials.

In composing *Open Doors and Parallel Windows,* I sought to create a work that used timbre and gesture as the primary source of narrative and emotional affect. My propositions operated as the conceptual basis of the work and greatly influences the compositional and artistic choices I made. Furthermore, the explicit and unrelenting consideration of timbre, familiarity, and gesture affected the compositional process and helped me achieve my artistic goals. For example, the idea to use the rapid succession of the door sounds to present the various timbres used in *I – Open Doors*—a significant transitional section in the piece—was the result of determining how to present both propositions simultaneously.

My search for gesture-eliciting auditory stimulus led to the creation of the abstracted door sound, as well as many of the other sounds used throughout the work. Unexpectedly, employing my propositions led to new and unexpected musical directions (e.g. the rapid succession of timbral modified doors *I – Open Doors).* The unintentional result of the conceptual function of my propositions suggests that they can be effective both as a creative platform, and as means to leverage timbre, familiarity, and gesture to enhance affect response. While it is ultimately up to the listener to decide whether or not my composition was successful in its attempt to create a unique emotional experience, the notion that my propositions were able to support a long-form electroacoustic work speaks to their viability as independant compositional tools.

While composing the various scenes and vignettes throughout *Open Doors and Parallel Windows,* it also became apparent that there is no single solution for applying my propositions. For example, convolution and impulse response processing was a particularly useful technique for combining or transferring timbral properties, but is not

suitable to emphasize envelope characteristics already present in a sound. Every tool, both existing and emerging, may have the ability to influence affective response in the manner described, but requires the experience, knowledge, and expertise of the composer. As such, I suggest that the successful application of my propositions will require the composer to holistically consider the potential experience and knowledge of their intended audience and evaluate the influence of every sound characteristic when making creative decisions and selecting audio processing tools. Furthermore, in accordance with Kendall's (2014) theory of blended emotions, I suggest the composer will find greater success when considering the cumulative effect of multiple applications of my propositions, as opposed to individual applications in isolation.

6.1 Future directions

Open Doors and Parallel Windows is the result of many concepts, ideas, and materials being brought together; research from the disciplines of music and psychology informed the development of my propositions, the application of the propositions informed the direction of my work, and project logistics dictated the musical materials. While composing the work, the application of my propositions determined my approach, and the available audio recordings guided the thematic direction (e.g. movement, trains).

One of the limitations of *Open Doors and Parallel Windows* was the self-imposed requirement that all of the sound materials were recorded prior to the composition of the work. Using materials from my existing catalogue of recordings (all of which were made in the three years prior to composition) allowed me access to a breadth of source material and helped define the creative boundaries of the project, but also restricted what types of environments, sounds, and sound gestures I was able to use. For example, in *I – Parallel*

Windows, I wanted an additional source of laughter in an outdoor environment. While it would have been easy to create such a recording, I was confined to what was available in my catalogue. In several situations, searching for a specific desired element in my existing recordings led to the identification of elements that may otherwise have not been discovered. The door sound used prominently in *I – Open Doors* was realized through this type of search.

As a response to these limitations, I would like to create a new companion work to *Open Doors and Parallel Windows* that is based on my two propositions, but allows audio materials to be made or collected explicitly for the purposes of the composition. Not only would this help to confirm the unexpected findings of the propositions as a useful conceptual centre, as opposed to only a tool that enables the elicitation of emotion, but it would be artistically rewarding to explore my propositions with musical materials recorded specifically for this purpose. Furthermore, moving the audio capture locations to increasingly foreign areas that are not necessarily familiar to the Western audience (e.g. the train theme of *Open Doors and Parallel Windows*) would provide insight into, and commentary on, how my own experiences and biases influence my compositional process and assessment of familiarity in sound materials.

Future empirical, data-producing research could be conducted to determine the degree of influence that timbre has on the elicitation of emotion, in a manner similar to that of Chau, et al. (2015). Perceptual studies that investigate a listener's ability to recognize timbral changes using the head-turning paradigm employed by Weiss, Zelazo, and Swain (1988) would also be valuable. The results of either study would provide insight into how best to implement my propositions in future compositions and music

production, and increase our understanding of the elicitation of specific emotions in the context of contemporary and electroacoustic music composition.

