The Sense Ensemble: An Approach to Music Composition for Deaf and Hearing Alike

George Charles Higgs

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Department of Electronic and Electrical Engineering
University of Dublin, Trinity College

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Declaration:

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SUMMARY

This thesis explores approaches to music composition for deaf and hearing individuals alike. Chapter 1 details how these investigations were inspired by time the researcher (a composer) spent working in a school for deaf girls in Dublin, Ireland between 2010 and 2013. Previous to this experience, he shared a commonly held belief that deaf individuals cannot experience music, and that music is for the hearing alone. Working in the school not only revealed to him that deaf people can engage with music, but that music has an extra-auditory potential, for both deaf and hearing individuals, which is often ignored. The researcher undertook 3 years of formal studies in the Music and Media Technologies activity of the Department of Engineering in Trinity College Dublin (supported by an Irish Research Council Fellowship) to explore harnessing this potential compositionally. This thesis documents the results of these efforts.

Chapter 2 begins by examining the many degrees, types and configurations of deafness, and demonstrates that the condition comprises a broad, multi-layered continuum between ability and disability. While members of a Deaf community may share a sign language specific to the region in which they live, every deaf individual's condition, and moreover his or her experience of deafness, is unique. For this reason, any assumption that deaf people are categorically capable or incapable of musical engagement is without foundation. The chapter goes on to argue that music, rather than being exclusively for the ears, is in fact a whole-body, crossmodal and intersubjective experience. Many forms of evidence, from clinical studies in the field of neuroscience to testimonies of deaf and hearing individuals, are presented to support these premises. The fact that music is not for hearing alone, as well as the reality that most deaf individuals have some degree of hearing, suggests a case for deaf participation in musical activities. The chapter concludes by citing numerous historical and contemporary examples of deaf individuals being musically engaged.

Chapter 3 discusses possible reasons for the widely held belief that music is a uniquely auditory experience. Neuroscientific studies have shown that multisensory awareness is problematic. This is due to the fact that multisensory stimuli are generally resolved into a unified percept, with an individual's awareness presenting in the dominant modality (Deroy *et al.*, 2014; Calvert, 2004). Further research in the fields of social psychology and phenomenology shows that the culture around music, specifically the audio-centric nature of the language used, has a decisive effect on limiting or increasing the scope of an individual's experience (Heidegger, 1971; Kahneman, 2011). To whit, if music is approached as an auditory experience, it becomes an auditory experience. The chapter concludes with the presentation of a vibrotactile experiment the researcher carried out, *The Balloon Study*, which suggests a way for people to extend awareness concerning the musical experience into modalities other than hearing.

Chapter 4 begins by outlining the background to this research, which was stimulated by three years working as composer-in-residence in a school for deaf girls and by a number of public music performances with students from the school. The chapter continues by giving an overview of the instrument technologies devised and employed by the researcher for the purposes of investigating the crossmodal and intersubjective nature of musical experience. The chapter then provides a detailed account of 4 workshops and 3 compositional studies (*The Sense Ensemble, Studies #1 - #3*) carried out in the course of this research to explore different approaches to composition for deaf audiences with a view to learning how to extend composition strategies for hearing audiences. These activities provided methods and results. Based on what was learned during the 4 workshops, *Study #1* was an experiment in using gesture as the 'voice' of a

composition, testing a number of different techniques for alerting an audience to the whole-body and intersubjective potential of musical experience. The study aimed both to encourage the audience to perceive the gestures as musical, and to have them participate in the performance of the gestures in a musical fashion. Results from participatory feedback, questionnaires and post-performance Q&As unequivocally show both deaf and hearing participants to have perceived the gestures (ISL signs) as a form of musical expression, and to have participated successfully in the performance of these gestures.

Study #2 took this use of gesture a step further with a performance involving 1) a larger venue, 2) a mixture of conventional and adapted instrument technologies (e.g., string quartet and vortex cannon) and 3) a refined use of selected techniques from *Study #1*. The study demonstrated the gestural interaction to be equally successful in the larger venue, and that again the audience perceived the gestures as musical. Moreover, the vortex cannons were integrated more thoroughly into the performance. Specifically, the string quartet took the smoke rings emerging from the cannons as their cue to begin a furious tremolando, and then governed the rate of rallentando by watching the rings gradually slowing down as they drifted across the auditorium and into the audience.

Chapter 4 concludes with *Study #3*: an attempt by the researcher to perform a composition under more controlled circumstances. *Study #3* is based on examples from the literature which demonstrate sound induced visual illusions, and visual illusions induced by vibrotactile stimuli (Shams *et al.*, 2002, 2004). The study aims to investigate such crossmodal correspondences with a view to exploiting them in composition. To be more precise, participants are instructed to report the number of flashes appearing on a screen while conflicting auditory and vibrotactile stimuli are presented as part of a multisensory composition. Overall, Study #3 provides valuable methodological insights in terms of composition as a form of research in a controlled setting. The results confirm sound induced visual illusions, while the influence of vibrotactile stimuli on either visual or auditory perception was uncertain in this case. Further studies are recommended.

Chapter 5 consolidates the results from the studies in Chapter 4 into a compositional approach – **a crossmodal harmonic technique** – the aim of which is to alert an audience to the whole-body, multisensory and intersubjective potential of music. First, the act of musical composition is acknowledged to be merely an initial step in the creation of a musical experience, necessarily followed by performance and audience interaction in an intersubjective event. Crossmodal harmonic technique is then outlined, its fundamental building block being a motive with multimodal potential, i.e., a gestural pattern that can be repeated and varied for the attention of other modalities. The chapter goes on to suggest ways of developing a multisensory narrative using this motive. Harmony and technology are then collectively considered in terms of human relationships, and their vital role in the musical experience. The chapter concludes with a clear outline of crossmodal harmonic technique, with the aim of providing others with a foundation on which to develop such methods further.

Chapter 6 provides a summary of the ideas presented in the thesis, and a discussion for future work in this field.

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CHAPTER 1

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BACKGROUND AND INTRODUCTION; MUSIC FOR DEAF PEOPLE

1.1 BACKGROUND

This thesis presents research concerning an approach to music composition for deaf audiences with a notion to broadening compositional approaches for all audiences. Prior to beginning this Ph.D. in 2015, the researcher had worked for three years in St Mary's School for Deaf Girls in Dublin, Ireland, exploring methods for musical interaction with the students. Up until that time, however, and for most of his career as a composer, the researcher had naturally assumed that the musical experience was not available to deaf people. A compositional project he carried out in 2007 called *The Electro Acoustic Exchange* gave him cause to rethink this assumption. The composition, which created rhythms based on fluctuations in the value of four different commodities, was exhibited as a sculptural installation in Project Arts Centre, Dublin (Higgs, 2007). Eight bare loudspeaker drivers were suspended upright in the darkened space, four of which held one of the designated commodities: grain, euro coins, minerals and bones (the last signifying human labour). Rhythms were produced when infrasonic pulses were sent through the loudspeakers, causing the commodities to vibrate percussively; an action which was audible, visible and tangible. While curating the exhibition for its week-long run, the researcher continuously watched visitors move amongst the loudspeakers, reacting in surprise to the sight of the animated materials and touching them cautiously.

Observing the public's reaction to the multisensory spectacle, it occurred to the researcher that deaf individuals might be able to have a musical experience through a similar approach. He imagined that investigating the deaf experience of music might better inform his own compositional practice, and his views on music in general. He began talking to as many people as he could: colleagues in the world of performing arts, as well as deaf organisations in Dublin where he lived. He sketched out plans for a deaf opera involving a full theatre set which deaf audience members would walk through and feel vibrations by means of multiple surfaces: through the floor, through the low ceiling via a cable, and through vibrationally conductive columns connecting the two. He even made a formal presentation of these plans to the director of the Project Arts Centre, where he had recently produced *The Electro Acoustic Exchange* (Figure 1.1).

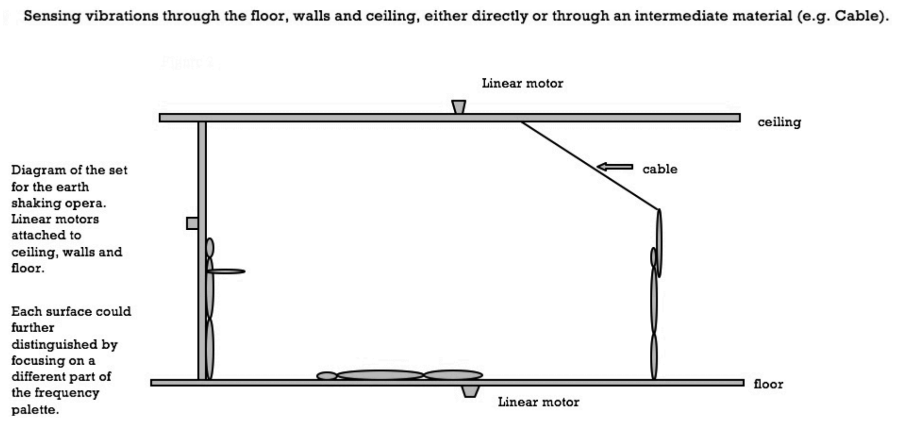


Figure 1.1. Sketches for a 'deaf opera' presented to the Project Arts Centre in 2007 (from the researcher's notes for the Earthshaking Opera).

On the whole, reactions to the researcher's idea were cautious. It became increasingly clear that most of his peers shared the same assumption he had long held: that deaf people cannot in fact have a *proper* musical experience. While many of those he consulted were willing to accept that deaf people were able to feel low-frequency vibrations, just as all people can when these vibrations are of prodigious amplitude, the consensus seemed to be that the most vital aspects of the musical experience would be lost on deaf individuals: e.g., melody, harmony and timbre. The general opinion was that exploring music for deaf individuals, while daring and novel in theory, in practice had limited value.

The researcher's solicitations to deaf organisations also failed to make significant headway for a long time, mostly due to basic cultural obstacles. Foremost was the researcher's ignorance of Irish Sign Language (ISL) at the time. Even if the people to whom he introduced himself in the various centres could read his lips, he could not understand when they signed in response. On the occasions he spoke to a hearing person working within a deaf organisation, the reaction almost invariably consisted of puzzlement and vague promises of follow-up emails never received.

Finally in 2010, with funding from Arts Council Ireland, the researcher was invited to attend two rehearsals of the Dublin Deaf Choir in the Catholic Centre for the Deaf in north Dublin, during which he could observe as well as interact with the choir. The experience began inauspiciously, however, when the researcher entered the rehearsals with a fundamental misunderstanding of the choir's musical approach: he thought the choir to be a *singing* choir, when they were in fact a *signing* choir. The conductor, who was hearing, explained that it was her job to cue the group to sign lyrics to songs in ISL at rehearsals and performances. The choir, all profoundly deaf women over the age of 60, would most often perform alongside a live church choir, signing lyrics for hymns during mass. Several of the choir members were taken aback to learn that the researcher had not been aware that they were a signing choir (they expressed this through ISL with the conductor interpreting). To their minds, the researcher's ignorance seemed to suggest that he might not be prepared to take what they were doing seriously. Several others also felt it was arrogant that he had come to the rehearsal with no knowledge of ISL. The researcher explained that his interest was in learning about the deaf experience of music through vibrations rather than sign language. This provoked further controversy. Many in the choir insisted that they were not interested in vibrations. In their opinion, the idea of the composer wanting to understand their 'musical experience', beyond the way they could perform through signing, seemed not only pointless but also an affront to their own Deaf musical culture[1].

Somewhat stubbornly, the researcher built a vibrating chair, which he felt might convince the choir otherwise. The chair consisted of plywood seat, back and armrests, each of which had a vibrotactile transducer attached with separate audio channels assigned to each (see Figure 1.2). The researcher's plan was to send the SATB (soprano, alto, tenor and bass) parts of a choral piece he had composed through these different channels. His research aim was to see if the beauty of the four-part choral harmony could be translated into vibrations through the surfaces of the chair. The choir, however, was unimpressed with the chair at its debut during the second rehearsal, and moreover unconvinced on the matter of vibrations. The members reacted mostly with expressions of discomfort as the choral piece buzzed and rumbled through the plywood and into their bodies. Some even refused to sit in it for longer than a few seconds.

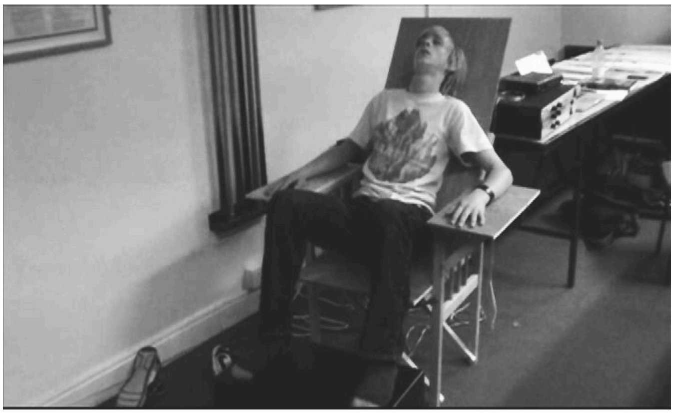


Figure 1.2. Vibrating chair built for Dublin Deaf Choir in 2010 (Photograph by author, 2010) .

[1] The following are prescribed by Shearer *et al.*(2017):
Deaf (small "d") is a colloquial term that implies hearing thresholds in the severe-to-profound range by audiometry.
Deaf culture (always a capital "D"). Members of the Deaf community in the US are deaf and use American Sign Language. As in other cultures, members are characterized by unique social and societal attributes. Members of the Deaf community do NOT consider themselves to be hearing "impaired," nor do they feel that they have a hearing "loss." Rather, they consider themselves deaf. Their deafness is not considered to be a pathology or disease to be treated or cured. See also Napier & Leeson (2016).

After the two meetings with the Dublin Deaf Choir, the researcher was prepared to conclude that his work with the deaf was at an end. But not long after, he was contacted by the principal at St Mary's School for Deaf Girls in Dublin. She had heard about his work with the choir, and invited him to visit the school. St Mary's had maintained a music programme for a number of years, and even had a dedicated music room equipped with a range of instruments. With the support of the principal, the researcher was able to secure funding to work musically with the students. The researcher found the musical culture in the school very different to the one he had encountered with the Dublin Deaf Choir. Indeed, the school had its own signing choir, but they were also equally interested in a broad range of musical activities that involved conventional instruments. The principal welcomed the composer to explore means of collaborating with the students.

For 3 years the researcher spent one day per week meeting groups of students in the music room of this deaf school in a kind of exchange of musical expertise. While the researcher was able to share his own musical background, the students in turn were able to introduce the researcher to an entirely fresh perspective on how to engage with music by using the entire body for the listening and performing experience. The signs he had previously dismissed in the case of the Dublin Deaf Choir, for one, came to be an integral part of the musical vocabulary for the composer's interaction with the students (the researcher went on to take an ISL course in Trinity College Centre for Deaf Studies). Together, they attempted to view the musical experience as a 'sense ensemble', with no one modality being given primacy. It was the beginning of a very inspiring dialogue for all, resulting in a number of large scale projects over the next 3 years by the group, which came to refer to itself as The Sense Ensemble (see Figure 1.3). These projects - *Machine of Song* (2010/2011) and *The Lost and Found Sound Assembly* (2012/2013) - will be detailed in later chapters of this thesis.

Figure 1.3. Students from St Mary's School for Deaf Girls performing as the Sense Ensemble on *The Machine of Song* - an instrument built by the researcher - in the Irish Museum of Modern Art, Dublin, September, 2012. (Photograph by Katherine Atkinson, 2012, courtesy of CREATE Ireland)

The researcher also came to learn in his time at the school that there were a surprising number of people in Ireland and abroad who had long been making music with deaf audiences, of which Chapter 2 will provide further details. The researcher's experience in St Mary's School for Deaf Girls and correspondence with a number of these organisations led to his decision to undertake the research which informs this thesis.

1.2 INTRODUCTION

The background to this research supports the view that while there is a community of people who are aware of the possibilities of music for deaf people, the majority opinion is that deaf people cannot properly experience music (Maler, 2015). Such a belief is not limited to lay circles, and is well-documented in traditional musicology. Further statements to the effect that music is "the one thing that a deaf person can never possess, a form of discourse unthinkable and unattainable" are as common in musical literature as they are in conversation (Abbate, 1991, p. 130). As the previous section also demonstrated, this is not unique to the hearing community. A considerable number of people in the Deaf community not only think the musical experience *unattainable*, but also *undesirable* for a number of reasons which will be addressed in Chapter 2 (Burch, 2004; Higgs, 2010).

The prevalent assumption that deaf individuals cannot properly experience music suggests a deeper misunderstanding around the nature of the musical experience for all individuals, hearing or deaf. For, if most people find it unlikely that deaf people can experience music because they cannot hear, it follows that most people believe music to be an experience for audition alone.

This thesis will attempt to redress both of these misconceptions: demonstrating that music can indeed be experienced by deaf individuals, and furthermore that music is by no means limited to auditory experience for any individual, whether they have full hearing or not (Darrow, 2006). The research has specifically investigated ways of composing for deaf audiences, but it maintains the broader aim of better understanding how music affects all of the senses of hearing and deaf individuals alike. It will be argued that there is not one 'music' for deaf people, and another 'music' for hearing people; but rather that all music involves a whole-body hearing that is appreciable by any and every person, irrespective of auditory condition (Essid, 2012; Ceraso, 2014).

It would be remiss not to volunteer a counter-argument to these claims: i.e., if music involves all the senses, why is it commonly believed that deaf people cannot experience music and that music is in fact for audition alone? Such a question relies on an assumption that absolute definitions of music can reasonably be established; that music can be described as being a certain thing, and not another thing. Yet, rather than determine what music is or is not, perhaps it is more rewarding to consider what music can be. In fact, this thesis argues that music is to a large extent what the listener makes of it; which can be many variations of experience based on a given set of conditions (Bharucha, 2006).To be more precise, this thesis adopts the viewpoint that music composition/performance does not present a finished product ready for consumption, but a set of conditions to be interpreted by a listener who invariably approaches the musical encounter with a host of cultural and cognitive preconceptions (Garfias, 2004). Rather than being necessarily negative, such preconceptions are natural to all people, and in fact provide the only means for having a meaningful musical encounter. The musical experience itself, to appropriate a phrase from Hans-Georg Gadamer, is a *fusion of horizons*; that of the stimulus conditions presented and the preconceptions of the listener (Gadamer, 1989, p.302).

It might seem that a huge degree of control is being taken away from a composer in such a dialogical scenario; as the listener assumes a large amount of responsibility for the musical outcome. It must not be forgotten, however, that composers are listeners, too. Moreover, they are listeners who require a prodigious imaginative capacity for the possible experience of their audience. It is not the composer's job to predict a definite outcome, but merely a range of possibilities for an unknown audience (Cage, 1961). Even if the audience can be identified in advance, a composer is clearly not able to control how such known listeners will attend to a composition. On the other hand, a composer has a wealth of options at hand to set up conditions for a musical experience. Those conditions a composer chooses to include – the instruments, the performance techniques, theatricality, et cetera – can be arranged using a narrative strategy which, though it cannot be deterministic, will exert a huge influence on the listener's experience.

It should be clarified that the author of this thesis subscribes to the view that all composition at one level involves a narrative strategy. This is admittedly a hotly debated issue (Eyre, 2007). Ball describes narrative 'as simply not an essential, or even important, part of music', and Levinson speaks of narrative, or drama, as being evident only in instrumental music (Ball, 2010, p. 392; Levinson, 2004). Le Poidevin counters such claims in his definition of narrative: 'a representation of a sequence of events between which there is some connection' (Le Poidevin, 2005). At the very least, musical events invariably bear a connection to each other at a temporal level, thereby satisfying Le Poidevin's definition. Taylor, however, another opponent of the notion of musical narrative, concedes that while all music is narrative in a literal sense, the fact becomes irrelevant because the narrative intentions of a composer are not always clear to a listener (Taylor, 2012). Countering this once again is the scholarship of Fischer and Klein, both of whom have a more expanded view of narrative (Fischer, 1984; Klein, 2005). Klein describes narrative as 'an emplotment of expressive states rather than a sequence of actors and their actions' (Klein, 2005, p.23). Almén decisively side-steps most objections to music as narrative, claiming that such theories rely on what he terms a descendent model of narrative; that is to say that music must be shown to have structures of literary narrative. Almén instead proposes:

> . . . the more productive model with respect to music is the sibling model. If narrative is understood as an ideal structure, a way of articulating the dynamics and possible outcomes of conflict or interaction between elements, then many of the difficulties attached to the descendent model do not apply. Music has its own syntactic potentialities, its own ways of manifesting conflict and interaction. A theory of musical narrative that recognizes the different languages and organizing principles of literature and music would not be focused on the question: "How is music really like literature in disguise?" (Almén, 2003, p. 3)

While compositional narrative strategies differ in detail, they all have in common pattern making, and playing with expectations of pattern repetition and variation (Meyer, 1956). The narrative strategy to be presented as part of this thesis – crossmodal harmonic technique – is an attempt to encourage listeners to correlate what they hear with what they see and feel tactilely in a meaningful way. Thus, patterns primarily addressed to one modality (e.g., tactition) might be juxtaposed with repetitions or variations of the pattern addressed primarily to another modality (e.g., vision). This example, however, is misleading as it might suggest an atomistic view of perception contrary to the spirit of this research. One of the first things the researcher discovered working in St Mary's School for Deaf Girls was that an attempt to focus exclusively on specific modalities was in practice extremely difficult. All modalities arguably come into play in any experience (Calvert, Spence & Stein, 2004). While it is true that the researcher later developed methods to achieve a certain modal specific focus through controlled experiments (Chapter 3), as a newcomer in a deaf environment such an approach was still a long way off.

As it has been explained, this thesis takes the view that musical experience is a sense ensemble. More than a fanciful notion, sense ensemble describes a working ethos developed by the researcher in the course of interacting musically with a group of deaf students. Such a method did not begin with a formal examination of hearing, vision or somatosensory perception. Instead, it focussed on the physical actions, or gestures, that the students used to create music - e.g., striking a drum, ringing a bell, scraping a washboard with a stick – and identifying the actions themselves as the essential musical elements. Initially, this 'action approach' was applied only to rhythm, but eventually came to encompass melody and harmony; all of which were regarded essentially as gestural events, i.e., expressions of human bodily movement rather than theoretical abstractions. While the physical events thus produced were easily shared by the Sense Ensemble in performance, they could later be discussed variously as sonic, visual, tactile or kinaesthetic. In fact, these modal identities – e.g., that striking a certain marimba key produces the note called G while also comprising a downward movement with a mallet both visible to the audience and vibrotactile for the performer - were all merely different aspects of the same physical activity. The advantage was that an inability to partake fully of one aspect – sound in the case of the deaf students – did not inhibit the ability to perceive rhythm, melody or ultimately harmony. Crossmodal harmonic technique will be described more thoroughly in Chapter 5, with studies using the technique presented in Chapter 4.

In addition to the studies undertaken as part of this Ph.D. work, this thesis presents existing research supporting an embodied, crossmodal and intersubjective view of musical experience. The scope of such research is not limited to music, however, and has been applied to all levels of meaning-making among humans, including language and gesture in general (Gallese, 2009). Johnson suggests a non-propositional bodily basis for meaning with his theory of embodied schemata; metaphorical cognitive representations of physical patterns encountered in one's environment that serve as the basis for meaning-making (Johnson, 1990/2007). The establishment of such schemata are not based on unimodal processes, but multimodal stimuli that have been integrated to create a coherent, seemingly singular percept (Calvert *et al*., 2004). Our making of meaning is to a certain extent a constantly developing cognitive narrative between 1) actions that occurred in the past and the embodied schemata that were developed for their representation and 2) the actions that are perceived in a present context. Kukkonen has argued that such a narrative operates on a type of Bayesian predictive-processing model (Kukkonen, 2016). Research shows that not only is perception embodied and crossmodal, but furthermore intersubjective at the most basic level; with embodied simulation essential to gestural perception in humans as demonstrated by the study of mirror neurons for one (Gallese, 2009).