Bibliography

Ali, S. O., & Peynircioğlu, Z. F. (2010). Intensity of emotions conveyed and elicited by familiar and unfamiliar music. *Music Perception, 27*(3), 177-182.

Balkwill, L., & Thompson, W. F. (1999). A cross-cultural investigation of the perception of emotion in music: Psychophysical and cultural cues. *Music Perception, 17*(1), 43-64.

Balkwill, L., Thompson, W. F., & Matsunaga, R. (2004). Recognition of emotion in Japanese, Western, and Hindustani music by Japanese listeners. *Japanese Psychological Research, 46*(4), 337-349.

Battier, M. (2007). What the GRM brought to music: from musique concrète to acousmatic music. *Organised Sound,12*(03). doi:10.1017/s1355771807001902

Beethoven, L. (1976). First, second, and third Symphonies: In full orchestral score. New York, NY: Dover Publications Inc. (Original work published 1803)

Bharucha, J., & Krumhansl, C. L. (1983). The representation of harmonic structure in music: Hierarchies of stability as a function of context. *Cognition, 13*(1), 63-102.

Bhatara, A., Tirovolas, A. K., Duan, L. M., Levy, B., & Levitin, D. J. (2011). Perception of emotional expression in musical performance. *Journal of Experimental Psychology: Human Perception and Performance, 37*(3), 921-934.

Botvinick, M., Jha, A. P., Bylsma, L. M., Fabian, S. A., Solomon, P. E., & Prkachin, K. M. (2005). Viewing facial expressions of pain engages cortical areas involved in the direct experience of pain. *NeuroImage*, 25(1), 312-319. doi:10.1016/j.neuroimage.2004.11.043

Bowie, D. (1976). "Heroes". On *"Heroes"* [Vinyl]. London: EMI.

Brandt, A. (2005). Mental spaces and cognitive semantics: A critical comment. *Journal of Pragmatics, 37*(10), 1578-1594. doi:10.1016/j.pragma.2004.10.019

Brandt, A. (2006). Form and meaning. In *The artful mind: cognitive science and the riddle of human creativity* (pp. 171-189). Oxford, United Kingdom: Oxford University Press.

Brandt, A., Gebrian, M., & Slevc, L. R. (2012). Music and early language acquisition. *Frontiers in Psychology, 3, 327*. doi:10.3389/fpsyg.2012.00327

Cage, John. (1995). Imaginary landscapes no. 1. On *Imaginary landscapes* [CD]. Basel, Switzerland: Hat Hut Records Ltd. (Original work published 1939)

Chau, C., Wu, B., & Horner, A. (2015). The emotional characteristics and timbre of nonsustaining instrument sounds. *Journal of the Audio Engineering Society, 63*(4), 228-244.

Cheng, Y., Yang, C., Lin, C., Lee, P., & Decety, J. (2008). The perception of pain in others suppresses somatosensory oscillations: A magnetoencephalography study. *NeuroImage*, 40(4), 1833-1840. doi:10.1016/j.neuroimage.2008.01.064

Chopin, F. (2006). Chopin: Nocturnes. München, Germany: G. Henle. (Original work published 1832)

Christiano, L., & Fitzgerald, T. (1999). The band pass filter. NBER Working Paper No. 7257. doi:10.3386/w7257

Clarke, E. F. (1987). Levels of structure in the organization of musical time. *Contemporary Music Review, 2*(1), 211-238.

Cochrane, T. (2010). A simulation theory of musical expressivity. *Australasian Journal of Philosophy, 88*(2), 191-207. doi:10.1080/00048400902941257

Cross, I. (2014). Music and communication in music psychology. *Psychology of Music, 42*(6), 809-819.

Davidovsky, M. (2005). Synchronisms No. 6. On *The Music Of Mario Davidovsky Volume 3* [CD]. Bridge Records. (Original work published 1970)

Davies, Hugh. (2017). Electronic instruments. In *Groves Music Online. Oxford Music Online*. Oxford University Press. Retrieved from http://www.oxfordmusiconline.com/subscriber/article/grove/music/08694pg2

Deacon, T. (2006). The aesthetic faculty. In *The artful mind: cognitive science and the riddle of human creativity* (pp. 21-53). Oxford, United Kingdom: Oxford University Press.