Such an embodied, crossmodal and intersubjective narrative of meaning making is represented in the mechanics of music itself (Cox, 2011; Zbikowski, 2002). While this interplay exists already in any musical setting, Chapter 5 will demonstrate how significant a composer's attempts to direct the listener's attention to it through a crossmodal approach can be. In truth, the strategy does not fundamentally differ from any other compositional approach, except that it enlarges the pool of conditions available to a composer to include musical expressions directed more conspicuously at other modalities. The compositional studies resulting from this research are not limited to deaf people, but are explorations in alerting all audiences to an expanded awareness of the potential for musical experience. The research has largely concentrated on deaf individuals, however, because of the insights offered by taking into consideration their unique perspective. Simply put, this thesis adopts neither a hearing-centric nor deaf-centric perspective on music. Instead, it has attempted to mediate between the two, presenting a number of open-ended techniques that allow participants to choose the manner of engagement best suited to their own needs and strengths (see also Dirksen, Bauman and Murray (2014)). Ultimately, the question that gradually emerges from the initial aims of this research - to explore approaches to composition for deaf audiences with a notion to broadening compositional approaches for all audiences (p.1 of this chapter) – can be expressed as: what compositional strategies can be adopted to alert and sensitize a mixed deaf and hearing audience to the physical, multisensory and intersubjective potential of the musical experience?

This thesis is set out as follows:

Chapter 2 begins by examining what it means to be deaf, outlining the various degrees, types and configurations of deafness, and underlining how heterogeneous the condition is. The chapter goes on to demonstrate that music, rather than being limited to audition, is in fact a whole-body, crossmodal and intersubjective experience. Citations are drawn from the fields of neuroscience, psychoacoustics, musicology and philosophy. The chapter concludes by evaluating a selection of existing approaches to deaf involvement with music.

Chapter 3 suggests a number of reasons that music is seen as mainly auditory, in spite of the fact that it is a whole-body, crossmodal and intersubjective experience. First, examples from neuroscientific literature indicate that multisensory awareness is problematic in that multisensory stimuli are generally resolved into a unified percept, with an individual's awareness presenting in the dominant modality (Calvert *et al.,* 2004). A social psychology approach then applies the notions of System 1 and System 2 thinking as being possibly responsible for our bias toward an auditory hegemony (Kahneman, 2011). A more philosophical approach then argues that the musical experience is profoundly influenced by the disclosive nature of language, whereby our vocabulary around music carries an assumption of musical experience as primarily auditory (White, 1994; Heidegger, 1971). It is suggested that this linguistically defined scope for musical experience can be expanded through certain measures, and the chapter concludes with an experiment which tests the ability of participants' vibrotactile awareness to be extended.

Chapter 4 gives an account of the 4 workshops and 3 compositional studies conducted in the course of this research which experimented with different approaches to composition for deaf audiences, detailing methods and results, and assessing the merits and errors of the studies.

Chapter 5 presents a method for composing for deaf and hearing individuals alike - a crossmodal harmonic technique – based on the arguments presented in Chapters 2 and 3, and the studies presented in Chapter 4. The chapter also details the background work in St Mary's School for Deaf Girls in Dublin that helped inform this approach, which makes deliberate use of patterns in separate modalities to set up inter-modal relationships which are harmonic in nature.

Chapter 6 is a conclusion to the ideas presented in this thesis, and a discussion for future work in this field.

CHAPTER 2

DEAFNESS AND MUSIC

Chapter 1 introduced the subject of this thesis – an approach to music composition for deaf audiences - and explained the background that led to its investigation. Chapter 2 presents the premises on which such an approach is based, and is structured as follows:

Section 2.1 discusses ethical issues in this research.

Section 2.2 addresses the research perspective, i.e., how this research is positioned with regard to the Deaf community, the hearing community and music.

Sections 2.3, 2.4 and 2.5 examine what it means to be deaf from both a medical and cultural perspective.

Section 2.6 demonstrates that music, rather than being limited to audition, is in fact a whole-body, crossmodal and intersubjective experience. Citations are drawn from the fields of neuroscience, psychoacoustics, musicology and philosophy.

Section 2.7 evaluates a selection of existing approaches to deaf involvement with music.

2.1 ETHICAL ISSUES

Due to their physiological impairment, deaf individuals are considered vulnerable participants in research settings. Before this research could begin in the autumn of 2015, ethical approval had to be applied for and granted by the School of Engineering Research Ethics Committee of Trinity College Dublin. The application and letter of approval can be found in Appendix 2.1. The researcher had to demonstrate that he would follow the guidelines set out in "The School of Engineering's Guidelines When Testing Adults" contained in the application. The researcher also demonstrated that he would adhere to the ethical principles of Trinity College Dublin, which have been summarised as:

-respect for the individual subject or population,
-beneficence & the absence of maleficence (research should have the maximum
benefit with the minimum harm) and

-justice (all research subjects and populations should be treated fairly and equally).
(Trinity College Dublin, 2002)

The primary issue assessed by the Ethics Committee is the potential for risk, discomfort, stress or embarrassment to participants in the research (see “Key Concepts in Research Ethics” in Appendix 2.1). The committee requires that each participant provides informed consent. In accordance with this requirement, participants in the studies for this research were given an Information Sheet (aka, PIV) at the beginning of the session and a Debriefing Sheet at the end, to make them fully aware of the nature of the research and how their involvement might inform the research. Each participant was asked to sign an Informed Consent Form, giving the researcher permission to publish the resulting data anonymously. All these forms can be found in the application to the School of Engineering Research Ethics Committee of Trinity College Dublin, (Appendix 2.1).

2.2 THE RESEARCH PERSPECTIVE

It should be acknowledged that one’s point of view on deafness – e.g., as a deaf person living primarily in the Deaf community (communicating through sign language), as a deaf person living primarily outside the Deaf community (not using sign language), as a hearing person working in the Deaf community (for example, a teacher communicating through sign language) or as a hearing person outside the Deaf community (not using sign language) - has inherent implications for one’s approach to the issue. These implications will be discussed more in the following sections, but it is worth taking the time to identify the point of view of this researcher in such a discussion. As Chapter 1 details, this research began with time spent by a hearing individual (the composer) with basic knowledge of ISL working in a Deaf community (St. Mary’s School for Deaf Girls). The researcher chose not to isolate himself from the activities he undertook with the deaf students, e.g., operating as a detached hearing observer in a deaf environment (if that is indeed possible). Instead, he included himself as part of activities with the deaf students, working alongside them as a musical participant. Rather than adopting either a hearing-centric or deaf-centric perspective, the researcher made every effort to nurture a mediated point of view, collaborating with the deaf students to investigate the nature of a shared musical experience, i.e., a sense ensemble.

2.3 DEFINITIONS OF DEAFNESS

As this thesis addresses an approach to music composition involving deaf audiences, the complex nature of deafness should first be examined. Deafness is not an identical condition shared by all those who are diagnosed as being deaf or hard of hearing. Such a heterogeneous condition is clinically assessed using a number of parameters which indicate wide variation amongst individuals (ASHA, 2015). While it is tempting to consider a singularly deaf experience of music, this is no more valid than considering a uniquely hearing experience of music (Glennie, 2015). This does not mean that all considerations of deafness as an experience should be summarily discounted. Certainly, speaking about the deaf experience from the point of view of culture is necessary, as it involves the members of the Deaf community with regard to a larger society dominated by people who hear; i.e., their shared concerns and advocacy for better representation and provision (Hehir, 2002). In fact, this distinction of cultural versus experiential identity is represented in the language used in relation to deafness. It is understood by many that Deaf culture is distinguished by an upper case 'D' while deafness as a condition is represented as a lower case 'd'; a practice which this thesis does its best to follow (Shearer *et al.*, 2017). In terms of music perception, however, grouping all deaf people together is misleading, due to not only differences in the nature of deafness between individuals but the equally varied cultural experience of and exposure to music for different deaf individuals (Ament, 2010).

The following two sections offer two perspectives on deafness. Section 2.4 gives an overview to medical definitions of deafness, while Section 2.5 examines deafness from a cultural perspective.

2.4 MEDICAL DEFINITIONS OF DEAFNESS

From a medical perspective, the condition of deafness is usually described in terms of three aspects – degree, configuration and type – each of which the following sections briefly address (ASHA, 2015). Degree refers to the amount of hearing loss, configuration to the nature of this hearing loss (e.g., frequency dependence of hearing loss) and type refers both to the aetiology of the condition as well as when it occurred in an individual's life.

2.4.1 DEGREE OF HEARING LOSS

While psychologic tests (auditory brain stem response testing, auditory steady-state response testing, evoked optoacoustic emissions and acoustic immitance testing) objectively determine the functional status of the auditory system, audiometry subjectively assesses hearing loss (HL) using controlled sonic stimuli (ASHA, 2015). During the researcher's time in St Mary's School for Deaf Girls, pure-tone audiometry was regularly carried out for students on the school grounds by a resident audiologist (St Mary's, 2010). Such pure-tone audiometry (both air and bone conduction) involves determination of the lowest intensity at which an individual "hears" a pure tone as a function of frequency. Octave frequencies from 250 Hz (close to middle C) to 8000 Hz are tested using earphones. Intensity or loudness is measured in decibels (dB), with 0 dB HL being the average threshold for a normal hearing adult.

The results of such tests can be represented and interpreted in many ways. Commonly employed among audiologists, and the public in general, is the adjective descriptor, or better ear pure tone average (PTA). This is an average of HL in the better ear (in the case of asymmetric HL) taken from three points the frequency spectrum, and is aimed to provide an overall sense of HL for an individual; i.e., mild, severe, profound, etc. (Clark, 1981). Table 2.1 features one of many existing charts presenting adjective descriptor classifications of HL. At first glance it might seem straightforward: classifications range from normal hearing at the top of the chart to profound HL at the bottom, with dB ranges specified for each category. Exploring these ranges further, however, will give an initial sense of just how ambiguous assessing the condition of being deaf, and indeed hearing, can be (Timmer *et al.,* 2015).

Hearing loss

Degree of hearing loss	Hearing loss range (db HL)
Normal	-10 to 15
Slight	16-25
Mild	26-40
Moderate	41-55
Moderate severe	56-70
Severe	71-90
Profound	91+

Table 2.1. Ranges of hearing loss classified in terms of dB HL (AHSA, 1981).

The first thing the chart in Table 2.1 suggests is that most people with 'normal hearing' in fact have some degree of HL. While those at the lower end of this category may have insignificant HL, individuals at the other end of the normal spectrum, with as much as 15 dB HL, are still regarded as having normal hearing. This range of 25 dB between the two extremes of normal hearing is considerable. In effect, pure tones detectable to someone at the lower end of the range must be three and a half times louder to be detectable by someone at the higher end[1]. In the research conducted for this thesis, most of the individuals involved were diagnosed as being either severely or profoundly deaf (St Mary's, 2010). The chart above provides a substantial range for a severely deaf person, between 71 and 90 dB HL, and then simply indicates that anything beyond 91 decibels is classified as profound deafness. Experience in the school would confirm such a massive spread in HL to exist among those categorised as severely and profoundly deaf, and how nebulous the terms become in practice. Two people assigned to the category of severe deafness might not

[1] That is, taking 10 dB as a doubling in loudness. For an explanation on the nature of decibels see Handel, 1989.

only differ in terms of their amount of HL, but the configuration and type as well (Clark, 1981; more on this in 2.1.3). In fact it was often the case that students who fell under different categories of HL would have far more in common in terms of how they communicated with the researcher musically than those from the same category (St Mary's, 2010).

The chart in Table 2.1 is not the last word on HL classifications. Table 2.2 presents six different adjective descriptor labelling systems which demonstrate wide variation in both HL range and category. As an example of the latter, Davis & Silverman (1970) and O'Neill & Oyer (1973) each have a category for 'extreme' deafness not represented by the other systems, designated as beginning with 90 and 91 dB HL respectively. Northern & Downs (1978) uniquely go further in establishing a level for anacusis (or total HL) at 101 dB HL. At the opposite end of the HL spectrum, none of the systems in Table 2.2 provide a classification for normal hearing, as did the chart in Table 2.1 above. Instead, the different systems present a hotchpotch of minor categories that are incrementally subnormal, including *slight, mild, moderately severe* and *marked*. Noteworthy is that fact that the *slight* and *mild* categories give an average threshold of 24 dB HL. Clark points to research suggesting that such a level of HL has a documented negative effect on speech acquisition in children, so the choice of adjective for these categories is dubious. He suggests the category for slight HL should be reduced to at least 16 dB HL; which is more in line with the ranges in the Table 2.1 chart (see below for more on this point). The most commonly used category in Table 2.2 is *severe*, which is designated by levels of HL differing by as much as +/- 30 dB.

A Plethora of Hearing Loss "Labels" (Hearing Level in dB re: 1969 ANSI).
(From Clark, *Audiology for the School Speech-Language Clinician*, CC Thomas, 1980).

	Davis (1970)	Goodman (1965)	Northern and Downs (1978)	O'Neill and Oyer (1973)	Rintelmann and Bess (1977)	Sweitzer (1977)	
						Children	Adults
Slight	25-40			27-40			
Mild	40-55	27-40	15-30		25-40	21-35	27-40
Moderate		41-55	31-50	41-55	40-65	36-55	41-55
Moderately Severe		56-70				56-70	56-70
Marked	55-70			56-70			
Severe	70-90	71-90	51-80	71-90	65-95	71-90	71-90
Profound		91+	81-100		95+	91+	91+
Extreme	90+			91+			
Anacusis (or total hearing loss)			101+				

Table 2.2. A Plethora of Hearing Loss Labels - A chart showing 7 different systems for classifying Hearing Loss (ASHA, 1981).

With all the variation in categories and ranges in HL classification systems, it might seem unreasonable that audiologists use adjective descriptors at all. Clark comments:

> In spite of the recognized inadequacies of adjective descriptors, they enjoy a

> general acceptance among hearing-health professionals. There appears to be a strong desire among these professionals and the public to have a readily applied label for differing degrees of hearing impairment. Such practice is useful only if the meanings attached to various labels are clearly stated and understood by all hearing-health professionals. Unfortunately, descriptive labels have never been standardized, and consequently, their use varies. A loss that might be referred to as only slight by some may be called mild, or even moderate, by others [Table 2.2]. The lack of standardization for these hearing loss labels can easily create confusion for the professional attempting to interpret an audiologic report. (Clark, 1981, p. 497)

It should be clarified that just as a person with normal hearing does actually have a degree of HL, a person who is profoundly deaf most often has a degree of hearing. The Scottish percussionist Evelyn Glennie clarifies:

> . . . I am not totally deaf, I am profoundly deaf. Profound deafness covers a wide range of symptoms, although it is commonly taken to mean that the quality of the sound heard is not sufficient to be able to understand the spoken word from sound alone. With no other sound interfering, I can usually hear someone speaking although I cannot understand them without the additional input of lip-reading. (Glennie, 2010)

Beltone gives a similar account of profound deafness to Glennie, defining it as a situation where the individual has “difficulty hearing and understanding speech, even with amplification” (Beltone, 2017). On the other hand, in his book, *Seeing Voices*, Oliver Sacks adopts a more extreme view of what constitutes profound deafness (in medical terms), apparently on the basis of extensive correspondence with the Deaf community in the USA. Sacks comments, “Then there are the “profoundly deaf” - sometimes called “stone deaf” – who have no hope at all of hearing any speech, whatever imaginable technological advances are made” (Sacks, 1989, p. 5).

Such disparities in definitions of either profound or severe deafness were commonly encountered by the researcher in St Mary’s School for Deaf Girls (St Mary’s, 2010). It often happened, in fact, that two different teachers would employ different HL descriptors for the same student; irrespective of the student’s audiogram (see Marschark & Spencer, 2009). The researcher speculates that differing judgements by deaf educators probably have less to do with the “lack of standardization” in the labelling system that Clark points to, and more with the fact that many other parameters are involved in deafness, which the following sections will summarise.

2.4.2 CONFIGURATION OF HEARING LOSS

A single adjective descriptor does not tell the whole story in terms of HL. Equally significant is how that HL is 'configured' around other sonic parameters (ASHA, 2015). For one, loudness is frequency dependent for all people; that is, the ear does not respond to the amplitudes of different frequencies in a linear way (Moore, 2003). Certainly, between hearing impaired individuals there is no uniformity concerning loudness and frequency. That is, one deaf person might have severe to profound HL for tones above 1 kHz, while another can hear those reasonably well but reports severe HL for tones starting at 2 kHz. Clark comments on the inadequacy of HL adjective descriptors in light of this:

> . . . the adjective descriptors often fail to account for the handicapping effects of high-frequency hearing loss. A pure tone average (PTA) of the frequencies 500, 1000, and 2000 Hz is generally considered the most important for speech perception and , therefore, adjective descriptors are usually based upon this average. Studebaker (1968) states that for a child who is often unfamiliar with the vocabulary and/or concepts presented in a school lesson, 3000 or 3500 Hz is a more appropriate upper limit for the frequencies needed for normal functioning. For adults as well, the need for adequate hearing beyond 2000 Hz is often apparent (Clark, 1981, p.496).

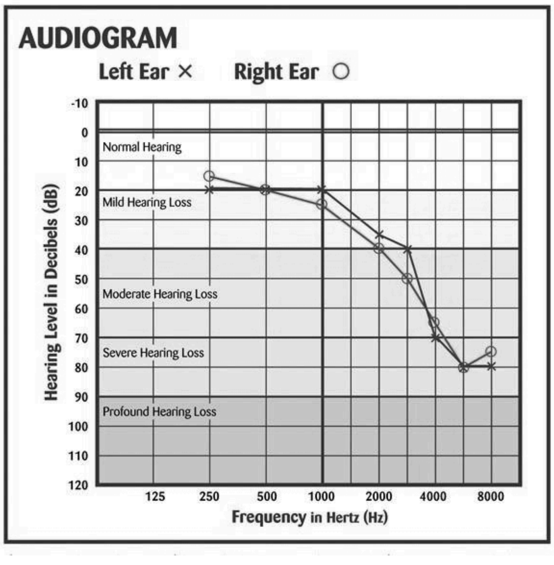


Figure 2.1. Audiogram (ASHA 2015).
It's worth noting that the HL classifications and their ranges are slightly different to the chart in Table 2.1, as well as the charts cited in Table 2.2.

Figure 2.1 features an audiogram with HL in dB represented on the vertical axis and frequency in Hz on the horizontal. The results of an audiometry test are plotted for each ear, with an 'X' on the line plotted for the left ear and an 'O' on the line for the right. The audiogram indicates that the subject's hearing is reasonably symmetrical, and is considered normal for up to approximately 1000 Hz, then steadily declines as the frequency increases. This gives a much clearer picture than a single adjective descriptor in terms of what an individual experiences, and the chart in Figure 2.2 below goes even further in identifying the functional consequences of such HL. First, the commonly employed 'speech banana' has been superimposed on the Figure 2.2 drawing to give a sense of the intensity and frequency content of principal phonemes and how different degrees of HL will impact on an individual's speech comprehension. Second, a notion of intensity and frequency for a selection of environmental sounds has been provided (Olson *et al.*, 1987). Using this Figure 2.2 chart as a guide in terms of speech, the individual in Figure 2.1 has normal hearing for most vowel sounds as well as voiced consonants, whereas sensitivity to unvoiced consonants such as plosives, fricatives, affricatives and sibilants is much lower (see also Fogerty *et al.*, 2012). Such an HL spectrum effectively means that the individual will have trouble understanding speech without the aid of lip-reading (NHT, 2017). Interestingly, if using the PTA Clark cited above (i.e., overall HL PTA = {HL at 500 Hz + HL at 1000 Hz + HL at 2000 Hz} / 3), this individual could be said to have 27 dB HL, or mild hearing loss. Such a descriptor seems inappropriately mild for someone who has the symptoms described by Glennie and others for profound deafness (Glennie, 2010; Beltone, 2017).

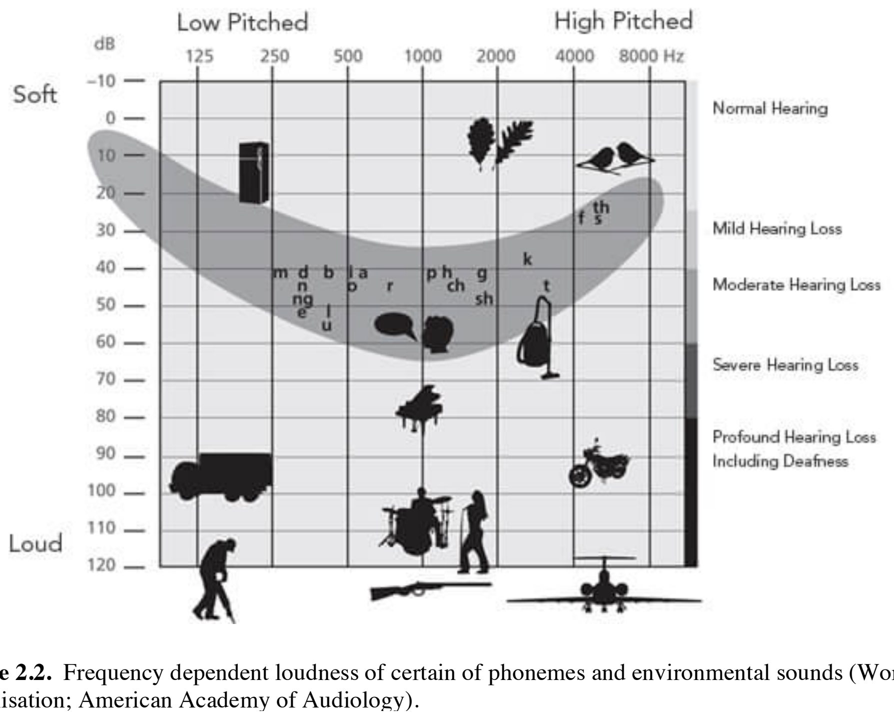


Figure 2.2. Frequency dependent loudness of certain of phonemes and environmental sounds (World Health Organisation; American Academy of Audiology).

The sloping audiogram of Figure 2.1 presents only one of many variations on spectral configurations of HL, and Figure 2.3 gives a number of other curve possibilities. The upper left example more or less repeats the slope for Figure 2.1, while the upper right presents an audiogram with a rising slope scenario; high HL at the lower frequencies and low HL at the upper frequencies.

Such HL in both ears would make the individual incapable of hearing vowel content and voiced consonants, and far more attuned to the unvoiced consonants (Hepner, 1998). The next two audiogram examples in Figure 2.3 represent more irregular patterns, with dips and spikes at the centre frequencies, and respective high and low sensitivity to frequencies at the extremes of the audio range. The flat audiogram in the lower left hand corner shows equal HL for all frequencies, while the final audiogram shows a slope of such an extreme that the individual would find it impossible to engage with speech or timbre at all, even with the use of hearing assistive technologies (Gfeller & Lansing, 1991).

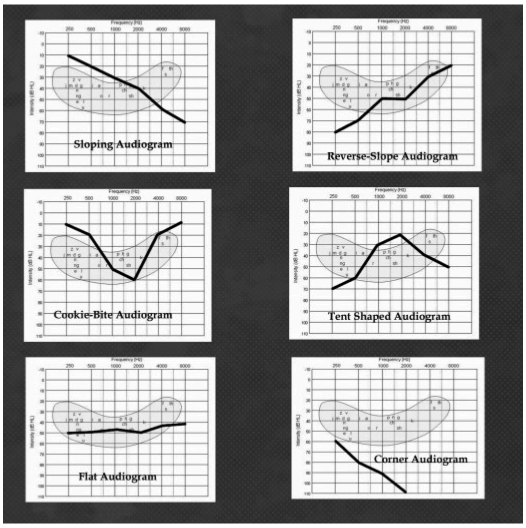


Figure 2.3. Audiogram slopes (Lefler, 2011).

Such configurative assessments are vital in the calibration of hearing assistive technologies to improve speech perception, which will be addressed in Section 2.1.5. For now, it is simply worth appreciating: 1) the huge variety in the spectral configuration of hearing loss, 2) how that variety will pose widely different problems for people with HL and 3) how this variety makes idealising a deaf music participant problematic.