Dunsby, J. (1983). Music and semiotics: The nattiez phase. *The Musical Quarterly, LXIX*(1), 27-43.

Echols, C. H., Crowhurst, M. J., & Childers, J. B. (1997). The perception of rhythmic units in speech by infants and adults. *Journal of Memory and Language, 36*(2), 202-225.

Emmerson, S. (1986). *The Language of electroacoustic music*. London, United Kingdom: Macmillan.

Ferrari, Luc. (1969). Hétérozygote. On *Hétérozygote / J'ai Été Coupé* [Vinyl]. Netherlands: Phillips.

Fischman, R. (2008). Mimetic space – Unravelled. *Organised Sound, 13*(2), 112-122.

Fiske, H., & Heller, J. (2014). Music psychology. In *Grove Music Online. Oxford Music Online*. Oxford University Press. Retrieved from http://www.oxfordmusiconline.com/subscriber/article/grove/music/A2267271

Freedberg, D., & Gallese, V. (2007). Motion, emotion and empathy in esthetic experience. *Trends in Cognitive Sciences,11*(5), 197-203. doi:10.1016/j.tics.2007.02.003

Gabrielsson, A. (1999). Studying emotional expression in music performance. *Bulletin of the Council for Research in Music Education, 17*(141), 47-53.

Gallese, V., Keysers, C., & Rizzolatti, G. (2004). A unifying view of the basis of social cognition. *Trends in Cognitive Sciences, 8*(9), 396-403. doi:10.1016/j.tics.2004.07.002

Geringer, J. M., & Madsen, C. K. (1995/1996). Focus of attention to elements: Listening patterns of musicians and nonmusicians. *Bulletin of the Council for Research in Music Education, 15*(127), 80-87.

Giordano, B. L., & McAdams, S. (2010). Sound source mechanics and musical timbre perception: Evidence from previous studies. *Music Perception, 28*(2), 155-168.

Gopnik, A., Meltzoff, A., & Kuhl, P.K. (2001). *The scientist in the crib: what early learning tells us about the mind*. New York, NY: Harper Collins.

Grisey, G. (1987). Tempus ex machina: A composer's reflections on musical time. *Contemporary Music Review, 2*(1), 239-275.

Hallam, S., Cross, I., & Thaut, M. (2009). *The Oxford handbook of music psychology*. Oxford, United Kingdom: Oxford University Press.

Hannon, E. E., & Trehub, S. E. (2005). Tuning in to musical rhythms: Infants learn more readily than adults. *Proceedings of the National Academy of Sciences, 102*(35), 12639-12643.

Hartline, D. K. (2008). What is myelin? *Neuron Glia Biology, 4*(02), 153. doi:10.1017/s1740925x09990263

Hayes, B. (1994). *Metrical stress theory: Principles and case studies.* Chicago, IL: University of Chicago Press.

Huron, D. B. (2006). *Sweet anticipation: Music and the psychology of expectation*. Cambridge, MA: MIT Press.

Huron, D.B., & Margulis, E. H. (1993). Musical expectancy and thrills. *Handbook of music and emotion: Theory, research, applications* (pp. 575-604). doi:10.1093/acprof:oso/9780199230143.003.0021

Jabbi, M., Swart, M., & Keysers, C. (2007). Empathy for positive and negative emotions in the gustatory cortex. *NeuroImage*, 34(4), 1744-1753. doi:10.1016/j.neuroimage.2006.10.032

Juslin, P. N., & Madison, G. (1999). The role of timing patterns in recognition of emotional expression from musical performance. *Music Perception 17*(2), 197-221.

Juslin, P. N., & Västfjäll, D. (2008). Emotional responses to music: The need to consider underlying mechanisms. *Behavioral and Brain Sciences, 31*(06), 751.