2.4.3 TYPES OF HEARING LOSS

Whether congenital or acquired later in life, various degrees and configurations of HL are ultimately the result of a physiological condition, the diagnosis of which is made through one of the several physiologic tests listed earlier (auditory brain stem response testing, auditory steady-state response testing, etc.). While Moore cites two categories for such conditions, conductive and sensorineural, ASHA adds in the category of mixed; a combination of conductive and sensorineural (Moore, 2003; ASHA, 2015). Shearer *et al.* (2017) makes the addition of a fourth category by identifying central auditory dysfunction.

Conductive hearing loss results from adverse conditions in the external ear and/or the ossicles of the middle ear. Such hearing loss might be temporary, as in the case of an accumulation of earwax (cerumen), or a permanent condition caused by chronic infection (Moore, 2003). For about 2% of the UK/Irish population, otosclerosis is responsible for such conductive hearing loss in the inner ear, and involves abnormalities in the bones responsible for transmitting vibrations from the eardrum to the inner ear (Sargent, 2001). Otosclerosis can be treated using hearing assistive devices, and in many cases can be reversed by surgical procedures; e.g., stapedectomy or stepedotomy.

Sensorineural hearing loss (SNHL), on the other hand, resulting from malfunction of inner ear structures (i.e., cochlea or auditory nerve), is most often irreversible. SNHL is responsible for 90% of all HL reported in the UK and Ireland (Matsunaga, 2009). In some cases the normal ageing process (sensory presbyacusis) or noise exposure damages the sensitive hair cells in the cochlea that are responsible for frequency discrimination, while in other cases, these hair cells can be abnormal at birth. Other forms of presbyacusis (broadly defined as HL associated with degenerative changes of ageing) can affect cochlear neurons (neural presbyacusis), loss of the stria vasularis with ageing (striatal presbyacusis) or involve a thickening of the basilar membrane (cochlear conductive presbyacusis).

While some researchers include it as a form of SNHL, central auditory dysfunction[2] (CAD) - resulting from damage or dysfunction at the level of the eighth cranial nerve, auditory brain stem, or cerebral cortex – is arguably the least understood of all the types of HL (Shearer *et al.*, 2017). The nature of CAD is more complex than a simple matter of spectral HL, and does not in fact always manifest itself as HL on routine audiometry screenings or audiograms. CAD can involve diverse cognitive dysfunctions with many possible symptoms: difficulty localising sounds, distortion of sounds, trouble making sense of the order of sounds, trouble analysing the auditory scene and short attention span, to name but a few (LDA, 2017). CAD is thus viewed by some not so much as a form of HL, but as a learning disability (LDonline, 2017). Gates *et al.* (2011) provides conclusive evidence that CAD is a precursor to Alzheimer dementia. In the researcher's experience in the school, students diagnosed as having CAD posed very different challenges to those with SNHL, seemingly due to a severely limited attention span. Bellis claims, however, that CAD is often blamed for other impairments that a particular individual may also suffer from: autism, intellectual disabilities and other similar impairments (Bellis, 2017).

As well as the physiological conditions for deafness, a significant typological distinction involves the time at which HL occurs in a person's life: that is, whether it was prelingual or postlingual (ASHA, 2015). The definition between prelingual and postlingual can be blurred by the fact that speech development is an extended process, not considered by some to be complete until

[2] Also known as audio processing disorder.

the age of 6 (Shearer *et al.*, 2017). Moreover, while deafness can be sudden, it can also take a number of years to progress; making it difficult to determine the prelingual or postlingual nature of the HL. Nonetheless, the time of life when HL occurs is naturally of huge importance. A review of the available literature by Pierson *et al.* (2007) suggests that prelingual onset has significant effects on not only speech acquisition, but also functioning in the visual cortex. The same review, however, suggests that research is insufficient in this area, and that the existing testing methods are inadequate due to a methodological bias; specifically a tendency to test deaf individuals who were educated outside of the 'speech mainstream' with methods informed by hearing culture. In any case, it seems well established that early intervention by means of hearing assistive technologies can increase receptivity to spoken language skills (Bubbico *et al.*, 2007; see also Marschark and Spencer, 2009).

Though less severe in terms of immediacy, post-lingual HL should not be underestimated as a challenge, either for an individual or the society that needs to address its effects. This category covers not only HL in youth (e.g., the case of Evelyn Glennie, who will be discussed later in this chapter), but also HL in the elderly. Studies of the latter have been on the increase in recent years, and have tended to make strong links between HL and dementia; supporting a number of other studies suggesting that HL does indeed have cognitive effects (Lin *et al.*, 2011). Still, more studies need to be made to detail both the provenance and nature of these effects (Wingfield & Peele, 2012; for work on acquired deafness and implications on dementia, see also Loughrey, 2017).

The above 3 classifications – level of HL, configuration and type - still do not give a full assessment of the effects of HL on an individual. Other factors include intelligence, motivation to overcome the barriers presented by HL, the educational and linguistic backgrounds of the individual, the age at which a hearing aid was fitted, the person's speech discrimination abilities in various listening environments, the vocational setting and the general acceptance of the HL by both the individual and the family (Clark, 1981). A person's hearing condition, as with all the senses, is further influenced by an individual's unique morphology. It is also massively dependent on moment to moment changes in physical state and environment: how tired the person is, whether the person has recently heard a loud noise and the auditory context (a.k.a., the auditory scene), to name but a few. An individual's perceptual ability differs from day to day, and event to event, perhaps as much as it differs to that of other people (ASHA, 2015).

2.4.4 ASSISTIVE LISTENING DEVICES

Assistive listening devices (ALDs) – hearing aids (HAs) and cochlear implants (CIs) – have proved effective for many people with HL in improving speech perception, but there is continuing debate around the musical effectiveness of ALDs (Townshend *et al.*, 1987). It is important to understand that the efficacy of these technologies will differ among individuals. As previous sections have shown, the level, configuration and type of HL vary to such an extent that it is never the case that a specific technological remedy has the same effect for any two people. From Robert Fulford's helpful review of ALDs, it is clear that:

1) There is considerable research on CIs for music, but little research for HAs.
2) While rhythmic perception can be improved by CIs, the perception of melody and timbre can be very poor.
3) Many individuals fitted with CIs later in life are disappointed by the device's treatment of musical phenomena.
4) Both CIs and HAs are generally optimised for speech perception rather than music perception.
5) Music has a much broader range both in terms of dynamics and frequency, thus optimisation of speech perception can be responsible for distortion of auditory musical phenomena.
6) While new approaches can be made for optimising ALDs for music, such measures are costly.

(Fulford, 2013, Section 2.1.2).

In the course of this research, ALDs proved to be both a help and a hindrance to musical interaction with the participants for the reasons cited above. Many participants seemed to prefer to work musically without their ALD, whether a CI or a HA, complaining that certain sounds that became audible by means of the ALD were unpleasant for them (Higgs, 2010). In any case, participants would regularly fail to have batteries for their ALDs, and thus the devices were often not functioning, or worse semi-functional and more sonically confusing than clarifying. It therefore seemed to the researcher that each participant had a variable auditory condition, depending on the status of their ALD. The workshops undertaken in this research attempted at times to capitalise on this duality. Participants would be asked to engage with music in two ways: 1) as a deaf person wearing an ALD and 2) as a deaf participant with their ALD either turned off or removed.

2.5 CULTURAL DEFINITIONS OF DEAFNESS: DEAF IDENTITY

In Section 2.4 of this chapter, the condition of deafness was described from a medical perspective by means of three categories: degree, type and configuration. Before assessing existing approaches to music for deaf people, what remains to be discussed is deaf identity and its bearing on any consideration of music for people who are deaf. Deaf identity is complex. It means different things to different people and can be an extremely contentious issue with regard to how deaf people are identified by themselves and society; e.g., whether or not the condition is considered a disability

(Chen, 2014). It is clear that a deaf individual's sense of identity will fundamentally influence how he or she will interact with music (Darrow, 1993).

Chen points out that many factors influence a sense of identity for deaf individuals: whether they were born into a deaf or hearing family environment, whether their deafness was prelingual or postlingual, whether their school was mainstream or a dedicated deaf educational institution, their having or not having an ALD and their use of sign language or speech. Two points of view are often proposed for deaf identity: physiological and socio-cultural (Chen, 2014). Physiologically, deaf identity simply refers to individuals identifying that they have some degree of HL, and taking measures to adapt themselves to what constitutes a disability in the context of a hearing society: to be precise, negotiating a hearing world with a condition that puts them at a disadvantage. It should be remembered that identifying deafness is far from automatic. The condition can often go officially undiagnosed, especially in poorer societies. Recent WHO statistics show that twice as many people living with deafness in developing countries as compared with first world economies, the principal reason being greater incidence of and lack of treatment for illnesses causing deafness (e.g., chronic ear infections such as ottis media). A 2013 report points out that this statistic is even conservative, as diagnostic audiometry for HL is not nearly as common in underdeveloped societies as in developed ones (WHO, 2013). Sadly, the majority of HL cases in developing societies could be successfully treated through early diagnosis and intervention if it were available (WHO, 2013). The WHO report also draws attention to the fact that of those people identified as being deaf in third world countries, a small percentage are ever able to access services to manage their condition. The WHO report states that less than 3% of those individuals requiring an ALD in such countries actually have one. Wherever it may occur, if deafness is not identified and addressed in a child (whether by treatment, intervention or inclusion in a Deaf community that uses the local sign language), it will have a serious impact on the individual's development, socialisation, education and ability to live a fruitful life. Equally, older people with progressive deafness often fail to identify their condition, leading to a sense of isolation and, according to a growing body of research, cognitive degeneration (WHO, 2017).

In contrast to the physiological view, the socio-cultural view presents deaf people 'as part of a cultural, linguistic, and ethnic minority' (Chen, 2014, p. 1). For members of the Deaf community in the United States, for example, it refers to a comprehensive identity; based principally on a deaf person's rights to cultural self-determination, and mainly represented by the use of sign language (Baynton, 1996). Most every country (to say nothing of each region in that country) possesses a unique sign language, with a distinct gestural vocabulary and grammar. There are currently 300 sign languages listed on Project Gutenberg, but this is certainly a conservative estimate, especially considering the regional variations (Project Gutenberg, 2017). For example, members of the Irish Deaf community sign in ISL, but Dublin alone has two dialects, resulting from deaf girls and boys traditionally being educated separately (St Marys, 2010). There are approximately 5,000 deaf people who use ISL as their preferred language in the Republic of Ireland, and 1,000 in Northern Ireland (Matthews, 1996). It has been further estimated that 50,000 non-deaf people on the island know and use ISL to some extent (Leeson, 2001). In spite of this fact, ISL is not recognised officially by the Irish government, although it has de facto recognition for use in court proceedings and educational settings (Leeson, 2004). Sign language is notoriously hard to codify, as it exists in three-dimensional space using the hands, arms, head, shoulders, torso, eyes, eyebrows, nose, mouth and chin to express meaning (Leeson, 2001; Matthews, 1996).

The North American perspective on such a socio-cultural view of deaf identity is an important one around the world, due to the fact that much of the foundation for what is now considered Deaf Studies originated there (Myers & Fernandes, 2010). Music is, for some members of the Deaf community, still historically linked not only to the aim of encouraging speech, but simultaneously to the suppression of sign language. Early deaf educators in France and the USA encouraged both speech and sign language in their students: an approach that reasonably saw the two forms of communication as being complementary. A paradigm shift occurred, however, where sign language began to be dismissed as inferior, and even as an impediment to effective speech acquisition (Sacks, 1989). While there was no valid research to support such notions, many schools on both sides of the Atlantic ceased sign language instruction, and even banned its use in numerous cases. The results were calamitous, and many deaf individuals were left with extremely poor communication skills, whether they operated in the deaf or hearing world, and functional illiteracy (O'Sullivan, 2015; Leeson, 2006, 2007). As Nolan & Leeson (2009) comment:

> Deaf children too have been actively discouraged from signing, or even punished for using signed languages: in Ireland, for example, children were forced to sit on their hands to prevent signing and encouraged to give up the use of signed language for Lent, the CCatholic period of preparation for Easter, while parents were advised (incorrectly) that use of a signed language would impede acxquistiion of oral language skills (e.g., McDonnell and Saunders, 1993; Leeson and Grehan, 2004, Leeson, 2006/2007)
>
> (Nolan & Leeson, 2009)

This pedagogical derogation of sign language was only quite recently put out of practice, and the wounds are still fairly fresh. A deep pride exists in the Deaf community around sign language, and justifiably so. They have had to fight for their right to express themselves in their chosen manner (Conroy, 2006; Crean, 1997; Griffey, 1994; Leeson & Saeed, 2012; Marschark & Spencer, 2009; Matthews, 2011; Mathews, 1996; McDonnell & Saunders, 1993; Pollard, 2006). An unfortunate consequence, however, is that music has sometimes ironically been associated with limiting expression within the community, rather than enabling it.

Myers and Fernandes clearly identify a reactive stance inherent in US Deaf Studies, 'born out of a movement in the 1960s and 1970s when linguistic scholars were struggling to prove that American Sign Language (ASL) is a language and that Deaf people have a culture, history, and educational practices that are important to learn about' (p.1). A great deal of early Deaf Studies, perhaps justifiably, cite audism (the belief that individuals who can hear or behave in the manner of those who can hear are superior to those that cannot), phonocentrism (that only spoken language is legitimate) and colonialism as the driving forces behind the suppression of Deaf culture (Bauman, 2004). Meyers and Fernandes argue that such views, however relevant at one time, need to change as mainstream society has changed its perception of Deaf culture, and even embraced it (Myers and Fernandes, 2010).

Any research around deafness and music must operate with the awareness that, whether physiological or socio-cultural, the nature of ones deaf identity will have significant impact upon a potential musical experience (Darrow, 1993). This should not come as a surprise, and the importance of identity is hardly unique to collaborating with deaf musicians. It has been the experience of this researcher while working as a composer that all respectful musical collaboration requires an awareness of the different backgrounds and ethos of collaborators, and the problems that can occur when such backgrounds clash. Classically trained musicians will have a distinctly different musical approach to jazz improvisers or folk musicians, and mixing the two is not always harmonious. Even within classically trained orchestras, divisions between instrument families are common, if not the norm (Hash, 2003). A study by Davies reports on the often troubled relationship between string and brass players. In the study, string players commonly described brass players as 'coarse, unrefined, less intelligent, heavy drinkers, loud-mouthed and unable to take anything seriously', while brass players described string players as 'precious, oversensitive, touchy and physically delicate' and moreover tended to take themselves 'too seriously' (Davies, 1976, p. 596). A more recent study by Langendörfer *et al.* gives further examples of such internecine issues, and even suggests how such conflicts can lead to performance anxiety (Langendörfer *et al.*, 2006). It is fascinating to consider the instrument subcultures that exist within the world of orchestral music alone, and a reminder that a group's musical identity is highly dependent on the specific nature of their musical encounter, their methods for interaction and the grammars that result from each. To whit, music with deaf participants which takes on a socio-cultural view of Deaf identity can be distinctly different from those operating under a physiological model. While there is not a single such view for the former, many would involve signing in the musical encounter, and the notion that a deaf musical perspective is unique aspect of Deaf culture, and one methodologically distinct from mainstream practices.

2.6 MUSIC AS A WHOLE-BODY, CROSSMODAL AND INTERSUBJECTIVE PROCESS

It is commonly believed that deaf individuals cannot experience music. The previous section provides clear evidence that deafness is not an all or none condition, but one that comprises a broad range of degrees, configurations and types. Many deaf individuals in fact have a degree of hearing, with or without an ALD, making the notion that they are wholly incapable of appreciating music invalid from an auditory point of view alone. This section will address the fact that music is in any case not limited to hearing, but is a whole-body, crossmodal and intersubjective experience; a reality which makes the deaf experience of music entirely plausible.

2.6.1 MUSIC AS A WHOLE-BODY PROCESS

Music perception is fundamentally a physical act, involving the coordinated 'performance' of many areas of the human body in interaction with its environment (Dufrenne, 1989; Gibson, 1979). Cognitivist approaches to musicology, based on a Cartesian mind/body dualism, have long viewed the body as merely a receiver of musical stimuli and the mind as a processor of that stimuli. Cognitive functions and musical phenomena (structure, harmony, melody, timbre) were the interdependent foci of this dominant research paradigm, with the bodily act of perception being largely overlooked in terms of shaping experience (Laske,1989; Merleau-Ponty,1989). Embodied music cognition research in the early 21st century, based on embodied cognitive science developments in the late 20th century, argued instead for the body's primacy in musical experience on the basis that human bodies actively participate in the musical events rather than serving as passive conduits for stimuli (Clarke, 2005).

This body-based point of view can be traced back to pragmatist philosophy of the late 19th century. John Dewey posits an active, embodied approach to vision in his essay *The Reflex Arc Concept in Psychology*:

> The real beginning is with the act of seeing, it is the looking, and not the sensation of light . . . an integrated view of the relation between organism and environment. Organisms act to alter their own stimuli. (Dewey, 1896, pp. 358-359)

Merleau-Ponty pursues such an active, embodied view using a phenomenological method, focussing on modal perception as an act of interpretation rather than a mere transmission of sensory data between environment and cognitive structures (Merleau-Ponty, 1945). He argues that the foundation of perceptual experience is the gestalt – the meaningful whole of figure against ground - and explores how an attentiveness and organisational approach to the world through physical acts of perception are decisive in a comprehension of it (Toadvine, 2016; see also Talmy, 1996 and Leeson and Saeed, 2007). Merleau-Ponty explores a kinaesthetic awareness based on a preconscious system of bodily movement and spatial equivalence, which he terms 'body schema' (Merleau-Ponty, 1945, p. 100). Following on from Dewey, Merleau-Ponty's concept of body schema does not present an organism as a passive subject positioned in Cartesian space, but as one situated spatially and oriented specifically towards actual or possible tasks.

J.J. Gibson takes this thinking a step further by describing such task-based bodily directedness in terms of 'affordances' of the environment, or 'what it offers the animal, what it provides or furnishes for good or ill' (Gibson, 1979, p. 127). In *The Ecological Approach to Visual Perception* Gibson specifically analyses the nature of these affordances in terms of visual perception, and in doing so demonstrates that visual perception is in truth a whole-body performance in an environmental context.

> We are told that vision depends on the eye, which is connected to the brain. I shall suggest that natural vision depends on the eyes in the head on a body supported by the ground, the brain being only the central organ of a complete visual system.
>
> When no constraints are put on the visual system, we look around, walk up to something interesting and move around it so as to see it from all sides, and go from one vista to another. That is natural vision . . . (Gibson, 1979, p. 1)

While Gibson concentrates on visual perception in his book, this ecological approach equally applies to other modalities, as all the senses and bodily structures co-operate in order to interpret the environment rather than operating as independent modules. Mark Johnson expands upon such ideas by proposing a model for bodily-based meaning, developing a dedicated hypothesis for the body's interactions with the world and the cognitive structures resulting from such interactions (Johnson, 1987). Johnson argues against a rationalist, linguaform and propositional approach to meaning, suggesting instead that cognitive metaphors based on the body's engagement with the world, preconscious embodied image schemata, are responsible for human meaning-making. As Johnson observes in *The Meaning of the Body*:

> . . . meaning is not just what is consciously entertained in acts of feeling and thought; instead, meaning reaches deep down into our corporeal encounter with our environment. (Johnson, 2007, p. 25)

Zbikowski and others more recently have applied this embodied schematic approach to music, arguing that it is at the level of the conceptual metaphor that musical meaning is established (Zbikowski, 2002). Thus, human cognition derives concepts from patterns of bodily interaction with the world, and uses these concepts metaphorically as a basis for all other meaning including music. Cox gives further examples of such conceptual metaphors by exploring, for example, how we relate pitch in a seemingly arbitrary fashion to verticality; when pitch itself is does not possess such linear spatiality (Cox, 1999).

It is worth noting that while Cox and Zbikowski base their theories on an embodied view of the world, their chosen scope for the study of musical experience is arguably not whole-body, and to a certain extent maintains an audio-centric notion of music. For one, their analyses concentrate on the sonic content of musical scores rather than the concomitant gestural and sensorimotor aspects of a score's performance. This is not to blame the groundbreaking scholarship of either Zbikowski or Cox for failing to treat music as a whole-body phenomenon, but to identify the difficulties inherent in any such an attempt. In truth, such a multimodal analysis of music is problematic owing to a number of linguistically limiting factors which Chapter 3 addresses.

Visuospatiality, Kinesthetics and Musical Gesture

Music rots when it gets too far from the dance. (Pound, 1934)

In modern times physical movement associated with music is commonly addressed as dance, and is treated most often as a separate discipline. In the experience of this researcher working in many multidisciplinary performance settings, musicians are rarely considered to be knowledgeable about movement, and dancers are not usually credited with a musical expertise. This is strange, for the simple fact that musicians must move and dancers must function in a musical context. It is not necessary to establish whether a musician's movements, either as a direct or secondary function of performance, can or cannot be classified as dance; they are undeniably music-related movements. Similarly, there are of course numerous examples of dancers moving in silence, but arguably there is a persistent rhythm – or, at the very least, a temporal pattern which constitutes a quasi-rhythm – that tacitly remains situated in the dancer's movements even in the absence of music *per se*. Curiously, dancers more than ever become their own musicians in such a case, as they provide an inner rhythmic structure for their own movements.

While there is insufficient scholarship in this area, perhaps it can be hypothesised that the real issue with musicians not being identified as movers, and dancers not being identified as being musical has to do with self-awareness, or lack of it. Musicians generally see themselves as concentrating on sound production, and not the movement required for it. There are exceptions to this, of course: e.g., singers who dance or move to choreography, or musicians who incorporate movement into an ensemble act to name but two. It can be argued, however, that musicians in the western tradition (music from the past classical repertoire, contemporary classical, jazz) generally do not develop a working consciousness as *movers*. Conversely, dancers see themselves as concentrating on movement and not the music which it accompanies, is accompanied by or which informs it. This convention is faulty in its approach for both musicians and dancers. There simply is no sound production without movement. A musician, therefore, first concentrates on movement, of which sound production is a product. A dancer, meanwhile, can only move in sequence (even a single flowing movement is bordered by a stationary beginning and end to the dance) and has no choice but to think of the movements as patterns in a temporal framework; which is the essence of rhythm. In a sense, a dancer does not simply dance to music, the dancer dances his or her own music, entraining to the external accompaniment if it is present. To borrow a phrase from Maxine Sheets-Johnstone, both musicians and dancers 'think in movement', even if each artist may consciously view these movements more as an expression of either musical or spatial exploration (Sheets-Johnstone, 2009, p.30). While it is the choice of each practitioner, musician or dancer, to address or not address the duality of their discipline's conventions, it can be argued that this constitutes a common blind-spot in musical and dance practice. Moreover, the lack of self-awareness of the body's ecological interplay in the musical experience lies at the foundation of the belief that music is for the hearing alone.

Emile Jaques-Dalcroze's notion of eurhythmics cannot go unmentioned here. Dalcroze wished, through a new approach to music education, to fuse the sensory and intellectual phenomena of music into one neuromuscular experience (Frego, 2009). Mead cites 4 premises which characterise Dalcroze's eurhythmics:

> 1) Eurythmics awakens the physical, aural and visual images of music in the mind.
>
> 2) Solfège (sight-singing and ear-training), improvisation and purposeful movement together work to improve expressive musicality and enhance intellectual understanding.
>
> 3) Music may be experienced through speech, gesture and movement. These can likewise be experienced in time, space and energy.
>
> 4) Humans learn best when learning through multiple senses. Music should be taught through the tactile, the kinaesthetic, the aural and the visual senses.
> (Mead, 1994)

Dalcroze's ideas were revolutionary in terms of Western performing arts practice, and found their way into theories of dramatic technique through Konstantin Stanislavski and dance through the work of Rudolf von Laban. From a compositional perspective, this thesis has much in common with Dalcroze's pedagogical approach: to promote a whole-body, active take on musical experience.