Kahneman, D., & Miller, D. T. (1986). Norm theory: Comparing reality to its alternatives. *Psychological Review, 93*(2), 136-153. doi:10.1037//0033-295x.93.2.136

Kane, B. (2012). Acousmate: History and de-visualised sound in the Schaefferian tradition. *Organised Sound,17*(2), 179-188. doi:10.1017/s1355771812000118

Kendall, G. S. (2014). The feeling blend: Feeling and emotion in electroacoustic art. *Organised Sound, 19*(2), 192-202.

Kolber, D. (2002). Hildegard Westerkamp's kits beach soundwalk: Shifting perspectives in real world music. *Organised Sound, 7*(1), 41-43.

Krumhansl, C. L. (1995). Music psychology and music theory: Problems and prospects. *Music Theory Spectrum, 17*(1), 53-80.

Krumhansl, C. L. (2010). A theory of tonal hierarchies in music. In M.R. Jones, R.R. Fay, & A.N. Popper (Eds.), *Music perception* (pp. 51-87). *Springer handbook of auditory research*, Vol. 36
. New York, NY: Springer.

Kuhl, P., Conboy, B., Padden, D., Nelson, T., & Pruitt, J. (2005). Early speech perception and later language development: Implications for the "critical period." *Language Learning and Development, 1*(3), 237-264.

Lamb, E. (2012, December 11). Uncommon time: What makes Dave Brubeck's unorthodox jazz stylings so appealing? *Scientific American*. Retrieved from http://www.scientificamerican.com/article/uncommon-time-dave-brubeck/

Lansky, P. (1994). Six fantasies on a poem by Thomas Campion. On *Fantasies and Tableaux* [CD]. New York, NY: Composers Recording Inc. (Original work published 1979)

Laukka, P., Eerola, T., Thingujam, N. S., Yamasaki, T., & Beller, G. (2013). Universal and culture-specific factors in the recognition and performance of musical affect expressions. *Emotion, 13*(3), 434-449.

Le Caine, H. (1997). *Dripsody* [CD]. Scarborough, ON: Naxos of Canada Ltd. (Original work published 1955)

Lee, Y. H., & Qiu, C. (2009). When uncertainty brings pleasure: The role of prospect imageability and mental imagery. *Journal of Consumer Research, 36*(4), 624-633.

Lemaitre, G., Heller, L. M., Navolio, N., & Zúñiga-Peñaranda, N. (2015). Priming gestures with sounds. *PLOS One,10*(11). doi:10.1371/journal.pone.0141791

Levitin, D. J. (2006). *This is your brain on music: The science of a human obsession*. New York, NY: Dutton.

Martin, J. (in press). Allusion and timbre: A theory of implicit reference, emotion and familiarity bias in contemporary music. *CEC eContact!*

Matyja, J. R. (2015). The next step: Mirror neurons, music, and mechanistic explanation. *Frontiers in Psychology, 6, 409*. doi:10.3389/fpsyg.2015.00409

McAdams, S. & Giordano, B. L. (2009). The perception of musical timbre. In S. Hallam, I. Cross, & M. Thaut (Eds.), *The Oxford handbook of music psychology* (pp. 72-80). Oxford, United Kingdom: Oxford University Press.

McMullen, E., & Saffran, J. R. (2004). Music and language: A developmental comparison. *Music Perception, 21*(3), 289-311.

Mercury, F. (1977). We are the champions. On *News of the world* [Vinyl]. New York, NY: Elektra Records.

Morrison, I., Lloyd, D., Pellegrino, G. D., & Roberts, N. (2004). Vicarious responses to pain in anterior cingulate cortex: Is empathy a multisensory issue? *Cognitive, Affective, & Behavioral Neuroscience*, 4(2), 270-278. doi:10.3758/cabn.4.2.270

Nattiez, J.-J. (1977). Under what conditions can one speak of the universals of music? *The World of Music*, *19*(1/2), 92–105.

Overy, K., & Molnar-Szakacs, I. (2009). Being together in time: Musical experience and the mirror neuron system. *Music Perception, 26*(5), 489-504. doi:10.1525/mp.2009.26.5.489

Page, J. and Plant, R, (1971). Stairway to heaven. On *Led Zeppelin IV* [Vinyl]. London, United Kingdom: Atlantic Records.