Recent scholarship into musical gesture has made an attempt to address the disconnect between audible music and visuospatial music. This area of scholarship is vast, and includes parallel research into language on the importance of gesture as co-speech (see Dick *et al*., 2010). In certain instances, however, discussions on gesture can confuse as much as they can elucidate; much of it getting bogged down by complexities of nomenclature. For example, Jensenius *et al.* spend as much time providing contradictory notions of musical gesture and explaining why gesture is a better word than movement for physical actions (e.g., the former blurs the distinction between movement and meaning) as they do applying meaningful analysis to physical actions themselves (Jensenius *et al.*, 2010). A good example is in the following passage:

> Musical gestures – that is, human body movement that goes along with sounding music – can be divided into two main categories: the gestures of those that produce the sounds (the musicians), and the gestures of those that perceive the sounds (the listeners or dancers). Obviously, the musicians also listen to musical sounds, but their role is nevertheless somewhat more specific in that they are involved in the creation of sounds, whereas listeners or dancers respond to these sounds. When dancers are connected to a computer system that produces music based on features of the dance movements, then dancers also can be considered musicians because they generate sounds. (Jensenius *et al.*, 2010, p. 13)

This passage presents a fundamental contradiction by dividing those who create musical gestures into two categories: musicians and listeners/dancers. It could be argued that anyone who enacts a musical gesture – if it is to be taken in its broadest sense - is also, by tautology, a musician. In any case, is it true that dancers only generate sounds when they are connected to computers? No dancer operates in silence, and many, such as tap dancers, make sound a vital component of performance. The study goes on to make increasingly confusing subcategories of each of these initial categories; e.g., for musicians, ‘sound producing, communicative, ancillary or sound facilitating, and sound accompanying’. (Jensenius *et al.*, 2010, p. 13)

The benefit of such lexical systems is worthy of debate. In its defence, hearkening back to the earlier discussion of Zbikowski and Cox, language itself often seems to be at odds with an attempt to bring gesture into the musical fold. Fulford *et al.* (2015) speaks about the communicative aspects of gesture in musical practice, averring that gesture ‘exists within a wider context of non-verbal communication, outside that of musical performance’ (p. 22). Although Fulford continues with a highly capable taxonomy of such gestures, this statement begs a few questions. First, to limit gesture to a category of non-verbal communication ignores the fact that speech itself is widely regarded as an ‘articulatory gesture’ by speech and phonology researchers (Browman & Goldstein, 1989, p. 69). While much of the research investigates less visible aspects of speech gestures (e.g., constriction actions produced in the vocal tract), it is clear that lip movement is not only vital for deaf individuals, but also for hearing individuals in noisy environments (Mitra *et al.,* 2012; Blank & von Kriegstein, 2013). Second, if music is indeed a form of communication as it has so often been stated, why should communicative gestures involved in the creation of music be separated from the music itself? Surely the entire process is a flow of communication from performer to performer, to audience and back. Once again, this is not to assault the scholarship of Fulford, which is invaluable in its assessment of interactive performance for deaf musicians. Instead, the shortcomings of language with regard to multisensory processes must be underlined if meaningful analysis is to be achieved. Fulford, Zbikowski, Cox and this researcher all face a similar challenge of applying a unimodal language paradigm to a multimodal experiential reality. Chapter 3 of this thesis addresses the issue of language around what is generally considered music (sound) and what is generally thought of as being extra-musical (gesture and touch).

Tactition in Music

It is easier to argue for the place of tactition in the musical experience than that of musical gesture. Most people acknowledge that physical vibration is fundamental to music, whether transferred in the air to become sound in the inner ear or sent through solids to be sensed as tactile vibration through the skin. Nevertheless, the latter is generally overlooked in any serious analysis of music. It has been demonstrated, both in the course of this research and elsewhere, that human bodies are far more sensitive to tactile vibrations than many people ever get the chance to appreciate (Celen, 2008; Glennie, 2011). Existing research often centres around technologies that serve as aids to performance, whether to enhance entrainment or note perception. A study by Hopkins *et al.* represents significant steps towards identifying ranges of vibrotactile sensitivity to pitch for both hearing and hard of hearing subjects (Hopkins *et al*., 2016). The study exposes subjects from both groups to sinusoids through the fingertip, forefoot and heel. While conclusions are reached regarding the ranges of pure tone vibrotactile sensitivity, many questions are raised methodologically, including how complex tones might fare in the same setting, how exposure to other parts of the body (see quotes from Signmark and Glennie below) would expand or reduce vibrotactile awareness and finally how such a restricted clinical context either extends or limits vibrotactile awareness as compared with an actual performance setting.

While scholarship is still lacking in this area, subjective accounts strongly suggest that different parts of the body have distinct sensitivities to different frequencies. The Finnish deaf rapper, Signmark, imparts his experience of vibrations on his body when he ‘listens’ to music:

> I can feel it [the music] here in my gut, my palms, my fingertips, the tips of my ears. Very low and long sounds go to the fingertips. Fast and sharp beats I only feel in my

> belly. Low frequencies push all the way from my arms to my fingertips. You have to experience it yourself; so cover your ears! (Celen, 2008)

This account offers a very different notion of pitch to the vertical concept analysed by Cox (Cox, 1999). By Signmark's reckoning, the body can perhaps be related to a three-dimensional map of pitch phenomena, or even a polymorphous analogue to the basilar membrane. Such a concept is paralleled by Branje *et al.* in their paper, *Vibrotactile Display of Music on the Human Back* (Branje *et al.,* 2010). In this study, vibrotactile musical stimuli was mapped onto an 'artificially deafened' subject's back, in an arrangement based on the model human cochlea. The findings suggest that 'vibrotactile information can be used to support the experience of music even in the absence of sound' (Branje *et al.,* 2010, p. 1). It is often assumed that enhanced tactile awareness of pitch is limited to deaf indiviuals. While some studies point to cortical plasticity being responsible for a deaf person's sensitivity to vibrations, other research posits that such an awareness can be increased by a conscious shift in attention (Neville *et al.,* 1983; Higgs, 2017). It is not unreasonable to surmise that the frequency dependent sensitivity of different parts of the body could potentially play an important role in not only musical understanding, but also general human comprehension of the environment. As Evelyn Glennie puts it:

> If we can all feel low frequency vibrations why can't we feel higher vibrations? It is my belief that we can, it's just that as the frequency gets higher and our ears become more efficient they drown out the more subtle sense of 'feeling' the vibrations. I spent a lot of time in my youth (with the help of my school percussion teacher Ron Forbes) refining my ability to detect vibrations. I would stand with my hands against the classroom wall while Ron played notes on the timpani (timpani produce a lot of vibrations). Eventually I managed to distinguish the rough pitch of notes by associating where on my body I felt the sound with the sense of perfect pitch I had before losing my hearing. The low sounds I feel mainly in my legs and feet and high sounds might be particular places on my face, neck and chest. (Glennie, 2015)

It is interesting to contrast Signmark and Glennie's differing morphological pitch awareness. This could possibly be accounted for by the physical differences between the two musicians. It is more likely, however, that Glennie and Signmark have markedly different notions of what constitutes a 'low' sound, a 'high' sound, a 'long' sound, a 'sharp' sound, or a 'fast' sound. Signmark was prelingually deaf. Glennie was not only post-lingually deaf, but she had also trained as a musician (with perfect pitch) before going deaf; allowing her to take on a hearing concept of pitch. It is first of all very hard to know how someone who is pre-lingually deaf (e.g., Signmark) will comprehend vibrations using language. Secondly, the language Signmark uses is Finnish Sign Language rather than speech, while Glennie uses English, rather than British Sign Language, to communicate. Any account of sound involves not only the description of a sonic experience, but the interpretation of that description. Many questions arise, particularly in the case of Signmark. How does a deaf individual translate sonic experience into signs? How does a translator choose to interpret what is signed, first into Finnish and then into English? There is clearly an inherent linguistic issue in any investigation in this direction, as it is probable that attempts at reliable accounts for either the deaf or hearing experience could become lost in translation.

Virtual Reality and the Future

Study of haptic and visual interaction for sound and music is of great interest to current research and development into virtual reality (VR). Gaming systems have long included bass shaker speakers as an optional component to enhance the sense of tactile verisimilitude. Biocca *et al.* investigate how crossmodal techniques can generate a sense of presence in a VR environment (Biocca *et al.,* 2006). Interestingly, the reverse methodology can be equally instructive; i.e., using VR techniques to explore crossmodal effects. Harjunen *et al.* used VR headsets to study how visual clues of a subject's body affect their visuotactile interaction in endogenous spatial attention, and when the effect takes place (Harjunen *et al.,* 2017). It is certain that the development of VR will both benefit from and contribute to research into multimodal perception. This clearly could be of interest to both deaf individuals interested in enhancing their music experience, as well as hearing individuals.

2.6.2 MUSIC AS A CROSSMODAL EXPERIENCE

Experience of music, as with all phenomena, is not only whole-body and multimodal (experienced through more than one sensory modality; e.g., hearing, sight, touch, etc.), it is more importantly crossmodal, multiple senses collaborating at both the peripheral and central level (Berthoz, 2000; Stein and Meredith, 1993; Shimojo & Shams, 2001). Such a premise is vital to this thesis as it allows not only for extra-auditory access to music in the case of deaf individuals, but also the use of auditory cortical networks for other senses in deaf individuals by means of neural plasticity (Shibata, 2007). The percussionist Evelyn Glennie presents the following phenomenological account in her *Hearing Essay*:

> Hearing is basically a specialized form of touch. Sound is simply vibrating air which the ear picks up and converts to electrical signals, which are then interpreted by the brain. The sense of hearing is not the only sense that can do this, touch can do this too.

> If you are standing by the road and a large truck goes by, do you hear or feel the vibration? The answer is both. With very low frequency vibration the ear starts becoming inefficient and the rest of the body's sense of touch starts to take over. For some reason we tend to make a distinction between hearing a sound and feeling a vibration, in reality they are the same thing. It is interesting to note that in the Italian language this distinction does not exist. The verb 'sentire' means to hear and the same verb in the reflexive form 'sentiri' means to feel. Deafness does not mean that you can't hear, only that there is something wrong with the ears. Even someone who is totally deaf can still hear/feel sounds (Glennie, 2015, webpage).

Research interest in crossmodality is clearly on the rise, as indicated by the creation of the International Multisensory Research Forum which, established in 1998, increased its membership by 80 times in its first ten years of existence[3]. The impact is felt beyond biological studies, as engineers and programmers use such notions to guide sensor research and robotics, as well as the aforementioned VR studies. This is a fairly radical change from the unisensory paradigm of the early years of perception research. It was not until the late 1990s that this emerging discipline gathered its critical mass, and the concept would still today seem counter-intuitive to most individuals. As Calvert *et al.* puts it:

> . . . it is interesting to note that with the specialization of modern research and the tendency to focus on the fundamental properties of individual senses, an early perspective was set aside, namely, that perception is fundamentally a multisensory phenomenon. There can be no doubt that our senses are designed to function in concert and that our brains are organized to use the information they derive from their various sensory channels cooperatively in order to enhance the probability that objects and events will be detected rapidly, identified correctly, and responded to appropriately. Thus, even those experiences that at first may appear to be modality-specific are most likely to have been influenced by activity in other sensory modalities, despite our lack of awareness of such interactions. Indeed, mounting evidence now suggests that we are rarely aware of the full extent of these multisensory contributions to our perception. (Calvert *et al.*, 2004, p. xi)

[3] The terms multimodal, crossmodal and multisensory can be confusing. This thesis uses multimodal to mean more than one modality, and crossmodal to mean where data from modalities are merged at a neuronal level. Calvert *et al.* uses the term multisensory, but many contributors to the *Multisensory Handbook* also use crossmodal.

The crossmodal nature of perception has been established by a number of neuroscientific studies of illusions induced by contradictory stimuli between modalities. Well-known early studies, such as the ventriloquist effect and visual capture, show vision to dominate over other modalities (Calvert *et al.*, 2004). The ventriloquist effect involves the conflict between spatial location of a visual and auditory stimulus, with the perceived location determined by the visual stimulus (Howard & Templeton, 1966). Visual capture involves a visual/proprioceptive conflict: the location of a subject's hand being visually displaced when viewed through a wedge prism. The perceived location is determined in such a case by the visual information, even for a period of time after the eyes have been covered. In other cases, visual information does not entirely dominate, yet influences the percept in a separate modality. One example is the McGurk effect, where visual information provided by a video of someone's lips enunciating a phoneme is in conflict with the phoneme that is heard in the audio track. In such a case the visual information modifies the auditory information (McGurk & MacDonald, 1976). Rather than this being a simple cognitive compromise between what is seen and heard, it has been argued that the visible utterance actually changes what the listener experiences hearing (Liberman, 1982; Summerfield, 1987). An example of nonspeech visual modification of auditory perception occurs with musical note perception in what is sometimes called the *pluck and bow study*; where visual information of a musician plucking or bowing a cello conflicts with varying auditory permutations of the same. In this case, the former repeatedly influences the later (Saldaña & Roseblum, 1993).

The primacy of vision in crossmodal studies – i.e., that it is generally dominant in multisensory conflict - was countered by a number of significant experiments in the early 21st century. In the often cited sound induced flash illusion, subjects perceived two flashes of light when exposed to only one flash in the presence of two beeps (Shams, Kamitani, & Shimojo, 2000). A parallel of this illusion was reported by Hötting and Röder, where auditory stimuli altered the perception of tactile stimuli (Hötting & Röder, 2004). The touch-induced visual illusion showed that tactile information could influence visual perception of the number of flashes in the same way that auditory information had (Violentyev, Shimojo & Shams, 2005). Specifically, observers reported seeing two flashes when a single flash was presented simultaneously with two, brief tactile stimuli. As the abstract states, '. . . these results challenge the notion that the processing of visual information is independent of activity in other modalities.' (Violentyev *et al.*, 2005, p. 1107).

Interesting three-way crossmodal experiments have been carried out using the Tadoma method of speech reading, where deaf (as well as deaf-blind) individuals watch the speaker's lips as well as feel the tactile vibrations by resting their hand on the speaker's shoulder and clavicle (Campbell & MacSweeney, 2004). Seen speech seems to combine readily with vibrotactile information, so that tacto-visual illusions similar to the McGurk effect have been generated for hearing listeners using the Tadoma method (Fowler & Deckle, 1991). Chomsky (1986) does extensive analysis of this method on 3 adult deafblind participants who use the face rather than the clavicle for vibrotactile communication. These participants are examples of deafblind individuals who have used the Tadoma method from an early age and reported it to be a highly effective method of communication (Chomsky, 1986).

Charles Spence and his Oxford Crossmodal Laboratory recently published a study, which gained considerable public attention, examining the influence that music has on taste (Wang *et al.,* 2017). The study comprises two preliminary stages: assessing what parameters matched spiciness and the composition of a spicy soundtrack. It is concluded that those listening to the soundtrack report higher spiciness than those not listening to the soundtrack, and higher spiciness than is actually present. The study also concludes that the 'mechanism behind spiciness enhancement is likely due to induced expectations' (Wang *et al.*, 2017). Spence's lab is thus drawing significant attention to the fact that our expectations are highly active in our perception.

Moving beyond the study of perceptual illusions induced by crossmodal conflict or reinforcement, studies by Kohler *et al.* (2002) on monkeys identify mirror neurons which discharge both when the animals perform a specific action and when they hear the related sound. Furthermore, these neurons also fire when the monkey performs the same action. While perfectly analogous mirror neurons have yet to be identified in humans, it is accepted that these studies were carried out in the monkey homologue of the human Broca's area. Furthermore, recent research has demonstrated a human mechanism directly mapping action perception and execution, defined as the Mirror Mechanism (Gallese & Cuccio, 2015). This neuronal nexus for modalities has a crucial bearing on the crossmodal harmonic technique presented in Chapter 4 of this thesis. The technique takes gestural activity as its starting point. Thus, studies in mirror neurons which link the performance of sound-producing actions, the auditory experience of such actions as well as the visual observations of the same provide a clinical basis for such work. These mirror neurons are further discussed as a factor of embodied simulation (ES) in the next section, which concerns the intersubjective nature of the musical experience.

A great deal of work has been undertaken in crossmodal plasticity in the sensory cortices of both animals and humans. Studies with ferrets have shown that removal of the superior colliculus or depriving the medial geniculate of its major input pathways (auditory and somatosensory) can cause visual responses to be triggered from those neurons in the auditory or somatosensory cortex (Sur *et al*., 1990). That is to say that retinal stimulation of these rewired animals triggers neuronal activity in those areas of the cortex normally devoted to auditory and somatosensory processes. Similar plasticity has also been reported in humans deprived of senses in early life. Typically, such studies report that sensory deprivation in one modality early in a subject's life causes the area of the cortex normally devoted to the deprived modality to be rewired to another (Shibata, 2007; Neville *et al.,* 1983). Specifically, research has suggested that the neurons in the auditory cortex of deaf individuals is re-appropriated for vibrotactile and visual stimuli (Shibata, 2007).

Another research trend has been towards what might be termed multisensory scene analysis. This follows on from Albert Bregman's pioneering work on auditory scene analysis, which employed gestalt principles to analyse how human cognition makes sense of the auditory scene (Bregman, 1990). Prior to Bregman's work, these gestalt principles had originally been applied famously to visual phenomena, often employing visual paradoxes to demonstrate the selective perception of figure and ground; e.g., duck/rabbit paradox, young/old woman paradox, vase/two heads paradox (Metzger, 2006). Recent scholarship has brought such a scene analysis method to embrace multiple senses. What is interesting is how this research makes a clinical approach to what for Dewey and Gibson was a distanced philosophical observation of experience. The following excerpt gives a sense of this:

> When listening to a sound of interest, we frequently look at the source. However, how auditory and visual information are integrated to form a coherent perceptual object is unknown. The temporal properties of a visual stimulus can be exploited to detect correspondence between auditory and visual streams (Crosse *et al*., 2015; *Denison et al*., 2015; Rahne *et al*., 2008), can bias the perceptual organisation of a sound scene (Brosch *et al*., 2015), and can enhance or impair listening performance depending on whether the visual stimulus is temporally coherent with a target or distractor sound stream (Maddox *et al*., 2015). Together, these behavioural results suggest that temporal coherence between auditory and visual stimuli can promote binding of crossmodal features to enable the formation of an auditory-visual (AV) object (Bizley *et al*., 2016).
> (Atiglan *et al*., 2017, p.1)

In a review of current work in multisensory scene analysis, Kondo *et al*. draw attention to a recent change in approach to such research. This change involves moving from a bottom-up technique, where focus goes from low-level to high level sensory and cognitive structures, to a top-down approach. This top-down approach recognises that sensory processes are not unidirectional. As Kondo *et al*. explain:

> We perceive the world as stable and composed of discrete objects even though auditory and visual inputs are often ambiguous owing to spatial and temporal occluders and changes in the conditions of observation. This raises important questions regarding where and how 'scene analysis' is performed in the brain. Recent advances from both auditory and visual research suggest that the brain does not simply process the incoming scene properties. Rather, top-down processes such as attention, expectations and prior knowledge facilitate scene perception. Thus, scene analysis is linked not only with the extraction of stimulus features and formation and selection of perceptual objects, but

> also with selective attention, perceptual binding and awareness. (Kondo *et al*., 2017, p.1)

Crossmodal research has been carried out extensively with infants. Studies by Meltzoff and Borton show that neonates have an inborn ability to perceive a single pattern present in two or more modalities (Meltzoff & Borton, 1979). Citing such research, Stern has developed a psychoanalytic approach to perceived crossmodal patterns that he calls the vitality-affect contour (Stern, 1985). Unlike classic emotions such as fear, joy, anger and surprise, vitality-affect contour involves experiential patterns of flow and development, better described as 'surging, fading-away, fleeting, explosive, crescendo, decrescendo, bursting, drawn out, and so on' (Stern, 1985, p 54). Such patterns are shared, argues Stern, by many modalities, and are crucial for music (which is based on bodily experiences of time), but can be applied to texture, colour, taste, etc. Stern gives numerous examples of such vitality-affect contours, but one involves a mother cooing 'there, there' while stroking her baby's head with a caress dynamic that is analogous to the falling away of the 'th' in the soothing words. The baby experiences the same contour between the heard language and the tactile caress; not to mention the tactile vibrations of the words spoken against its cheek.

2.6.3 MUSIC AS AN INTERSUBJECTIVE PROCESS

The musical experience is invariably intersubjective, which is to say it involves sensorineural engagement, either real or imagined, with other human beings. This is true whether music is experienced in the company of other people or alone (Trevarthen, 1993; Rizzolatti & Gentilucci 1998; Stern, 1985). It has been convincingly argued that such intersubjective relationships established during human development, along with concomitant subjective bodily movements, lie at the heart of all human meaning making. Johnson cites considerable research on infant studies, indicating that embodied, intersubjective image schema for meaning are preconscious, and presuppose all other meaning: linguistic, musical or otherwise (Johnson, 1987). Meltzoff and Moore have documented the ability of neonates less than one-hour old to imitate gestures of those around them (Meltzoff & Moore, 1983/1989). Trevarthen goes on to say that 'The core of every human consciousness appears to be an immediate, unrational, unverbalized, conceptless, totally atheoretical potential for rapport of the self with another's mind' (Trevarthen, 1993, p. 121). Thus a whole system of preconscious meanings is established via bodily movements in relation to the self and bodily movements in relation to others.

As Trevarthen emphasises, neonates do not interact with an environment in their creation of meaning due to circumstance alone, but are specifically wired to interact with other humans to this end:

> . . . newborns act in expressive ways that appear to be peculiarly human and highly sensitive to human presence. Most impressively, an alert newborn can draw a sympathetic adult into synchronized negotiations of arbitrary action, which can develop in coming weeks and months into a mastery of the rituals and symbols of a germinal culture, long before any words are learned. In short, a human being is born capable of seeking and playing with others' attentions and feelings in a rich variety of provocative, humorous and teasing ways (Reddy, 2008). Infants, it appears, are born with motives and emotions for actions that sustain human intersubjectivity. (Trevarthen, 2010, p. 132).

From a neuroscientific perspective, the study of embodied simulation (ES) provides valuable insights into the role of human intersubjectivity. Recent work on motor cognition (the premotor cortical areas mapping tactile, auditory and visual events) and mirror neurons (neurons which fire when performing an action, observing the same action performed by others, and hearing a sound produced by the same action) has caused certain researchers in ES to suggest a shift from a neuronal focus to a broader perspective; one that is not only whole-body, but fundamentally intersubjective (Gallese & Cuccio, 2015; Uithol & Gallese, 2015). In their paper *The Role of the Body in Social Cognition*, Uithol and Gallese draw attention to the Husserlian notion of the *Leib*, 'the lived body entertaining experiences of self and others', and the *Körper*, 'the somatic object of investigation in bio-medical sciences' (Uithol & Gallese, 2015, p. 457). The paper observes, 'Although the physical body – *Körper* – is essentially individual, belonging to a single cognitive system, the world of phenomenal experience – the *Leib* – is thoroughly social, producing a self that is social and embodied' (Uithol & Gallese, 2015, p. 457).