Paney, A. S. (2014). The effect of directing attention on melodic dictation testing. *Psychology of Music, 44*(1), 15-24.

Pearce, M. T., & Wiggins, G. A. (2006). Expectation in melody: The influence of context and learning. *Music Perception, 23*(5), 377-405.

Peery, J. C., & Peery, I. W. (1986). Effects of exposure to classical music on the musical preferences of preschool children. *Journal of Research in Music Education, 34*(1), 24-33.

Penfield, W., & Roberts, L. (1959). *Speech and brain-mechanisms*. Princeton, NJ: Princeton University Press.

Pop, I. (1977). Lust for life. On *Lust for life* [Vinyl]. New York, NY: RCA Victor.

Poulin-Charronnat, B., Bigand, E., Lalitte, P., Madurell, F., Vieillard, S., & McAdams, S. (2004). Effects of a change in instrumentation on the recognition of musical materials. *Music Perception*, 22(2), 239-263. doi:10.1525/mp.2004.22.2.239

Rey, A. E., Roche, K., Versace, R., & Chainay, H. (2015). Manipulation gesture effect in visual and auditory presentations: The link between tools in perceptual and motor tasks. *Frontiers in Psychology, 6*, 1031. doi:10.3389/fpsyg.2015.01031

Risset, J. (1978) Mutations. On *Mutations* [Vinyl]. INA-GRM. (Original work published 1969)

Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Cognitive Brain Research*, 3(2), 131-141. doi:10.1016/0926-6410(95)00038-0

Roy, S. (1996). Form and referential citation in a work by Francis Dhomont. *Organised Sound, 1*(1), 29-41.

Sahin, E., & Erdogan, S. (2009). Towards linking affordances with mirror/canonical neurons. *Proceedings of the 24th International Symposium on Computer and Information Sciences*. doi:10.1109/iscis.2009.5291813

Salimpoor, V. N., Benovoy, M., Larcher, K., Dagher, A., & Zatorre, R. J. (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. *Nature Neuroscience,14*(2), 257-262. doi:10.1038/nn.2726

Schaeffer, P. (1966). *Traité des objets musicaux: Essai interdisciplines.* Paris: Éditions du Seuil.

Schaeffer, P. and Henry, P. (1973) Symphonie pour un homme seul. On *Symphonie Pour Un Homme Seul / Concerto Des Ambiguïtés*[Vinyl]. Philips. (Original work published 1950)

Schafer, R. M. (1973). Entrance to the harbour. On *The Vancouver soundscapes* [Vinyl]. London, United Kingdom: Ensemble Productions Ltd.

Schellenberg, E. G. (2006). Long-term positive associations between music lessons and IQ. *Journal of Educational Psychology, 98*(2), 457-468.

Schiavio, A., Menin, D., & Matyja, J. (2014). Music in the flesh: Embodied simulation in musical understanding. *Psychomusicology: Music, Mind, and Brain, 24*(4), 340-343. doi:10.1037/pmu0000052

Schrader, B., & Battier, M. (2013). Electroacoustic music. In *Grove Music Online. Oxford Music Online*. Oxford University Press. Retrieved from http://www.oxfordmusiconline.com/subscriber/article/grove/music/A2249352.

Sloboda, J. A. (1993). *The musical mind: The cognitive psychology of music*. Oxford: Clarendon Press.

Smalley, D. (1986). Spectro-morphology and structuring processes. In S. Emmerson (Ed.) *The language of electroacoustic music* (pp. 61-93). London, United Kingdom: Macmillan. doi:10.1007/978-1-349-18492-7_5

Smalley, D. (1991). *Valley Flow* [CD]. Montreal, QC: Empreintes DIGITALes IMED-9209-CD.

Smalley, D. (1997). Spectromorphology: Explaining sound-shapes. *Organised Sound, 2*(2), 107-126.

Smalley, D. (2007). Space-form and the acousmatic image. *Organised Sound, 12*(1), 35-58.

Soley, G., & Hannon, E. E. (2010). Infants prefer the musical meter of their own culture: A cross-cultural comparison. *Developmental Psychology, 46*(1), 286-292.