> . . . ES is the primary and earliest mechanism contributing to the foundation of the sense of self and others. That said, in conclusion, we would like to stress again the issue of the cognitive role ES has in relation to language. On the one hand, empirical evidence has shown the role ES plays in language comprehension. These data (for an overview see Gallese & Cuccio, 2015, p. 13) suggest that the bodily, sensory, and motor dimensions play a constitutive role in language, both ontogenetically and phylogenetically . . . Words or other forms of symbolic representations such as art, for example, allow us to activate and relive our bodily experiences. In this way, by means of symbolic representations, we can share our bodily experiences, enacted by ES, even with people far away from us in time and space. As argued in our paper, ES is a model of our own experiences and its defining features are best explained by resorting to the

> Aristotelian notion of *paradeigma*. ES as *paradeigma* (and not just as motor resonance) provides a neurobiologically-based new perspective on human social cognition and ultimately on the very definition of human nature.
>
> (Gallese, 2014, p. 4)

In his paper *Embodying Music; Principles of the Mimetic Hypothesis* Arnie Cox speaks of ES, which he refers to as Mimetic Motor Imagery (MMI), as being either overt or covert (Cox, 2011). As the name suggests, overt imagery consists of conspicuous displays of imitation: foot-tapping or even air-guitar. Covert imagery is not manifested outwardly, but exists in a very real way in our cognitive representations of these embodied schematic images. Cox points out that all levels of cognition correspond to representations in the perceiver, which in turn are necessarily 'embodiments, or bodily states' (Cox, 2011, p.4). The most common of these bodily states to be accounted for is neural activity, but Cox argues that there are many other bodily systems involved in this mimetic bodily dynamics: blood chemistry, skeletal-motor systems, etc. As Cox writes:

> When we overtly imitate someone or something, we represent the observed behaviour in our own skeletal-motor system and in associated neural activity and blood chemistry. When we covertly imitate someone or something (in MMI), we represent the observed behaviour in roughly the same way, except that the executions of the motor actions are inhibited, and the changes in other systems are attenuated.
>
> (Cox, 2011,p.4)

While an individual is unware of intersubjective realities at the level of *Körper*, some cultivate a much higher awareness at the level of *Leib*. It has been shown that entrainment, which refers to musicians keeping time with each other, shows synchronisation patterns with the behaviour of mirror neurons (Molnar-Szakacs & Overy, 2006). These intersubjective crossmodal mechanisms may remain hidden, but they give a much richer notion of how timing and musical gestures in general are shared in performance. This profound, imitative behaviour is explained eloquently, albeit from a slightly different perspective, by Christine Sun Kim, a profoundly deaf visual and musical artist. She described her way of watching others response to sound in her 2015 TED Talk:

> So how is it that I understand sound? Well I watch how people behave and respond to sound. You people are like my loudspeakers and amplify my sound. I learn and mirror that behaviour. At the same time, I've learned that I create sound, and I've seen how people respond to me. Thus, I've learned for example, "Don't slam the door!" and

"Don't make too much noise when you're eating!" (Kim, 2015)

2.7 MUSIC BY AND FOR DEAF INDIVIDUALS

2.7.1 DEAF ENGAGEMENT WITH MUSIC IN EDUCATIONAL SETTINGS

Music has been used in the Irish Deaf schools for at least 100 years. In St Mary's School for Deaf Girls, the Dominican nuns taught students to play wind instruments to promote steady breathing for speech acquisition (Quinn, 1963). Elegant wooden blow organs dating from the early 20th century can still be seen in the school museum; and plastic melodicas remain in use today. As referred to in Section 2.1.2.1 of this chapter, such musical training had unfortunate associations with the introduction of an oral education that came hand in hand with the suppression of ISL.

Philip Hash gives accounts of far less audist instances of music in schools for deaf individuals in the US. He reports on a number of extraordinary musical projects, speaking for one of Fred Fancher, a deaf bandmaster, leading a large ensemble of deaf musicians from the Illinois School for the Deaf between 1923 and 1942 on celebrated tours around the USA (Hash, 2003). Work of this kind continues to the present day in the US, an example being a singing choir in the Iowa School for the Deaf, which can be extolled for making 'no particular point of the singer's deafness', instead continually seeking 'new goals and new challenges' (Whittaker, 1986). In the UK, the Mary Hare School for the Deaf has had a music programme since the late 1970s. Between 1981 and 2001, pupils passed over 300 ABRSM examinations (Fawkes and Ratnannather, 2009; Fulford, 2015).

The many examples of music in deaf educational settings in the UK, US and Ireland, perhaps contrast with the relative lack of opportunities for deaf participation in music beyond secondary level education. Paul Whittaker, the UK deaf musician who founded Music for the Deaf UK in 1988, emphasises in his 1986 Oxford thesis *Music Potential for the Profoundly Deaf*, that the existing literature for deaf engagement with music at the time was overwhelmingly pedagogical in nature, rather than performance based (Whittaker, 1986). While there has been an increase in deaf engagement outside a school curriculum in the thirty years since (see below), it seems to still be the case that deaf engagement with music is dominated by work in schools. Whittaker gives a comprehensive review of the literature for music in deaf education up to 1986 both in the UK and North America. There continues to be a profusion of studies on the methods and benefits of musical engagement for deaf individuals, particularly at the level of primary and secondary school. In the UK, the NDCS (National Deaf Children's Society) and The UK Association for Music Education have collaborated on research to provide guidelines to both mainstream and deaf educational institutions for engaging deaf students musically (NDCS, 2017).

Fulford expresses the need to distinguish between deaf music education and music therapy, while noting that the two often overlap in sometimes unfortunate ways (Fulford, 2015). Whittaker identifies proponents of the former as those who see music as an end in itself, while the latter would primarily view the benefits for participants in terms of speech acquisition, socialisation and cognitive development. Whittaker cites Lois Birkenshaw's statement, now almost infamous, that 'it must always be remembered that music is used primarily as a means to an end [in deaf education]. The prime goal is not to attain musical perfection, but to improve skills such as auditory training and speech through the means of music' (Birkenshaw, 1965, p. 222). This philosophy, while by no means universally held, is widely employed in deaf educational circles (Whittaker, 1986). It is easy to see how proponents of a socio-cultural sense of deaf identity would be riled by such an approach. It underscores their argument that audism is alive and well, in the sense that music, rather than being an art form available to deaf people, is merely a normalising strategy. There is the real danger that such an approach disenfranchises deaf musicians from genuine musical participation by presenting music as a mere utility for speech acquisition. Thus, Fulford's implication that deaf music education can become remedial music therapy is clearly made here. Paul Whittaker's work through Music for the Deaf UK has done much to counter this tendency by providing genuine training for deaf youth orchestras, seeking to encourage the talent that has been shown to exist in the cases of people like Evelyn Glennie and Ruth Montgomery.

2.7.2 SIGNING CHOIRS IN THE DEAF COMMUNITY

At present, arguably the most popular way for the Deaf community to engage in music is through the signing choir; a group of people who sign the lyrics to a song while it is played over loudspeakers or by a live ensemble. Most often, a hearing conductor, well-versed in sign language, cues the ensemble in and out, signing along with them. Song signing seems to have originated sometime in the early twentieth-century as a face to face Deaf community art form, involving mostly hymn interpretation in a religious setting (Bahan, 2006). The 21st century, however, brought technological changes which catapulted song signing to a new level. Easy access to video technology and video sharing web sites have provided unexpected musical inroads for deaf people. Before the radical democratisation of video through cheap cameras and smartphones, deaf individuals were largely cut off from music technology because it primarily catered for an auditory experience (Maler, 2015). With the modern ease of sharing visual interpretations of music, the Deaf community has something unique to contribute by virtue of their signing culture. In Ireland, signing choirs have gained considerable attention in recent years, with some performing at high-profile events[4].

[4] President Michael D. Higgins' 2011 inauguration, for one.

Paul Whittaker is hugely invested in bringing music to deaf individuals through song signing, which he refers to as 'signed singing'. He has single-handedly set up a website to that end and has frequently presented at academic conferences on the subject. In spite of this, he seems loth in his Oxford dissertation to put song singing on a par with traditional lessons in musicianship for participation in orchestras. Whittaker's reluctance to do so may have less to do with his personal views, and more to do with his interest in effectively promoting deaf inclusion in professional music in a greater hearing musical context. In other words, it may be that Whittaker believes it too much of a leap for the conventional musical world to accept signing as musical expression in the strictest sense, even if he believes this to be the case himself. This would stand in stark contrast to some of the professional artists listed below (SIGNMARK and Christine Sun Kim) who take on a much greater socio-cultural sense of deaf identity; insisting on signing being taken seriously as a form of expression. It is unfair, however, to force Whittaker into such an Uncle Tom position between the Deaf community and the hearing world. Undoubtedly, he has done as much to promote signing as the more assertive members of the Deaf community, but has simply done it after his own fashion. Whittaker points out a list of considerations when translating a song into British Sign Language:

1) the meaning and intelligibility of the lyrics themselves
2) the rhythm of the music
3) the tempo
4) the dynamics
5) the phrasing of the song
6) the mood that is being expressed through the song

Song signing itself has even moved beyond the Deaf community. Video sharing sites also boast a large volume of song signing videos from hearing individuals. While this might suggest a positive trend toward acceptance of Deaf culture by the mainstream, the phenomenon has sparked a certain amount of debate between Deaf community song signers and those from the hearing community. In a nutshell, some Deaf community members feel that the sign language interpretations of the hearing community pay too little attention to the semantic value of the signs, using them merely as dance-like gestures (Maler, 2015). Furthermore, hearing community approaches seem to be polyglotic, or macaronic, with multiple gestural languages being merged into one signing performance. Criticisms by the hearing community on song signing by the Deaf community generally centre around a lack of correspondence between rhythm in the sound and rhythm in the signs.

2.7.3 DEAF ENGAGEMENT WITH MUSIC AT A PROFESSIONAL LEVEL

History has witnessed a surprising number of professional deaf musicians. It is well-known that Beethoven was severely deaf for much of his working life. Although none can be verified, many causes for his deafness have been proposed: syphilis, lead poisoning, otosclerosis and even his habit of dunking his head in cold water to stay alert (Barry, 2008). While the exact dates of its onset are equally controversial, Beethoven's deafness was certainly post-lingual and progressive. From his letters, it seems reasonable to suggest that he was losing his hearing in his mid to late twenties, was severely deaf by his early thirties and profoundly deaf by his mid-forties (Kalischer & Shedlock, 1909). His progressive deafness is interesting, both in terms of how he learned to manage it, and the fact that he strove to keep it a secret. Some of Beethoven's coping techniques are described in his letters, and include using tactile conduction between the top of his piano and his head by means of a piece of wood, as well as ear horns built by his friend, Johnan Nepomuk Maelzel (inventor of the metronome).

Other examples of famous musicians with HL include Brian Wilson (life-long profound deafness in his right ear), Czech composer Bedřich Smetana (deaf for the last 10 years of his life, during which time he wrote movements of his symphonic cycle *Ma ́Vlast*), Gabriel Fauré (deaf in later life when he composed his only piano trio) and Ralph Vaughan Williams (exposure in the First World War to artillery led to deafness in later years when he composed his *Symphony No. 9* (Wilson, 2016; Ottlová *et al.*, 2001; Voss, 2016). All these examples fit a physiological view of deaf identity: each individual seeing their HL as a disability and finding ways to compensate for it.

There are a considerable number of present day examples of performers for whom being deaf is a significant, if not integral, part of their musical persona. The Scottish percussionist Evelyn Glennie has gained immense media exposure by developing an inspiring and insightful message based on her experiences as a deaf musician. It is important, however, to clarify that Glennie is an advocate of listening with one's entire body; not of deafness *per se* (Glennie, 2011). Glennie began to lose her hearing at the age of 8 and was profoundly deaf by the age of 12, but had been exposed to a great deal of music before then. Her father was a keen, amateur musician, and she had been trained on both clarinet and piano. Furthermore, while going deaf, Glennie worked extensively with her music teacher, Ron Forbes, learning to feel pitches with her body. Glennie has never learned British Sign Language, which makes her somewhat of an outsider to the Deaf community, and mostly works with hearing musicians. Further to this, Glennie has stated clearly that her interest is not in deafness, but in ways of listening.

> To summarize, my hearing is something that bothers other people far more than it bothers me. There are a couple of inconveniences but in general it doesn't affect my life much. For me, my deafness is no more important than the fact I am female with brown

> eyes. Sure, I sometimes have to find solutions to problems regarding my hearing and its relation to music, but so do all musicians. Most of us know very little about hearing, even though we do it all the time. Likewise, I don't know very much about deafness. What's more, I'm not particularly interested. I remember one occasion when, uncharacteristically, I became upset with a reporter for constantly asking questions only about my deafness. I said 'if you want to know about deafness, you should interview an audiologist. My speciality is music'. (Glennie, 2015)

There are musicians who locate their socio-cultural deaf identity at the heart of their musical experience. Signmark (born Marko Vuoriheimo) is a deaf Finnish rapper who has gained significant exposure internationally. He is an exuberant and articulate spokesperson (through Finnish Sign Language, American Sign Language and International Sign) on the subject of deafness and music, and the vitality of Deaf culture and history. He performs his own music, creating visual rhymes through repeated hand forms and signs. Facial expression, as with all signing in the Deaf community, is a crucial reinforcement to the meaning of his hand gestures. He has released three albums, each of which includes a CD soundtrack and a DVD of the signed music video. He has a recording contract with Warner Music, making him the first deaf person to be represented by an international record company (Moisalla *et al.*, 2017).

Christine Sun Kim provides an interesting case for a deaf person making a living from music. Profoundly deaf since birth, she became interested in 'the rules society attached to sound', and how she could choose to play or not play by those rules (Kim, 2015). Although she started her career as a visual artist, she became invested in conceptual sound art and has exhibited this work internationally, as well as being a twice-named TED Fellow. Her *FACEOPERA* draws on the expressive potential for the face in American Sign Language. The *FACEOPERA* involves Kim conducting an ensemble of prelingually deaf individuals performing her score, which comprises notated emotions: suspicion, anger, joy. Members of the ensemble are meant to 'sing' with facial expressions: raised eyebrows, furrowed brow, grinning (Kim, 2013; See also Leeson and Saeed, 2012(A); Leeson and Saeed, 2012(B); O'Baoill & Matthews, 2000).

An interesting inclusion to the field of music is the dj for deaf discos. One early proponent was Troi Lee, aka D.J. Chinaman, who has been hosting an event known as Deaf Rave around the UK since 2003. Lee organised the first Deaf Rave because there were few nightlife opportunities for deaf people. In Lee's words, 'There was a need for it; nobody was doing it.' (Lee, 2013) According to Lee, the Deaf Rave events have always taken an eclectic approach.

> Every deaf person goes through a different musical experience. My experience is that I must have my hearing aid on, so I can tell the difference between different genres; while

> others will come to the rave with no hearing at all. They can only feel the vibrations and watch other people moving on the dance floor. (Lee, 2013)

Thus, the events are open to any approach imaginable: e.g., the presence of sign artists on stage, the use of subwoofers to enhance low-end delivery from the audio system and even aroma-jockeys who send invisible jets of fragrance wafting across the venue.

Dance related approaches to deaf involvement in music provide fascinating representations of intersubjectivity. The Disabled People's Performing Arts Troupe, a Chinese based group, has performed the *Thousand-Hand Guan Yin, The Bodhisattva of Compassion* at the 2010 VSA (Very Special Arts) Festival (VSA, 2010). In this extraordinary spectacle, the deaf performers used a complex and nuanced choreography that relied on their touching each other's backs for numerous movement cues. Another example is 'Nyle and Peta', a dance duo, one of whose members (Nyle DiMarco) is profoundly deaf. Again, touch and tap cues are used by the hearing partner to guide the deaf partner (DiMarco, 2016).

2.7.4 MUSICAL TRAINING FOR DEAF PEOPLE

As discussed earlier (Section 2.3.2), there has historically been a lack of training opportunities for deaf musicians at the post-secondary level to prepare them for professional musical life. Evelyn Glennie, SIGNMARK and Christine Sun Kim all found their way into careers by exceptional means, rather than tried and true avenues: Glennie through timely training with resourceful teachers, SIGNMARK through an interest in vibrations and KIM through a more conceptual manner of addressing the experience of sound's absence for a deaf person. Paul Whittaker has done a great deal to improve this situation, having founded Music and the Deaf, UK, a charity which provides musical opportunities for children and adults with HL. The organisation, now run by profoundly deaf pianist Danny Lane, offers workshops to interested musicians with any level of deafness. Music and the Deaf, UK has produced a respected quartet, The Forte Ensemble, featuring 4 deaf musicians. The flautist for the Forte Ensemble, Ruth Montgomery, has also composed multisensory works. For her most recent creation, *The Unheard World*, she collaborated with a composer, a variety of musicians, live painters and British Sign Language interpreters (Shape Arts, 2017).

2.7.5 VIBROTACTILE RESEARCH INTO MUSIC FOR DEAF PEOPLE

Specifically vibrotactile approaches towards music have been carried out in a variety of academic and industrial settings. SMARTlab at Ryerson University in Toronto has been hosting research for the past 10 years on the Emoti-Chair (Figure 2.4); a seat which translates audio signals into vibrotactile stimuli and delivers them strategically across different areas of the seated individual's back, posterior and legs using dedicated vibrotactile transducers, motion actuators and air jets. Beyond clinical investigations in the lab, the chairs have been introduced into performance settings, with up to five chairs available for the use of a mixed deaf and hearing audience (Holland, 2015). Following on from that is Subpac, originally a Toronto based firm, which has produced a vest/back pack endowed with tactile transducers (Figure 2.5). The advertisement states: "Powerful and accurate physical audio in a wearable form factor which is quiet to the outside world." Controversially, Studiofeed's developer, James Williams, states that deaf people cannot feel mid to high frequency vibrations, a claim which Signmark, for one, has countered in interviews (Moisalla *et al.*, 2017). There is also a vibrating 'collar' developed by German designer Frederik Podzuweit. It is called 'Music for Deaf People', and uses an undivulged substance in the collar to transmit vibrations to particular areas (Figure 2.6). Bass comes out at the back, mids atop each shoulder and highs towards the front (Ridden, 2010).

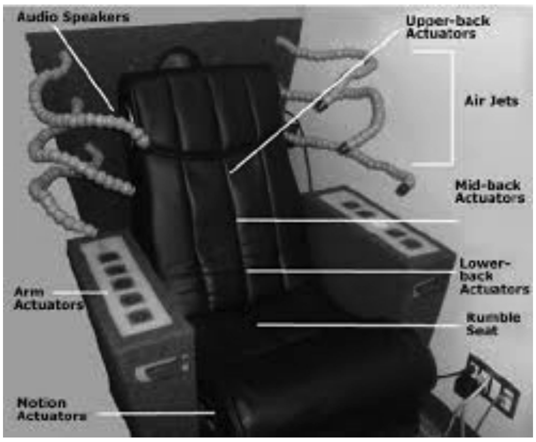


Figure 2.4 The Emoti-Chair; a vibrotactile chair designed at Ryerson University in Toronto (Russo, 2009).

Figure 2.5 Subpac: a vest designed to transmit a vibrotactile musical experience (Williams, 2012).

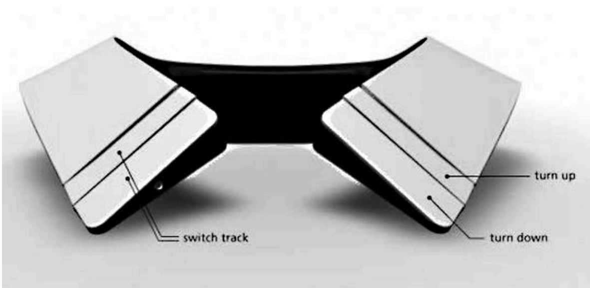


Figure 2.6 Music for the Deaf: a vibrating collar for a deaf musical experience (Podzuweit, 2013).

As described in Chapter 1, this researcher himself designed a vibrating chair for the Dublin Deaf Choir in 2010. The chair comprised a plywood seat with 4 vibrotactile speakers placed at different points: one under either arm rest, one at the back and one on the seat itself. At the time the researcher was not aware of SMARTlab's Emoti-chair, nor Brodsky's related research (Brodsky, 2000). More recently, however, the researcher has been in contact with Frank Russo (lead researcher on the Emoti-chair) and they have exchanged ideas on the design of such a vibrotactile seat.

Robert Fulford's Interactive Performance for Musicians with a Hearing Impairment is likely the most comprehensive and informative study to date on vibrotactile technologies for music (Fulford, 2013). Admirably, in his research on interactive performance technology Fulford does not so much focus on the technology itself, as he does on how it can be useful for deaf musicians in ensemble performance. Fulford first interviews both hearing and deaf/HOH musicians to establish to what degree vibrations are important in performance interaction, and judges that they are less important than visual and physical cues for keeping time and staying in tune. Fulford then conducts a series of tests with a simple haptic device to compare pitch discrimination between deaf and hearing musicians. Fulford's research also involves a stage built for the delivery of haptic tempo information. The very thorough feedback from deaf and HOH performers suggests that haptic approaches which seem disembodied for the musician – that is, separated from the performer or instrument performed upon – can seem alienating. Fulford impressively concludes that 'considering the psychological, behavioural and qualitative data together, it is suggested that signal processing strategies in vibrotactile technology should take social, cognitive and perceptual factors into account' (Fulford, 2013, p. iv)[5]. Such an observation echoes what has been said so far in this chapter concerning the heterogeneous nature of deafness, as well as the whole-body, crossmodal and intersubjective reality of all musical experience.

[5] It should be noted that Fulford specifies in his thesis that this research is still in its infancy. See also Fulford et al. (2011).

CHAPTER 3

MULTISENSORY MUSICAL EXPERIENCE; LIMITING AND EXTENDING AWARENESS

While it was argued in Chapter 2 that the musical experience is active, multimodal and intersubjective, it is rarely the case that an audience, hearing or deaf, is simultaneously alert to such a breadth of phenomena. The fact is that many individuals operate under the assumption that music is a passive experience for the ears alone. Before exploring multisensory approaches to music composition in Chapter 4, it is important to attempt to understand why this assumption exists. This chapter will address the possible reasons, and consider ways of extending awareness of the musical experience beyond audition.

3.1.1 UNIMODAL ANALYSIS OF PERCEPTION AND THE ISSUE OF AWARENESS IN MULTISENSORY STUDIES

Until quite recently, the scientific study of the senses had traditionally confined itself to a unimodal approach. As Stein explains:

> From a practical perspective the scientific strategy [i.e., a unimodal approach] generally involved manipulating cues in the sensory modality being probed while minimizing cues in the other senses to avoid their possible "confounding" influences. The approach was exceptionally successful, yielding rapid advances in our understanding of how an individual system processes information: from the molecular aspects of signal transduction in unique receptor cells to the roles played by higher-order processes (such as attention) that modulate the flow of its information as it loops through the neuraxis. (Stein, 2012, xi).

According to Stein, this unimodal approach has offered great benefits in terms of preparing investigators for future research into multisensory integration. He continues:

> . . . it was the results of these sensory-specific studies that armed us not only with an understanding of the basic physiological principles by which these systems operate but also with the sophistication required to examine interactions among them.

While this is encouraging, Deroy *et al.* claim that unimodal models pose a problem when addressing multisensory awareness (Deroy *et al*., 2014). They point out that for multisensory research 'the focus, then, is not so much on awareness *per se*, but rather on multisensory processing, that is, how the brain deals simultaneously with information from different sensory systems' (Deroy *et al*., 2014, pps 1-2). They further argue that 'studies using binocular rivalry, bistable figure perception, continuous flash suppression, the attentional blink, repetition blindness and backward masking can demonstrate multisensory influences on unisensory awareness, but fall short of tackling multisensory awareness directly' (Deroy *et al*., 2014, p. 1). It would seem that existing studies of multisensory awareness can be divided into two kinds of cases: 1) a single amodal property present via two modalities and 2) two modally specific properties bound into a single audio-visual object (Figure 3.1). According to Deroy, however, no existing research provides a case where multisensory awareness has unambiguously occurred, suggesting 'the need to question the very idea of multisensory awareness' (Deroy *et al.*, 2014, p.1).

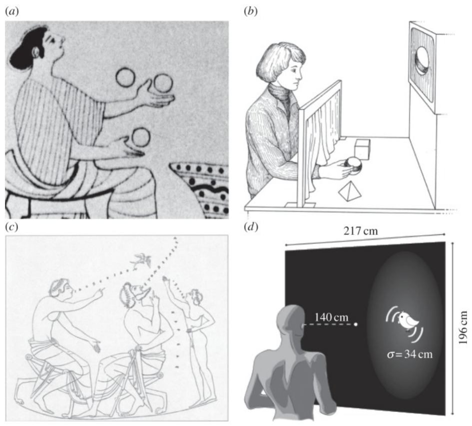


Figure 3.1 Multisensory awareness and its empirical study classically encompass two kinds of cases. In (*a*), the same common sensible or putatively 'amodal' property (e.g. shape) is present in consciousness via two different modes of awareness (e.g. visual and tactile) leading to a visuotactile experience of shape; experimental designs similar to that shown in (*b*) show that the visual awareness of the shape about which the participants have to report in a case of crossmodal matching includes tactile elements. In (*c*), two modally specific properties (e.g. the colour/look of the bird and its song) are bound into a single audio-visual object (that is, a singing bird), and this integration crucially depends upon the synchrony (or, more likely, the statistical correlation) between the component unisensory signals, as studied in protocols such as (*d*). (Deroy et al., 2014, p.2)

What Deroy identifies in the laboratory as 'methodological constraints' seem to parallel similar constraints in everyday perception; i.e., that while perception may be thoroughly multisensory in its processes, there may only be a clear awareness of a seemingly dominant modality (Deroy *et al*., 2014, p.1). As Calvert says, it 'has been known for some time that when conflicting signals are presented via the different sensory modalities, the emergent percept is typically dominated by the most persuasive sensory cue in that particular context; e.g., Rock and Victor, 1964; Welch and Warren, 1980' (Calvert *et al.*, 2004, p. xii). As Angelaki *et al.* put it, a 'fundamental aspect of our sensory experience is that the information from different modalities is often seamlessly integrated into a unified percept' (Angelaki *et al*., 2009, p. 452). Calvert makes the case even clearer, when he states (cited in Chapter 2):

> Thus, even those experiences that at first may appear to be modality-specific are most likely to have been influenced by activity in other sensory modalities, despite our lack of awareness of such interactions. Indeed, mounting evidence now suggests that we are rarely aware of the full extent of these multisensory contributions to our perception. (Calvert, 2004, p. xi)

How to address the question of multisensory awareness in the form of neuroscientific study is a matter for debate. Examining the precise nature of our awareness of a singing yellow bird (Figure 3.1[c]), for example, involves considering a visual experience (the yellow bird that is seen), a mostly synchronous auditory experience (the song of the bird that is heard) and the relationship between the two (the volume of the song that is heard varying with its proximity to the listener as seen). The study of multisensory awareness in such a situation, particularly with regard to timing, presents huge challenges. Fujisaki *et al.* explain: "Given that the multisensory signals come from different sensory organs with different sensory delays, the judgement of simultaneity across the different sensory channels is by no means a trivial problem.' (Fujisaki *et al*., 2004, p. 773). Fujisaki adds that his team found the need to divide their assessment of timing into separate perspectives: 'event time, brain time, and subjective time' (Fujisaki *et al.,* 2004, p. 773). From a phenomenological point of view, Fujisaki's terms are worth unpacking. First, it could be suggested that event time and subjective time are interrelated, if not the same thing. Whether the judgement is made by the participant or the author of a study, the perception of event time is invariably a subjective matter. A participant reports an event as happening at a particular time, which Fujisaki identifies as subjective time. Is it not the case that Fujisaki, or any scientist running the study, does precisely the same thing as the participant when he or she registers, by his or her own report, what represents 'event time'[1]. Furthermore, brain time is often an uncertain quantity, especially with the poor temporal resolution of the prevailing brain imaging technique of fMRI. Gallese and Cuccio point out that:

> . . . action potentials, or 'spikes' as neurophysiologists like to call them – the electric code employed by neurons to communicate with each other, and ultimately the true

[1] For more on time perception, see Wearden (2016) and Phillips (2014).

> essence of neurons' activity – last less than one millisecond. fMRI cannot match such temporal resolution because it measures the delayed (of about five seconds) local hemodynamic response providing neurons with all the oxygen their electrical activity requires. (Gallese & Cuccio, 2015, p.3)

Gallese strongly advises a move away from neuroscience predicated on brain imaging techniques, particularly fMRI, due to their limitations. He suggests that such techniques can only be useful when discrete correlations are made between brain activity and specific mental states. Due to its poor temporal resolution, fMRI rarely allows for such specificity.

On the other hand, because brain imaging techniques are often seen as the hard science of neuroscientific research, there is a reluctance to rely too heavily on subjective accounts of mental states. Given what Deroy says, however, it is hard to know how to approach multisensory awareness if not through subjective accounts. In any case, how can human experience be properly presented except through an individual's subjective account? This is a perennial issue for all sciences, according to students of consciousness like Anthony Marcel, in that empiricism – the bedrock of the scientific method – is, needless to say, itself based on experience. In examining the reliability of both the participants in a study and the scientists running it, Marcel presents a formidable list of reasons to question 'whether we can ever get a firm grasp on our own experience' (Marcel, 2003a, p. 171). Marcel's main argument is that consciousness, in spite of human kind's deepest assumptions, is non-unitary in a number of ways. Marcel's rationalisation of the fragmentation of consciousness includes the following:

> 1) The reported existence of different levels of consciousness. This comprises a) first order non-reflective consciousness and b) second order reflective consciousness, both being distinct from nonconscious representation (Lambie & Marcel, 2002). As examples of these different levels of consciousness, Marcel cites hemiplegiacs reporting confusion about limbs (e.g., at one point in time believing they can feel the paralysed limb, and at another time believing they cannot), the phenomenon of blindsight (loss of conscious visual experience with preserved nonconscious vision) and Anton's syndrome (unawareness of blindness) (Marcel *et al*., 2004).
>
> 2) The reported existence of divisions within each level of consciousness. Such cases would involve a differential access to experience as well as what is referred to as a horizontal split in awareness (rather than the vertical conception described by first and second order consciousness). Both of these are demonstrated in anosognosia for hemiplegia (lack of awareness of paralysis), as well as the hidden observer in hypnosis

and anaesthesia; e.g., people 'seem to be simultaneously aware and unaware of an aspect of their phenomenal experience' (Marcel, 2003a, p.175).

3)The reported existence of non-unification within a single consciousness, shown by:

a) studies by Duncan, 1984, and 'impossible objects such as Penrose triangles (a triangular, 'impossible' object) and Escher depictions' (drawings which depict paradoxical notions of space and movement) (Marcel, 2003, p. 176)

and

b) Albert Bregman's Auditory Scene Analysis (ASA) examples using sequences of tones that can be heard as a single stream or independent streams. Marcel comments that Bregman's ASA work reveals that:

> All perceptual experience entails segmentation into figure and ground, but no determinate relation between the two is experienced and they do not cohere. Moreover, we do not usually notice such noncoherence. To that extent, all perceptual consciousness is dis-unified. (Marcel, 2003, p.176-177)

4) The reported phenomenon of recessiveness. Marcel explains his meaning clearly here, by saying that 'much of our experience is perceptually recessive, or in the background . . . we are aware of and report a small part of it' (Marcel, 2003a, p. 177).

5) Reported instances of non-observational awareness. In contrast to recessiveness, subjects can become aware in such instances, but usually only after the fact. This draws attention to the reality that many features of an individual's phenomenology, far from being explicit, are implicit. They simply do not notice them on a moment to moment basis. A good example here is egoreception, James Gibson's term for perception of self (Gibson, 1979). Gibson's point is that a human engaged in an activity must focus on the activity itself, rather than the idea of themselves engaged in the activity. This bears an interesting relation to the notion of a person experiencing music in the moment, and a person thinking about how they experience music upon reflection.

If one is to accept the disunity of consciousness as presented by Marcel, the reliability of experience, particularly as it relates to reports of awareness, is seriously called into question.

Marcel additionally observes that disunity is not the only issue. There is the further problem of attending to this very experience, or as Marcel puts it, of 'gaining second-order awareness of it, whether to examine it, remember it or report it' (Marcel, 2003a, p.179) Marcel makes another list of ways that experiential content is affected and even created by the act of attention:

1) The influence of attention on the object can be observed in several ways:

  a) Attending to one's experience - the act of introspecting itself - can change the content of an experience.

  b) Mode of attention (as first put forward by William James) can influence the object. Marcel points to two modes in particular:

    i) Analyticism-syntheticism – one's experience becomes more abstracted and decontextualized the more analytic one's attention becomes.

    ii) Immersion-detachment – one has no phenomenal separation from experience when totally engrossed in it.

  A telling example of the influence of attention on the object is emotional experience and one's awareness of it. While individuals might experience an emotion – for instance, happiness – their awareness of that emotion is often limited. This can be to their advantage, because awareness of an emotion might even compromise the emotion to a certain extent. For someone to observe that they are happy intellectualises the experience in a way that is sometimes at odds with the experience itself.

2) Attention can create, destroy or distort its object.

  It has been shown that individuals will add or take away from an experience the more they analyse it. The example of happiness is appropriate here. One might insist they are happy, when they are not at all happy. It is not a matter of being truthful or not. Someone having to discuss this emotion, thereby drawing attention to it, will jeopardise their authentic experience. Authenticity is ultimately lost, and whether they are happy or not is academic in terms of the reliability of their report.

3) Theories tend to mask experience.

  People create theories on what an experience should be that conflicts with actual events (Nigro and Neisser, 1983). To use the example of happiness again, a person might feel it appropriate to experience happiness on their

> birthday or wedding day. Such a theory, based on an ideal, masks someone's true experiential encounter. Again, what is at stake here, for the purposes of scientific rigour, is the reliability of an individual's report.

Marcel identifies a list of strategies, briefly presented here, that can be used in scientific studies to reduce the distortions of experience. The first of these involves using more than one behavioural criterion, as Marcel *et al.* did in their study of hemiplegia (Marcel *et al.*, 2004). The second involves inference of the content of experience from a mixture of empirical data and conceptual analysis, which was used in Marcel's paper on agency (Marcel, 2003b). The third addresses the problem of apprehending first-order phenomenology through second-order awareness, and uses a 'corner of the eye' technique; where subjects are not given an opportunity for reflection on their experience. The fourth technique involves allying technical phenomenology with empirical science, specifying experiential content on logical grounds. This will be addressed presently in the work of Shaun Gallagher.

Before moving on, it is worth noting that Marcel does not see any of his measures as cures, but merely strategies which mitigate to some degree the effects of the disunity of consciousness and awareness/attention on the reliability of empiricism. Marcel also anticipates that these strategies go beyond what most cognitive neuroscientists 'would feel comfortable with' (Marcel, 2003a, p. 184). He concludes with a potent observation:

> What 'objective science' too often means to its practitioners is not just a matter of methodology; it is a matter of assuming that the object of study has a thing-like mind-independent reality. We cannot assume that this is the case when the object of study is phenomenal experience and the content of consciousness. If we assume that first-order consciousness is something independent of subjectivity and that the only problem arises when we try to become aware of it, try to introspect, then we are assuming the Cartesian Theatre, as Dennett (1991) has called it. Certainly, some people in the seventeenth century believed that one's phenomenal experience is something to which one can have 'accurate' access and which therefore has objective existence. If we are to emerge from the seventeenth century, or perhaps accept our continuity with it, we have to accept the intrinsic subjectivity and mind-dependence of phenomenal experience and the content of consciousness. (Marcel, 2003a, p. 184).

Both Thomas Nagel and David Chalmers have argued that an understanding of experience can only be gained through a first-person perspective (Nagel, 1974; Chalmers, 1996). As Olga Markič writes concerning Nagel's seminal work *What is it like to be a bat?*:

> Nagel argues that facts about consciousness can be only incompletely understood from an outside third-person perspective. Knowledge gained from the external, objective, third-person perspective of the natural sciences or cognitive sciences would thus, according to Nagel, not suffice to understand what the bat can understand of its own experience from its internal first-person subjective point of view. This epistemic form of subjectivity is associated with limits on the knowability and understandability about conscious experience. (Markič, 2012, p. 215)

Daniel Dennett has voiced a bleak outlook on the study of experience through first person reports, commenting that 'First-person science of consciousness is a discipline with no methods, no data, no results, no future, no promise. It will remain fantasy' (Dennett, 2001). Dennett's heterophenomenology – which calls for a third-person, verifiable method of reporting first-person introspective reports – is controversial, and moreover does not convincingly address Nagel's concerns (Markič, 2012). Shaun Gallagher has more optimistically identified three approaches which have introduced phenomenology into experimental design with varying degrees of success. The first, termed neurophenomenology, involves both the scientists who are designing an experiment and the experimental subjects being trained in phenomenological method. In doing so, the idea is that a scientist/subject is able to bracket, or set aside, opinions or theories they may hold going into the experiment (Roy, *et al.,* 1999). This method, also put forward by Don Ihde as 'experimental phenomenology' in his eponymous book, seems to have been far more successful than it might sound, with Lutz *et al.* having used it with some success (Lutz *et al.,* 2009; Ihde, 1986; Gallagher, 2003). A second method is referred to as a retrospective use of phenomenology, where existing results are reinterpreted using the same phenomenologically reductive method. Gallagher is critical of this process, arguing that alternative interpretations would need to be tested again empirically in order to be verified. Furthermore, the question remains in such a case as to how phenomenology can be embedded in the experimental method. A third approach, front-loaded phenomenology, does incorporate phenomenological method into the experimental design itself. Gallagher reviews a number of successful experiments which, as Gallese was cited as recommending earlier, correlate brain activity with phenomenological mental states. Specifically, the experiments involved a subject's sense of agency in a number of situations. The results showed a high probability of correlation between a subjectively reported sense of agency and specific neural activity. It is worth quoting Gallagher's account of an experiment on agency/self-ownership for a precise sense of how one might be able to 'get the phenomenology right':

> For the first two experiments, the phenomenology concerns a distinction between self-agency and self-ownership. In the normal experience of intentional action these two aspects of self-awareness are close to indistinguishable. But consider the

> phenomenology of involuntary action. If, for example, someone pushes me from behind, I sense that it is my body that is moving — it is *my* movement and I experience ownership for the movement — but I do not experience agency for the movement (I have no sense that I intended or caused the movement). To get the phenomenology right, however, we need to distinguish between the first-order phenomenal level of experience and higher-order cognition. It is possible to make the distinction between 'attributions of subjectivity' (or ownership) and 'attributions of agency' on the level of higher-order, reflective or introspective report (e.g., Graham and Stephens, 1994; Stephens and Graham, 2000). It is also possible to make the distinction at the level of first-order phenomenal consciousness (Gallagher, 2000; 2003a). That is, in the case of involuntary movement, I directly experience the movement as happening to me (sense of ownership), but not as caused by me (no sense of agency). Ownership and agency are seemingly (and in the case of phenomenal experience, 'seemingly' means 'really') built into experience. They are part of a pre-reflective (non-conceptual) self-awareness implicit to the experience of action. Indeed, this is usually the basis for attributions of subjectivity and agency at the higher introspective level. (Gallagher, 2003, p. 92)

While existing neuroscientific studies do describe their methods as phenomenological, it is important to make a distinction between phenomenology on the level of method (Husserlian reductive method, which involves 'bracketing', i.e., suspending judgement to focus on experience itself) and phenomenology simply on the level of real experience, the reporting of which is subjective. It can be argued that many neuroscientific studies subscribe to the latter, thinking of phenomenology as being synonymous with subjective experience. This is not the case, however, for those scientists, psychologists and philosophers conscious of the phenomenological method; which invariably involves a reduction. How this reduction is accomplished problematically differs between phenomenologists. Overall, one might say that all phenomenological reduction proposes a subjective rigor which insists on openly describing experience, rather than interpreting it. It is reduction which attempts to avoid interpretation, by bracketing an individual's biases and assumptions. Such a phenomenological method is vital to this thesis. It focuses on the personal experiences of hearing and deaf individuals and the real-world conditions under which such experiences occur, rather than abstract explanations for the bodily processes and mechanisms behind those experiences.

As stated earlier, Marcel rightly claims that such reductive processes go beyond what most cognitive neuroscientists 'would feel comfortable with' (Marcel, 2003a, p. 184). However, by their own admission, neuroscientists have identified a serious blind spot in the study of awareness that cannot be remedied by so-called hard science and objective methods: e.g., brain-imaging techniques (Deroy *et al.,* 2014). It would seem time for neuroscience to avail of some of the philosophical insights proposed by Husserl and Heidegger, right on down to more practical suggestions by Marcel, Gallagher and Ihde. Researchers like Gallese are prepared to do this, but all scientists must proceed with caution when donning an apparently philosophical mantle, lest they be discredited by fellow scientists. It is, indeed, a clinical rock and a hard place. Nonetheless, all the aforementioned methods for research on multisensory awareness essentially focus on the same construct, but simply employ different levels of analysis.

Section 3.2 of this chapter introduces another phenomenological model for experimentation: *The Balloon Study*. It follows the front-loaded approach mentioned by Gallagher, in that it incorporates phenomenological method into the experiment design. The study involves a subject being exposed to the same piece of music three times under slightly, but significantly, altered circumstances (i.e., with a balloon and without a balloon). The contrasting reports after each exposure provide insights into the nature of multisensory awareness.

3.1.2 THE DISCLOSIVE NATURE OF LANGUAGE AND ITS INFLUENCE ON THE MUSICAL EXPERIENCE

Before proceeding to the experiment in Section 3.2, it is important to address the matter of language and its decisive influence on the musical experience. It can be agreed that the language used around music is heavily weighted towards the auditory experience. People generally talk about ‘listening’ to a tune, ‘hearing’ a song and the ‘sound’ of music. While one might say ‘I saw someone perform in a concert’, the phrasing indicates that what was seen was not the music itself, but the performance of the music. That is, the music was indeed listened to, but the person reporting the experience was also able to see the manner in which it was produced; something considered to be an added privilege, but not absolutely necessary to the musical experience. It is generally accepted that someone can experience music without seeing the performance. This would seem obvious, as people in the 21st Century world more often than not experience music outside live performance through recordings. Having said that, the identification of mirror neurons makes it clear that someone who experiences a sound is invariably also experiencing the performance of that sound cognitively (Kohler *et al.*, 2002). The issue at hand, however, is that this mirror neuron activity is covert; that is, the individual does not have awareness of this experience. It is for this reason that one must take very seriously the degree to which language limits conscious experience.

The surge in popularity of the music video in the 1980s did not introduce the notion that music can be seen, but allowed, as Carol Vernallis observes, ‘verbal, musical, and visual codes to combine’ (Vernallis, 2004). Interestingly, the Latin translation of video is ‘I see’, so the literal meaning of music video is ‘music I see’. Vernallis’s comments, however, reveal how the notions of what is heard as music, seen as image and understood as lyric are dissected in reflections on an audiovisual experience. Many have in fact criticised the music video as a distraction from the music itself (Goodwin, 1992). The implication in the phenomenon of music video, therefore, is that music is indeed a matter for listening only, but it can be combined with visual media for a different experience.

When a person talks about feeling the music, this would seem to be meant metaphorically. Rather than addressing tactition, feeling music carries the sense that the sounds were emotionally powerful, and 'touched' the individual in a meaningful way. Equally, someone might say 'I was moved by the music'. Again, this likely does not mean the person was moved physically, but expresses the emotional force of the experience. The title of Thomas Riedelsheimer's 2004 documentary about Evelyn Glennie, *Touch the Sound*, captures one's attention simply because the idea of touching sound is unusual, and goes against most people's expectations (Reidelsheimer, 2004). It is true that after watching the film one may be quite prepared to recognise that sound can be felt; as demonstrated not only by Glennie's vibrotactile performance strategies, but also by her inspiring discussions of a broader musical experience. Nonetheless, day-to-day language concerning music presents the concept of a largely unimodal experience: one that involves listening only.

These linguistic tendencies, far from being trivial, are of vital importance. It is commonly, but arguably incorrectly, assumed that language exists only to describe our experience; a referential tool that represents something that exists in and of itself. According to such a view, the word exists in response to the experience. However, phenomenologists have convincingly argued that language does not simply describe our experience of a pre-existing reality, but constitutes it. That is, the experience exists in response to the word. It is for this reason that Martin Heidegger's notion of epistemology is radically ontological; for knowing, embodied by language, is the essence of being. For Heidegger, words are 'the house of being', and disclose the world to every person as they grow and develop. Thus, the limitations of our conventional vocabulary for musical experience impose analogous limitations on our understanding of it (Heidegger, 1971).

That the mind has disclosive and representative faculties has been more recently indicated by the work of Nobel Prize winner Daniel Kahneman, who distinguished between System 1 (Intuitive, Experiential understanding) and System 2 (Analytic, Representational knowledge) ways of thinking (Kahneman, 2011). Arguably, the language around music introduces an audio-centric bias. The word 'bias', though a commonly used term, is formally identified by Kahneman as a systematic error in judgement which recurs predictably in particular circumstances. While Kahneman is not specifically speaking about the bias introduced by words themselves, it is clear that language, in its capacity for concepts, exerts a bias automatically in how it delimits what it describes. A by-product of such bias is what Kahneman describes as 'a puzzling limitation of our mind: our excessive confidence in what we believe we know, and our apparent inability to acknowledge the full extent of our ignorance and the uncertainty of the world we live in (Kahneman, 2011, p. 14; see also Kruger and Dunning, 2009).

A practical example of linguistic limitations on experiential awareness presented itself repeatedly during rehearsals for *The Sense Ensemble Study #1* (Chapter 4). Naturally, the researcher and assistants had the collective aim of addressing the musical experience as physical, intersubjective and crossmodal. As will be seen in the study, there were many musical elements which were based in physical gesture (one example being sign language), while other elements would have readily been considered more conventional expressions of music; e.g., performances on guitar, bass and drums. After the ensemble had rehearsed the 'gestural' aspects for a number of hours, it was not uncommon for one of the performers to remark casually, “Perhaps we'd better start working on the *music* now.” When eyebrows were raised, the offending party would quickly add, “You know what I mean.” Such a *faux pas* was telling. The performers were making determined efforts to expand musical awareness to encompass the non-auditory, but their language was profoundly embedded with the opposing notion: music is sound production, and gestures are just the means to that end.

Should it be a surprise that the language for music carries inbuilt limitations; focusing upon audition perhaps to keep matters more linguistically manageable? Music is already quite challenging to apply words to; arguably much harder than the visual arts, for example. A painting can be described directly in terms of colour and form, but the same cannot be done in the case of music. All of the language for music, in fact, has been shown to be based on metaphor that may be highly arbitrary, but which is frequently based on embodiment (Zbikowski, 2002; Cox, 1999). It is difficult enough to describe music in terms of hearing alone without trying to account for other senses involved. To make sense of the musical experience, it needs to be put it into words and to do so requires that limits be imposed. It cannot be overemphasised that the consequences of how music is discussed, however, undoubtedly shape how it is experienced. Language literally defines experience, as was demonstrated by the recollections of the deaf and blind Helen Keller when learning language (Keller, 1902). It follows that if music is described in terms of hearing alone, it will in effect become an experience for hearing alone.

This is not to cast blame on the listening public, but to point out a linguistic habit concerning music which has been culturally reinforced over time. People are of course entitled to think of music as an auditory experience if they choose. It seems unreasonable for anyone, the researcher included, to insist that music *should* be one thing or another; the point is to suggest what it *can* be. The fact that listeners are active in their musical experience means they can be selective in terms of what they want to find out. Thus, they have a degree of choice as to what they attend to. If musical experience is not a unidimensional chunk of data to take in passively, but a vast, multi-dimensional spectacle, it is quite natural to leave parts of it unexplored. It is entirely possible to pay attention only to the sonic aspects of music, and to be unaware of the vibrations hitting the chest and fingers, as well as the way neurons are in effect imagining the origin of the sound generation (Uithol, 2015). On the other hand, an added adventure is waiting for those who want to consider a broader expression of music; but it takes a certain willingness and effort on the part of the listener to break old habits.

The study described in the following section explores one way to negotiate such an adventure: presenting a method for investigating multisensory awareness with music.

3.2 *THE BALLOON STUDY*: EXPLORING HOW VIBROTACTILE AWARENESS CAN BE INCREASED AND MAINTAINED

The following study was conducted by the researcher in the studio of Music and Media Technologies, Trinity College Dublin, on September 14, 2017.

3.2.1 INTRODUCTION

Evidence suggests that a hearing person generally has a low awareness of vibrotactile stimuli when experiencing music under normal conditions (i.e., without the aid of timbral emphasis through non-linear amplification). Conversely, it is observed that deaf individuals generally demonstrate a heightened tactile awareness to the vibrations of music, both by virtue of crossmodal plasticity and attentiveness (Shibata, 2007; Neville *et al.*, 1983; Spence, 2010). Irrespective of hearing condition, it has been shown in experiments that awareness of vibrotactile stimuli can be increased considerably by means of an efficient tactile conductor (a material or object that effectively translates airborne vibrations into tactile vibrations in a solid), such as an inflated balloon, being held in the hands (e.g., Monster Science, 2017). The researcher surmised that such an increased vibrotactile awareness might be maintained on successive listenings without the balloon.