Stevens, C. J. (2012). Music perception and cognition: A review of recent cross-cultural research. *Topics in Cognitive Science, 4*(4), 653-667.

Sundara, M., & Scutellaro, A. (2011). Rhythmic distance between languages affects the development of speech perception in bilingual infants. *Journal of Phonetics, 39*(4), 505-513.

Swaine, J. S. (2014). Musical communication, emotion regulation and the capacity for attention control: A theoretical model. *Psychology of Music, 42*(6), 856-863.

Tan, S., Pfordresher, P., & Harré, R. (2010). *Psychology of music: From sound to significance*. Hove, United Kingdom: Psychology Press.

Teo, T., Hargreaves, D. J., & Lee, J. (2008). Musical rreference, identification, and familiarity: A multicultural comparison of secondary students from Singapore and the United Kingdom. *Journal of Research in Music Education*, 56(1), 18-32. doi:10.1177/0022429408322953

Tillmann, B., Poulin-Charronnat, B., & Bigand, E. (2013). The role of expectation in music: From the score to emotions and the brain. *Wiley Interdisciplinary Reviews: Cognitive Science, 5*(1), 105-113.

Truax, B. (n.d.). Granular synthesis. Retrieved from https://www.sfu.ca/~truax/gran.html

Truax, B. (1977). The soundscape and technology. *Interface, 6*(1), 1-8.

Truax, B. (1994). The inner and outer complexity of music. *Perspectives of New Music, 32*(1), 176-193.

Truax, B. (1996). Soundscape, acoustic communication and environmental sound composition. *Contemporary Music Review, 15*(1), 49-65.

Truax, B. (2001). Island. On *Islands* [CD]. Vancouver: Cambridge Street Records.

Truax, B. (2001). *Islands* [CD]. Vancouver: Cambridge Street Records.

Truax, B. (2002). Genres and techniques of soundscape composition as developed at Simon Fraser University. *Organised Sound, 7*(1), 5-14.

Truax, B. (2008). Soundscape composition as global music: Electroacoustic music as soundscape. *Organised Sound,13*(2), 103-109.

U2. (1991). One. On *Achtung baby* [Vinyl]. New York, NY: Island Records Inc.

Vuoskoski, J. K., & Eerola, T. (2015). Extramusical information contributes to emotions induced by music. *Psychology of Music, 43*(2), 262-274. doi:10.1177/0305735613502373

Waal, F. B. (2008). Putting the altruism back into altruism: The evolution of empathy. *Annual Review of Psychology, 59*(1), 279-300. doi:10.1146/annurev.psych.59.103006.093625

Walker, R. (1996). Open peer commentary: Can we understand the music of another culture? *Psychology of Music, 24*(2), 103-114.

Wapnick, J. (1980). Pitch, tempo, and timbral preferences in recorded piano music. *Journal of Research in Music Education, 28*(1), 43-58.

Ward, M. K., Goodman, J. K., & Irwin, J. R. (2014). The same old song: The power of familiarity in music choice. *Marketing Letters, 25*(1), 1-11. doi:10.1007/s11002-013-9238-1

Weale, R. (2007, May 1). Aural discourse and mimetic discourse. *ElectroAcoustic Resource Site*. Retrieved from http://ears.pierrecouprie.fr/spip.php?rubrique181

Weiss, M. J., Zelazo, P. R., & Swain, I. U. (1988). Newborn response to auditory stimulus discrepancy. *Child Development,59*(6), 1530-1541. doi:10.2307/1130668

Westerkamp, H. (1996). *Kits Beach Soundwalk* [CD]. Vancouver, BC: Empreintes DIGITALes. (Original work published 1989)

Westerkamp, H. (2002). Linking soundscape composition and acoustic ecology. *Organised Sound, 7*(1), 51-56. doi:10.1017/s1355771802001085

Young, J. (2015). Imaginary workscapes: Creative practice and research through electroacoustic composition. In *Artistic practice as research in music: Theory, criticism, practice* (pp. 150-166). Surrey, United Kingdom: Ashgate Publishing.