3.2.2 AIMS AND HYPOTHESIS

The researcher aimed to create a study which would 1) gauge deaf and hearing participants' relative vibrotactile awareness while listening to a piece of music under normal conditions, 2) gauge the same participants' vibrotactile awareness while holding a vibrotactile prop (e.g., an inflated balloon) during a second listening to the same piece of music and finally 3) gauge the same participants' vibrotactile awareness while listening to the same piece of music a third time without the balloon.

The researcher hypothesised that if a hearing participant listens to a piece of music while holding a balloon, increased vibrotactile awareness effected by the balloon might be maintained on a successive listening without the balloon, in conditions otherwise identical to the first listening. The researcher further questioned how a deaf participant would compare to a hearing participant in such an instance, considering that deaf individuals often have a relatively high vibrotactile awareness when experiencing music without the aid of a balloon. The researcher wished to investigate how much higher that awareness might become for the deaf participants when holding the balloon, and how that heightened awareness would be maintained or lost on a successive listening without the balloon.

3.3.3 METHOD

Participants

16 participants took part in a quasi-naïve study of vibrotactile awareness. 12 of the participants were hearing, while 4 of the participants were deaf. The participants were recruited though social media and posters around colleges in Dublin. Of the hearing participants, 67% were female. All the deaf participants were female. The median age for hearing participants was 31, while the median age among deaf participants was 21.

Ethical approval had been granted for the participation of vulnerable adults in advance of this research (see Chapter 2, Section 2.4 ETHICAL ISSUES for details and APPENDIX 2.1 for all related documentation). As described below, all participants were asked to read an Information Sheet (PIL) and sign a consent form in advance of the performance. After the performance, each participant was also given a debriefing sheet.

Materials, Design and Procedure

Going into the study, participants all knew the researcher's thesis concerned multisensory approaches to music. They were not aware, however, of the experimental procedure and how the ordering of successive listenings might affect their perception. Participants were brought into a soundproof recording studio and seated at a table with two active loudspeakers (Genelec 1032 CPM) positioned 2.3 metres in front of them at an angle of 60 degrees right and left respectively (Figure 3.2). The average SPL of the musical track to be used was rated at 75 dB from the seated position.

Eddie Bo's 'Check Your Bucket' (a piece of New Orleans funk music, 2 minutes and 40 seconds in duration) was chosen for its balance of frequency content, and the presence of an engaging bass line. While the bass signal is a prominent feature of the music, it was not considered with respect to experimental design to be overwhelmingly foregrounded relative to the other instruments (guitar, drums, vocals). The aim was to present a piece of music with an appreciable pulse at the mid to low end, but not one that would overshadow mid to high frequency content. Such a spectral balance was important, since sensitivity to the frequency spectrum would naturally vary greatly among participants.

One of the deaf participants and three of the hearing participants were randomly designated as controls in advance of the session. No participant, however, was led to believe that he or she would have a different role to any other participant.

Participants were first instructed to read a study information sheet that explained that the aims of the study were to investigate participants' vibrotactile awareness with repeated exposure to the same piece of music under different conditions. Participants were then asked to sign a research informed consent form. After the form was signed and collected, the researcher stated the following to each participant: 'Today I'd like to play a piece of music for you three times, and ask you some questions about your experience each time.'

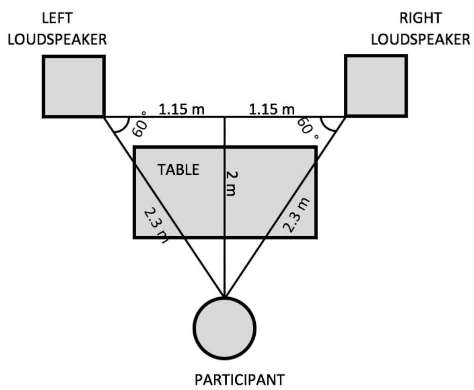


Figure 3.2 *Balloon Study*, Layout.
Participants were seated at a table with two active loudspeakers (Genelec 1032 CPM) positioned 2.3 metres in front of them at an angle of 60 ° right and left respectively.

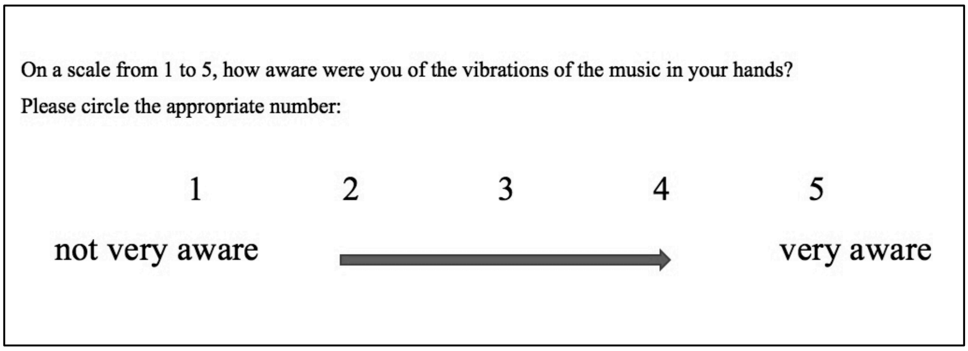
First Listening

It was confirmed that each participant's chair was in the same position (marked on the floor in advance) to ensure a uniformity of distance between participant and loudspeakers for each trial. Participants were briefly given two instructions on how to hold their hands: 1) placing their forearms on each thigh, and 2) resting their hands near the knees with the palms facing each other. Participants were asked to keep their hands as relaxed as they could, and to close their eyes. In the

case of the deaf participants, a method of tapping each participant's arm was agreed upon in order to avoid confusion as to when each listening trial was over.
NB: The deaf participants had their cochlear implants turned off. All were CI users.

The study then proceeded as follows:

1) The first thirty seconds of the piece of music was played.
2) After the excerpt had been played, the participants were given a slip of paper which asked them to rate their vibrotactile awareness by circling a number between 1 and 5: 1 indicating not very aware, and 5 indicating very aware (Figure 3.3). This five ordered Likert scale was chosen for its ease of answering. While it is often recommended to use higher orders for Likert scales (e.g., between seven to nine according to Preston *et al., 1999*) the researcher found in previous trials that offering such a broad range of tactile awareness could be confusing for the participants.


On a scale from 1 to 5, how aware were you of the vibrations of the music in your hands?
Please circle the appropriate number:

1 2 3 4 5

not very aware → very aware

Figure 3.3 *Study # 4* Questionnaire given to participants following each listening, which used a five ordered Likert scale for reporting vibrotactile awareness.

<u>Second Listening</u>

-Participants, with the exception of the controls, were each given an inflated balloon. They were asked to hold the balloon between their two palms, with their hands in a similar position to the first listening. They were told they should listen to the same piece of music with their eyes closed, and would again be asked to describe their experience.
The study then continued as follows:

1) This time, the piece of music was played in its entirety: 2 minutes and 40 seconds.
2) After the piece had been played, the participants were again given a slip of paper, identical to the first, asking them to rate their vibrotactile awareness (Figure 3.3).

Third Listening

-The participants, with the exception of the controls, were asked to hand the balloon back to the researcher. They were told they would be played the same piece of music, and again asked to describe their experience.

The study then continued as follows:

-The first minute and a half of the piece of music was played again.

- After the excerpt had been played, the participants were again given a slip of paper, identical to the first and second, asking them to rate their vibrotactile awareness (Figure 3.3).

3.2.4 RESULTS

Data Analysis

As this was a preliminary experiment, the sample was relatively small. Moreover, the sample sizes were quite different between groups of deaf and hearing participants and their respective controls. While the means provide adequate data for an initial testing of the hypothesis (see Table 3.1), a t-test for samples with independent means was also used to test for statistical significance (see Table 3.2). A t-test was chosen to cater for both the small and dissimilar samples. Specifically, the two sample t-test was used to compare 1) the hearing intervention and the hearing control group, 2) the deaf intervention with the deaf control group, 3) the hearing intervention with the deaf intervention group and 4) the hearing control with the deaf control group. Statistically significant differences between these groups would provide a method for supporting or negating the hypothesis.

		Listening 1 (baseline)	**Listening 2** (intervention with balloon)	**Listening 3** (intervention without balloon)
		Mean (SD)	Mean (SD)	Mean (SD)
Intervention	Hearing (n=12)	1.42 (0.67)	5 (0)	2.5 (0.91)
	Deaf (n=3)	3.6 (0.58)	5 (0)	3.33 (0.47)
	All (n=15)	1.87 (1.25)	5 (0)	2.7 (0.9)
Control	Hearing (n=4)	1.25 (0.43)	1 (0)	1 (0)
	Deaf (n=1)	4 (0)	4 (0)	4 (0)
	All (n=5)	1.8 (1.3)	1.6 (1.34)	1.6 (1.34)
Hearing	All (n=16)	1.38 (0.62)	4 (1.79)	2.13 (1.02)
Deaf	All (n=4)	3.75 (.5)	4.75 (0.5)	3.5 (0.58)

Table 3.1. Overall results for The Balloon Study, including means and standard deviations for hearing and deaf intervention and control groups for the three 'listenings'.

	Listening 1 t-value (p-value)	**Listening 2** t-value (p-value)	**Listening 3** t-value (p-value)
Hearing intervention v Hearing control	0.45374 (0.328484)	27.83051 (0.00001)	3.24037 (0.002963)
Deaf intervention v Deaf control	-0.7746 (0.247513)	2.04939 (0.066421)	-1.54919 (.109551)
Hearing intervention v Deaf intervention	-5.31879 (0.00007)	-0.48617 (0.317469)	-1.49712 (0.79121)
Hearing control v Deaf control	-7.333333 (0.00092)	-7.323333 (0.00092)	-7.333333 (0.00092)

Table 3.2
A chart giving the results of a one-tailed t-test for 2 independent means. This test was chosen due to both the small sample sizes, and the different sizes of samples between different groups.

Overall Results

For Listening 1 (baseline) there was no significant difference between the hearing intervention and the control groups, or between the deaf intervention and control groups. However, the mean for all deaf participants was significantly higher than for the hearing participants. It can be surmised that this is because the deaf participants were already responding to vibrations at baseline.

For Listening 2 (intervention with balloon) there was a significant difference between the hearing intervention and control groups, suggesting that vibrotactile awareness increased with the presence of the balloon. There was also a difference between the means of the deaf intervention and control group, indicating an increase in awareness for the deaf intervention group with the addition of the balloon. There was no significant difference between the hearing intervention group and the deaf intervention group, with both groups reporting a similar vibrotactile awareness with the presence of the balloon.

In Listening 3 (intervention without balloon) there was still a significant difference between the hearing intervention and control groups, although this difference was not as pronounced as in Listening 2. There was no significant difference between the deaf intervention and control groups, suggesting that the increase in vibrotactile awareness from Listening 2 was not maintained.

It is noteworthy that there was a significant difference between hearing and deaf control results across all three listenings. In contrast, there was no significant difference in awareness within either deaf or hearing control groups across all three listenings.

* (See Appendix 3.1, for the Raw Data for *Balloon Study*)

3.2.5 DISCUSSION, BALLOON STUDY

The reports of hearing intervention participants in Listening 2 of *The Balloon Study* clearly support what the literature has repeatedly demonstrated: that vibrotactile awareness for hearing individuals is increased when a vibrotactile conductive prop (a balloon) is held in the hands. The reports of these same hearing intervention participants in Listening 3 go on to support the principal hypothesis of this study, that such an increased awareness is maintained for hearing participants in a successive listening without the prop.

The results for deaf individuals confirm that vibrotactile awareness is considerably higher under normal circumstances than that of hearing individuals (Listening 1), and that the awareness increases with the addition of the vibrotactile conductive prop (Listening 2). Unlike the hearing participants, however, that increased awareness, relative to the first listening, does not appear to be maintained in Listening 3. These results should be approached with a degree of caution due to the small overall deaf sample group and the extremely small deaf control group.

For hearing participants, the results show that vibrotactile awareness increases when attention is directed toward tactition by an environmental change. Furthermore, the results suggest that while multisensory awareness may be limited in some respects, as argued by Deroy *et al.* (2014), an individual's awareness can shift focus from one modality to another. Thus, an individual arguably has the capacity for multimodal perspectives on experience, though such multiple perspectives may not necessarily be simultaneously presented. This non-simultaneous presentation of different perspectives of the same activity (hearing the same song repeatedly) offers a constructive phenomenology for the disunity of consciousness as posited by Marcel *et al*. (2004). It moreover offers a foundation on which to create multisensory perspectives in a music composition. That is to say, a composer has the capacity to alter the performance environment for an audience in a way that will increase their vibrotactile awareness of a musical event that is under normal circumstances appreciated primarily for its sonic potential. The balloon study offers only one example of such an environmental alteration. The following chapters of this thesis present numerous other possibilities.

The distinction between overt and covert multisensory processes in this modal interplay warrants further study. Future experiments could:

1) examine deaf participants' responses more comprehensively by a) using a larger sample group and b) more rigorously comparing deaf participants with and without ALDs;
2) use brain imaging techniques to investigate a correlation between reported awareness and neural activity in relevant cortices (Gallese & Cuccio, 2015);
3) engage a more gender balanced group (this study had a larger proportion of female participants); and
5) mix different orders of Likert scales (between 5 and 9) into the questionnaire process, to see if there is a statistical difference in terms of response.

3.3 CONCLUSION FOR CHAPTER 3

This chapter begins by exploring reasons for music being regarded primarily as an auditory phenomenon in spite of the fact that music is a whole-body, crossmodal and intersubjective experience (see Chapter 2). It offered a neuroscientific perspective, arguing that existing unisensory models for investigating multisensory processes cause problems when attempting to account for multisensory awareness. Deroy *et al.* went as far as to say that there is 'the need to question the very idea of multisensory awareness' (Deroy *et al.*, 2014, p.1). It is arguable that multisensory awareness of any experience might be problematic for humans both in laboratory and everyday settings.

These comments from the neuroscientific community were reinforced by an examination of the faithfulness of reporting experience itself; drawn from philosophers of science like Anthony Marcel, Shaun Gallagher and Daniel Dennett. Marcel (2003) offers a comprehensive argument for the disunity of consciousness: that our conscious experience is not coherent and its reliability is therefore in question. In addition, there is the issue of how attention profoundly influences our experience to the point of distortion. Both Marcel (2003) and Gallagher (2003) offer a number of solutions to these issues, with Gallagher's being embedded in a method which marries phenomenology with the scientific method.

Citations from philosophical and social science literature were then provided as evidence of the effects of language on musical experience. According to the reasoning in Heidegger (1971), the disclosive nature of language allows our experience to be shaped by it; i.e., music becomes an auditory experience by describing it thus. Kahneman (2011) supports this claim by arguing that bias can lead to repeated errors in judgement. That is, explanations people have for experience (i.e., music) are often the most readily available (i.e., an auditory experience) rather than the most accurate or well-informed.

Finally, the researcher presents *The Balloon Study; Exploring How Vibrotactile Awareness Can Be Increased and Maintained*. This study involved a number of hearing and deaf participants being exposed to a piece of music three times: the first time under normal circumstances, the second while holding a balloon and the third without the balloon. Results of the study support the principal hypothesis, indicating that not only was vibrotactile awareness increased in hearing participants while holding the balloon, but that this awareness was maintained in the 3rd listening without the balloon. Results for deaf participants show a high vibrotactile awareness for the first listening and an increase with the balloon in the 2nd listening, but indicate that this increase in awareness is not maintained in the 3rd listening. The results of the study suggest that in hearing participants, musical awareness can be extended to include modalities other than hearing through certain techniques, and that such an awareness can be maintained.

Chapter 3 ultimately puts forward the claim that while a person's awareness of multisensory processes may be not be robust, attention can move effectively between the stimuli offered by each sense regarding the same multisensory object, or related objects; thus offering a subject different perspectives on the same event. That is to say, whether or not people are simultaneously aware of multimodal processes, they can compare and contrast the different unimodal processes in a productive manner. This point is relevant to what follows in Chapter 4 (studies investigating multisensory approaches to music composition) and Chapter 5 (a compositional technique which uses related information from multiple modalities to inform a multisensory musical narrative).

CHAPTER 4

⚃

THE SENSE ENSEMBLE
BACKGROUND RESEARCH, WORKSHOPS AND STUDIES

4.0 CHAPTER 4 INTRODUCTION

The first three chapters of this thesis establish a basis for an approach to music composition for deaf audiences. After Chapter 1 presents the background to this research, Chapter 2 argues that deaf people are able to have a musical experience by virtue of the fact that:

1) Deafness is not homogeneous, and thus many deaf individuals have a degree of hearing.

2) Music is not in any case limited to audition, but is a whole-body, crossmodal and intersubjective experience.

Chapter 3 qualifies the second argument by drawing attention to the following:

1) While the musical experience may not be limited to audition, our whole-body awareness is most often limited due to a number of cognitive and linguistic tendencies.

2) Nevertheless, our awareness is capable of alternately attending to multisensory aspects, thus suggesting a multisensory awareness that may not be simultaneous, but capable of a relatively coherent perspective on a multisensory object.

Following on from these premises, Chapter 4 now gives accounts for the workshops and three studies which were carried out in the course of the research to investigate an approach to music composition for deaf audiences, as well as the background investigations which led to this research. Figure 4.1 provides a timeline of the research leading to the completion of this thesis, including initial background research.

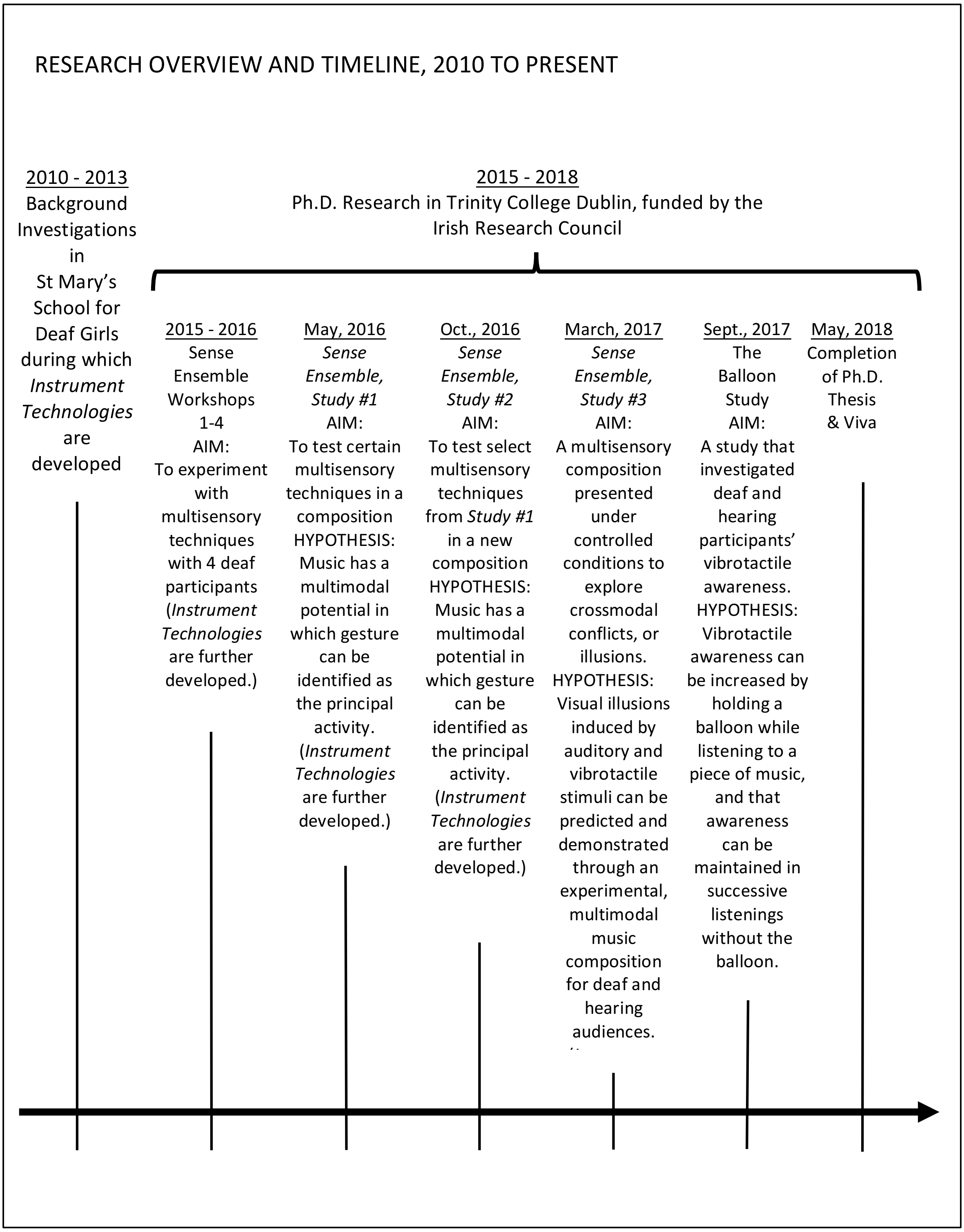


Figure 4.1. A timeline of the research leading to the completion of this thesis, including initial background research. This chapter treats each one of these research phases in much greater detail in the corresponding sections.
It is worth stating that the studies were not planned as a series of three from the outset of the research, but were developed one-by-one, with each successive study being a response to the previous one.
It is also worth noting that the Balloon Study, detailed earlier in Chapter 3, actually happened at the tail end of the Sense Ensemble studies, and was formerly named The Sense Ensemble, Study #4.

This chapter details each one of the research phases and aspects described in Figure 4.1 in the following order:

4.1 Background Investigations to Ph.D. Research
This section accounts for work undertaken in St Mary's School for Deaf Girls from 2010 to 2013 which led to this thesis research.

4.2 Instrument Technologies employed in this Research
This section itemises and describes the instrument technologies created and adapted for this research.

4.3 The Sense Ensemble, Workshops 1-4
4 workshops were held between January and May 2016 to explore different strategies for musical engagement between the researcher and 3 deaf musicians.

4.4 *The Sense Ensemble Study #1*
This study was performed in the Printing House Hall, Trinity College Dublin, May 26, 2016, and used a number of multisensory techniques to engage a mixed deaf and hearing audience.

4.5 *The Sense Ensemble Study #2*
This performance was undertaken in The Beckett Theatre, Trinity College Dublin, October 23, 2016, and further developed a selection of the multisensory techniques used in *Study #1*.

4.6 *The Sense Ensemble Study #3*
This study was carried out in The Trinity Long Room Hub, March 23, 2017, and was based on the Sound-Induced Flash Illusion (Shams *et al.,* 2002).

4.1 BACKGROUND RESEARCH IN ST. MARY'S SCHOOL FOR DEAF GIRLS, DUBLIN

The workshops and studies carried out during the course of the researcher's Ph.D. studies served to formalise and extend what had been discovered in prior collaborations with students from St Mary's School for Deaf Girls, Dublin between 2010 and 2013. It is fitting to provide some details of the work and performances undertaken in St Mary's, for which there were roughly speaking 3 phases.

Phase 1, St. Mary's School for Deaf Girls: *The Machine of Song*
September, 2010 to May, 2011

With funding from Arts Council Ireland, the researcher spent 1 day per week in the music room of the deaf school working with first, second and third year students. The researcher built instruments based on the strengths and tendencies of the students, and also drew from his existing arsenal of instruments (see Section 4.2). Overall, the researcher and students approached the musical experience as a sense ensemble (also the performing title for the group of musicians), operating on the premise that music is a whole-body, crossmodal and intersubjective experience. This premise is clearly expressed in the nature of the instruments built and the way they were exploited in group performance (more on this in Section 4.2). This work phase culminated with a composition called *The Machine of Song*, which was performed on two occasions: 1) May 18, 2011, in St Mary's School for Deaf Girls, Dublin and 2) May 19, 2011, in the Centre for Contemporary Music in Dublin City Centre (Figure 4.1) (video link: Higgs & St Mary's, 2011).

Figure 4.2 The Sense Ensemble performs *The Machine of Song* in the Contemporary Music Centre in Dublin on May 19, 2011 (Photograph by Amanda Feery).

Phase 2, St. Mary's School for Deaf Girls: Workshops, Teaching and *The Sound of Music*
October, 2011 – April, 2012

With funding from St Mary's School for Deaf Girls Board of Management, the researcher spent 1 day per week in the school conducting workshops with both primary and secondary school deaf students, and teaching them principles of music. The work culminated in a signed production of *The Sound of Music* in April, 2011. The researcher helped in the musical direction, and performed on stage with a number of students using the instruments built in the previous year. The school also funded the researcher's study of ISL at the Trinity College Dublin Centre for Deaf Studies.

Phase 3, St. Mary's School for Deaf Girls: *The Lost and Found Sound Assembly*
September, 2012 – April, 2013

With funding from a Dublin City Council Public Art Commission, the researcher undertook a collaborative project – *The Lost and Found Sound Assembly* - with 4 students from St Mary's School for Deaf Girls and a professional percussionist, Sean Carpio. The project involved building an instrument with materials sourced from 3 recycling centres around Dublin, composing a piece of music for this instrument and performing the composition outdoors at the different recycling centres, as well as several spots around Dublin city centre (Figures 4.2 and 4.3) (see video link: Higgs & St Mary's, 2013). The instrument was assembled in front of the audience as part of the performance; thus, the 'sound assembly' was a scored aspect of the composition.

Figure 4.3 *The Lost and Found Sound Assembly*, being performed on West Essex St., Temple Bar, April 13, 2013. The instrument was made from recycled parts sourced from Dublin recycling centres (Bring Centres), and assembled as part of the performance (Photograph by Jason Delwater).

Figure 4.4 *The Lost and Found Sound Assembly* (see Fig. 4.2 caption). Here audience members are led through the instrument structure on a platform fitted with tactile transducers, affording a vibrotactile experience (Photography by Jason Delwater).

4.2 INSTRUMENT TECHNOLOGIES EMPLOYED IN THIS RESEARCH

Specific instrument technologies, developed between 2007 and 2017, have been central to this research. Some of these were created by the researcher, while others were adapted from existing instruments and objects, both musical and non-musical. An attempt was made to lay bare the essence of the technology and the performer's interaction with it in what could be characterized as a Heideggerian approach (Heidegger, 1982). As Blitz describes Heidegger's concept of technology:

> . . . the essence of technology [according to Heidegger] is not something we make; it is a mode of being, or of revealing . . . to consider technology essentially is to see it as an event to which we belong: the structuring, ordering, and "requisitioning" of everything around us, and of ourselves (Blitz, 2004, p. 71).

At the time of their creation, the researcher simply envisaged the instruments as music generation strategies which allowed for optimal engagement for deaf and hearing musicians and encouraged free interaction between the musicians during performance. It is only retrospectively that the instruments are being considered as somehow revealing an essential consideration of technology. Nonetheless, such an analysis is significant. Before giving details for each instrument, there are a few important general points to be made with regard to this strategy for optimal engagement:

1) Instruments were designed to invite participation and engagement by non-musicians as well as musicians.

2) Instruments were designed to allow for multisensory engagement.

3) Instruments incorporated materials and objects which were conspicuously non-musical.
Note: The researcher has found that building instruments by adapting recognizable objects and materials - e.g., a glockenspiel made from copper piping normally used for plumbing, marimba mallets made from spoons, *etcetera* - has a significant effect on musical participation, especially for those with limited musical experience. Adapted instruments tend not to intimidate a beginner in the same way that a conventional instrument can. In the case of novel instruments, everyone, even a professional musician, is somewhat of a beginner. The notion of a ‘correct’ or an ‘incorrect’ playing method does not exist.

4) Instruments were developed to encourage a clear relationship between players.
Furthermore, the manner in which the instruments are arranged – on a scaffold frame which constitutes one large instrument – has an additional result. Musicians are made to feel part of a collective by facing each other with little obstruction due to the skeletal nature of the scaffolding. The audience members seated around the scaffold frame are also able to watch the ensemble’s interaction clearly.

5) Instruments could often be assembled on the spot, and the act of building was at times considered a part of the instrument’s performance (Figures 4.2 and 4.3). The idea of building the instrument had a far-reaching effect for the performers and audience members. It was made clear that the performers were not only playing the instruments, but dwelling with them and within them (Heidegger, 1991). This again relates to an exploration of the essence of the interaction with technology in a Heideggerian sense.

All the above design elements encouraged the musicians to focus on their personal interaction with the instrument, their interpersonal relationships within the ensemble and their relationship with the audience. It might be argued that in the case of much conventional performance, the focus is on the performance of a 'piece' of music on instruments with recognized technical conventions. In such cases, there is the risk that an objectified musical reality is taken for granted or presupposed by the recognised identity of the piece of music to be performed, and the instruments on which it is to be performed.

Aluminium Friction Rods
Amplified Tuning Forks
Bass Shaker Speakers
Bell Jar/Percussive Speaker Telegraph Stations
Bicycle Wheel
Copper Pipe Glockenspiel
Copper Pot Cow Bell
DOOR
Electronic Multisensory Metronome/Percussion Unit
Guitars Mounted on Scaffold Frame
Irish Sign Language
Marimba (upright) with PVC Pipe Resonators
Percussion Table
Plosive Aerophones
Remote Hi-hat
Scaffolding Structure
Section Poles
Shadow Play
Slit Drum (two-pitched)
Subwoofers
Tactile Walkway
Tension Spring and Cymbal
Tubular Bells
Washboard
Wood Block (pair)
Vortex Cannons

The preceding sections (4.1 and 4.2) provide a brief overview of the instrument technologies which informed the current research, and the research period leading up to it in

St Mary's School for Deaf Girls. What follows is an account of the research specific to this Ph.D.

4.3 THE SENSE ENSEMBLE, WORKSHOPS 1 - 4

4 workshops were held in the Printing House Hall, Trinity College Dublin between January and May, 2016, to explore different strategies for musical engagement between the researcher and 3 deaf musicians[1].

4.3.1 OVERALL RESEARCH APPROACH

Initial work involved informal interaction, using a selection of instruments the researcher had built (see Section 4.2). The group communicated through sign assisted lip reading, the researcher having studied ISL while working in St Mary's. The musicians would at times wear their ALDs (a mixture of cochlear implants and hearing aids), but more often chose to remove them, or switch them off. This was based on experiences with ALDs proving more of a hindrance than a help to musical interaction (see Chapter 2, Section 2.1.5).

4.3.2 WORKSHOP PROCESS

Each workshop involved the following basic structure:

1) warm-up without instruments (a few musical exercises performed in a circle),

2) work with instruments and

3) discussion.

The researcher began by teaching rhythms to the musicians in either 12/8 or 4/4 metre on an assortment of percussion instruments. As the participants had limited knowledge of music notation, these patterns were taught using Time Unit Box Notation System (TUBS, 2017). The patterns included:

1) Ghanaian ensemble polyrhythms (including select Adowa, Sikyi, Gahu and Akom patterns; for notation, see Appendix 4.2) and

[1] The participants were all graduates of St Mary's School for Deaf Girls: Jaima Gago, Sophie Kennedy and Shauna Hathaway Farrell. The dates were: January 14, February 18, March 24 and April 7, 2016.

2) Afro-Cuban patterns - a) the Son and Rhumba Clave and b) the Bembé bell pattern.

From previous experience and from the literature on eye-gaze, the researcher was aware that the deaf musicians needed to see each other clearly (Metzger & Fleetwood, 2005). Thus, a framed instrument was used, around which the researcher and deaf musicians could stand facing each other and onto which the researcher could fix the percussion instruments (see Scaffold Structure, Section 4.2). In the course of the first session, the researcher came to understand what patterns worked best for the musicians, both in terms of rhythmic complexity and the ergonomics of the different instruments being played (these varied over the course of the workshops, but are all accounted for in Section 4.2). In the end, three rhythmic patterns were principally used: the bembé pattern, the son clave and the reverse son clave (Figures 4.4 – 4.6). These patterns were likely successful because they comprised short groups of sound - no longer than 2 bars each – and were memorable.

1	2	3	**4**	5	6	**7**	8	9	**10**	11	12
X		X		X	X		X		X		X

Figure 4.5 Bembé pattern in 12/8.

1	2	3	4	**5**	6	7	8	**9**	10	11	12	**13**	14	15	16
X			X			X				X		X			

Figure 4.6 Son clave in 4/4.

1	2	3	4	**5**	6	7	8	**9**	10	11	12	**13**	14	15	16
		X		X				X			X			X	

Figure 4.7 Reverse son clave in 4/4.

The rhythms were initially played on a single element of an instrument; e.g., one bar of a marimba, one block on a set of wood blocks, one pipe of a set of plosive aerophones, *etcetera*. The researcher encouraged the deaf musicians to identify with the rhythms using their bodies, and to explore the many subtle yet significant aspects of the activity. The researcher and musicians came to dissect movement into multiple perspectives: 1) the trajectory of the hand going to strike the instrument, 2) the body's supportive pose which is dynamic and reactive to the hand's movement, 3) the rebound from resistance of the object being struck (the force of the object striking back) as a tactile experience, 4) the striking of the object as a sonic experience and 5) the striking of the object as a visual experience. The experiences of these gestures thus had a multidimensional musical quality.

In the second session, the patterns were broken up between different percussion objects to introduce a multisensory melodic component; taking a broad view of melody as a rhythm with a varied pitch contour (Figures 4.7 - 4.9). For example, in the case of the wood block, two blocks of different mass and thus different pitch were assigned different parts of the rhythmic pattern. The different response of each wood block could be perceived melodically from three points of view:

1) auditory (a difference in pitch),

2) visual (a difference in location) and

3) vibrotactile (a difference in mass, which delivers a different felt response).

	1	2	3	**4**	5	6	**7**	8	9	**10**	11	12
High	X		X					X		X		
Low					X	X						X

Figure 4.8 The Bembé bell pattern broken up between high and low pitches to create a melody that can be perceived through audition, vision or touch.

	1	2	3	4	**5**	6	7	8	**9**	10	11	12	1**3**	14	15	16
High	X										X					
Low				X			X						X			

Figure 4.9 The son clave pattern broken up between high and low pitches to create a melody that can be perceived through audition, vision or touch.

	1	2	3	4	**5**	6	7	8	**9**	10	11	12	**13**	14	15	16
High			X						X							
Low					X							X			X	

Figure 4.10 The reverse son clave pattern broken up between high and low pitches to create a melody that can be perceived through audition, vision or touch.

In the third session, the researcher and the group continued to play these melody-endowed rhythms, again focussing on their embodied connectedness. The extent to which rhythms in general are often perceived as objects separate to the body was becoming increasingly apparent to both researcher and participants, and was brought up during discussions; e.g., the notated patterns in Figures 4.4 – 4.10. This system of notation, while useful for representing a rhythm, tends to suggest that the rhythm exists outside of human bodily experience, when in fact rhythm can only ever exist as a bodily experience. This notion of music as an object is discussed in greater depth in Chapter 5, as well as the potential hazards of such a perspective. By virtue of the method used in the workshop, one that focussed on the physical act, this trap seemed more easily avoided. It was noted by the participants that the melodic contour of the rhythms (when divided between different objects) could be perceived in many ways: sonically, visually, through the body's interaction with it: gesturally, vibrotactilely and notationally (i.e., looking at the TUBS notation).

With practice, each musician reported not only an improved awareness of what the other musicians were doing, but an increasing sense of what was being created as a group: what the researcher came to see as a larger tapestry of merged patterns; i.e., an emergent pattern (Figure 4.10). Essentially, the group had been able to develop a concept of multisensory harmony; taking a broad view of harmony as a combination of distinct elements which can be appreciated both independently and as a coherent whole. Deafness, far from being an obstacle to music making, had offered multiple modal points of entry into rhythmic patterns; i.e., once inside the complex of physical activity, the different aspects of the resulting structure could be appreciated in a variety of ways. It became clear to the researcher that the participants, even the most profoundly deaf of them, were now not only listening to the rhythms, but to the relationships of the rhythms to themselves and other musicians. This overall approach is itemised more succinctly in Section 6.2 of Chapter 6: Embodied Harmonic Technique. For more on how deaf experience can be harnessed for society at large, see the discussion of “Deaf Gain” in Bauman & Murray (2014).

B	**1**	2	3	**4**	5	6	**7**	8	9	**10**	11	12
Hi	X		X					X		X		
Lo					X	X						X

S	**1**	2	3	4	**5**	6	7	8	**9**	10	11	12	1**3**	14	15	16
Hi	X										X					
Lo				X			X						X			
S(r)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Hi			X						X							
Lo					X							X			X	

Figure 4.11 The combined patterns. B=Bembé, S=Son clave and S(r)=Son clave reversed. This TUBS notation has merged the melodically distributed bell patterns, to give a sense of an emergent pattern, or harmony resulting from their being blended. Importantly, this emergent pattern is not only a sonic rhythm or harmony, but a harmony of collective human activity.

4.3.3 CONCLUSIONS DRAWN FROM WORKSHOPS

The workshops provided the researcher with a firm basis on which to begin the compositional studies that are accounted for in the following sections. Some of the conclusions drawn from the workshop sessions (or confirmations of observations in background research) include:

> -Senses do not act discretely, but collectively in a way performers and audience members are rarely aware of; i.e., as a sense ensemble.
>
> -Rhythms are most fully realised when they cease to be viewed as objects, and become a form of embodied self-expression. It was noted repeatedly how detached an individual can become from the rhythm he or she is performing, to the detriment of his or her engagement.
>
> -An instrument is best engaged with when its object-like nature is disregarded, and the performer's relationship with it becomes the focus of a musical event.
>
> -Compositions (in the case of the workshop this refers to the notated rhythms) do not produce music. Instead, they provide the conditions for a musical experience in the form of instructions that musicians are generally meant to follow. These conditions can have

very different results, and can be perceived in different ways by audience members. Composers cannot control how faithfully a musician, or an ensemble of musicians, will follow the instructions put into a score, nor can a musician determine how an audience will attend to the performance of the instructions. In the case of music composition, the musical experience is a process where composers and performers transact with each other and their audience in a 'fusion of horizons' (Gadamer, 1989).

-While composers cannot determine or control how an audience or performers will respond to the musical conditions set out in a score, they can make conscious decisions about what is being offered, and how it is being offered. The ordering of these conditions, whatever they may be, can constitute a recognizable and memorable pattern. The pattern serves as the basis for a non-linguistic narrative, whereby expectations can be gratified when the pattern is repeated, or perturbed when the pattern is varied or completely changed.

-Bodily engagement with the environment, rather than sounds, can be addressed as the entry point for musical experience. Broadly speaking, bodily actions, or gestures, can be treated as events with a multimodal potential. A composer has a degree of influence as to how these events are perceived – i.e., with emphasis on a particular modality – by the manner in which they are presented to the audience.

-A multisensory composition could be one in which gestures with multimodal potential are presented in a way that helps direct an audience's attention through a multisensory musical narrative.

4.4 *THE SENSE ENSEMBLE; STUDY #1*

This composition was performed in the Printing House Hall, Trinity College Dublin, on May 26, 2016, and used a number of multisensory techniques to engage a mixed deaf and hearing audience.

4.4.1 INTRODUCTION

Following the series of 4 workshops described in the previous section, the researcher was eager to create a composition that investigated the human body as a sense ensemble, with all senses collaborating in the musical experience. The idea was to create a composition that used gesture, or bodily action, as the starting point for a multisensory musical narrative. Cox (2000) suggests that music cognition normally involves an understanding of all sounds in terms of our vocal experience. If gesture, rather than sound, were to become the principal area of musical investigation, where would this leave Cox's idea of vocal experience? Would actions not themselves represent a type of voice? The composer saw the need for a compositional study that investigated ways in which sign language - or to be more precise, a sequence of gestures appropriated from ISL - could be considered and treated as part of the 'vocal' experience, or at least an analogue; i.e., a deep formative aspect of cognition comprising personal and interpersonal comprehension of the life-world (that is, the perceived world), and the attempts of individuals to express themselves within that life-world (Husserl, 1988)[2].

4.4.2 AIMS AND HYPOTHESIS

The study aimed to use gesture as the 'voice' of a performed composition, with both the performers and audience being musically conducted by a silent signing musician. From the moment the audience entered the space, they would be encouraged as much as possible to communicate through silent gesture, without using their vocal cords. Gestural patterns would be set up that the musicians could imitate through related gestures and non-vocal sound production. The hypothesis was that music has a multi-modal potential – in which gesture can be identified as the principal musical activity – that is appreciable by an audience irrespective of hearing ability. The intention was for the audience to 1) perceive gestural patterns as music (when juxtaposed with each other, or analogous sonic and vibrotactile expressions), 2) to imitate these gestures and 3) engage in a call and response with the signing conductor; i.e., a musical-gestural conversation.

4.4.3 METHOD

Event and Participants

The researcher and 3 musical research assistants conducted *The Sense Ensemble Study #1* on May 26, 2016, in the Printing House Hall in Trinity College Dublin (see video link: Higgs, 2016). 26 participants - 22 hearing and 4 deaf - were recruited through poster advertising, social networking and email with the clear knowledge that they would be participants in a multisensory musical study (see *Study #1* poster, Appendix 4.3). Specifically, it was explained that the study was being devised to test a crossmodal and intersubjective approach to music through an interactive performance that involved no spoken or written language.

Qualitative assessment of this crossmodal, intersubjective experience was to be drawn in two ways: 1) through feedback from participant interaction during the performance (this involved

[2] This term, coined by Edmund Husserl, is potent, and deserves more explanation than the scope of this thesis affords. As Beyer puts it, 'The term "lifeworld' thus denotes the way the members of one or more social groups (cultures, linguistic communities) structure the world into objects (Beyer, 2016).

participants engaging in a gestural call and response with the performers) and from interviews directly following the performance (this involved both a written questionnaire and an oral Q&A). To assess participant interaction, the performance was captured on video and analysed later by the researcher to determine the extent of audience engagement in the gestural call and response. The written questionnaire given to each participant given to each participant is provided in Appendix 4.5. The Q&A was captured on video, potions of which were later transcribed by the researcher for use in this thesis.

Ethical approval had been granted for the participation of vulnerable adults in advance of this research (see Chapter 2, Section 2.4 ETHICAL ISSUES for details and APPENDIX 2.1 for all related documentation). All participants were asked to read an Information Sheet (PIL) and sign a consent form in advance of the performance. After the performance, each participant was also given a debriefing sheet.

Materials, Design and Procedure

Initial work was carried out between the researcher, a choreographer experienced with deaf participants (Jessica Kennedy) and a first-year student of ISL in the Trinity College Centre for Deaf Studies (Caoimhe Coburn-Gray)[3]. The composer proposed that the choreographer and signer choose a sequence of four ISL signs that would constitute a visual and, if possible, percussive rhythm; i.e., the gestures might involve an audible strike of the hands or body. It was agreed that the meaning of the signs, individually or collectively, should not factor into the choice. The signs would be chosen for their visual and percussive qualities alone, and their rhythmic (both visual and sonic) elegance in combination with each other.

The four chosen signs, demonstrated below by the researcher in Figures 4.11- 4.14, presented a compelling rhythm in 4/4 time. Three of the signs were percussive (numbers 1, 3 and 4), involving either the hands slapping each other, or one hand striking the upper arm. The silent sign (number 2) interestingly provided a provocative visual rhythm, which witnesses later claimed was the most musical of all. Several reported that they began to hear a ‘sweeping sound’ the more they saw it during the performance.

[3] It is worth mentioning that the composer was unable to secure the commitment of one of the deaf workshop participants due to the time demands of the study.

Figure 4.12 ISL Sign 1 (percussive): '*Beat*' Left hand in a fist, right palm moves left to right striking top of right fist (all photos by author, 2017).

Figure 4.13 ISL Sign 2 (silent): 'Hour' Right hand in letter 'H', palm facing body, moves swiftly anticlockwise in a circle.

Figure 4.14 ISL Sign 3 (percussive): '*What*' Palms to self in 'L'; alternately snap fingertips in one hand off fingertips in the other.

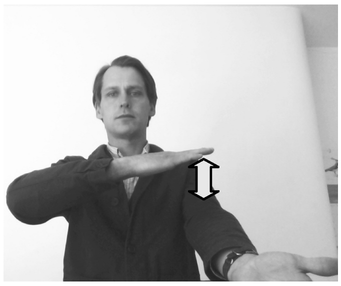


Figure 4.15 ISL Sign 4 (percussive): '*Walk*' Tap right fingers on left forearm twice. This sign has been adapted, as the arm position of the non-dominant hand is not correct for the "walk" sign.

The rhythm suggested by the four signs was further developed into a four-bar pattern which was to be repeated at regular intervals throughout the performance (see Figure 4.15).

Figure 4.16 The four-bar pattern using the four ISL signs. The first bar identifies each pitch with its respective sign. The pitch designation is purely arbitrary.

The composer used this gestural/percussive pattern as a quasi-lyric from which to compose the music for the overall piece; i.e., he used the gestures to inform the composition in the same way lyrics would conventionally inform the music they are set to (see score, Appendix 4.4). In this way the 'signer' was seen as the gestural analogue to a 'singer'. The signer's job was not merely to perform the signs, but to teach them to the audience during the performance so that they could participate musically. This intersubjective aspect was further developed by the separation of the audience into groups, each learning a different sign. Upon entry to the venue, participants were met by the signer who directed them to 4 separate seating sections, and also taught each section one of the four signs; i.e., a different part of the overall pattern (see Figure 4.16).

Figure 4.17 Signer teaching a participant Sign #2 when entering the venue [still image from video footage, (Higgs, 2016)].

Early in the performance, the signer demonstrated the entire pattern shown in Figure 4.15, and encouraged the separate sections to perform their signs at the appointed time in a form of gestural hocket[4]. The degree of success or failure for this enterprise was to provide key feedback during the performance in several respects. First, how well or poorly the groups were able to perform their parts, and furthermore coordinate with the other groups, would give a sense of the intersubjective efficacy of the composition and its performance; i.e., were the participants able to follow and join in with the narrative flow? Moreover, post-performance questions concerning this experience would give a full picture as to the sense of individual engagement. Another key element to be addressed through this gestural intersubjectivity concerned ideas from the motor theory of perception, as well as social cognition. The question here would be whether performing gestures related crossmodally to the sounds they made - as well as the haptic element of striking one's own body in coordination with a large group - might establish an increased sense of unity with the rest of the participants and performers.

In the course of the 15-minute piece, these minimalist unimodal gestures evolved into a multi-dimensional composition comprising crossmodal variations of the four-bar pattern using the following techniques (see also Instrument Technologies, Section 4.2):

1)Low frequency vibrations

Related to the chords in the composition, low frequency sounds (41 Hz, 49 Hz, 55 Hz, 65 Hz and 73 Hz), were transmitted using two different techniques: a) 4 bass shaker speakers attached

[4] hocket – Also known as *hoquet*, this technique involves a single melody being shared between two voices. French motets in the Notre Dame school (*ars antiqua*) are cited by some as the earliest documented instances, but it likely existed in a variety forms elsewhere long before. It can be found around the world: e.g., Bali (*Kecak, Gamelan*), Uganda (*Bigwala*) and Guinea (*balafon* arrangements for two or more players).

to the hardwood floor of the venue at strategic points, and b) a single subwoofer placed behind the stage area. The researcher was keen to discover which technique was more effective in performance, and conducted numerous experiments with the placement of each.

2)Colour coordination between seeds and 'section pole' flags

Upon entering the venue, each participant was handed a small seed, either a bean or a pea, with one of the following four colours: red, black, white or green. Along with their assigned gesture, the colour of the seed designated the seating section for the participant. Each seating section was identified by a pole at the top of which hung a flag with a colour corresponding to the seed colour.

3)Section poles being stamped on the floor

The performers used the section poles to stamp the gestural rhythm in a hocket; lifting the weighty structures a few inches, and letting them drop onto the hardwood floor to resonate thunderously throughout the venue.

4)Vibrating objects in speakers

A bare loudspeaker driver that pulsed infrasonically - so that it moved but made no sound - was brought around the venue. Each member of the audience was directed to drop the seed they had been given into the loudspeaker. The addition of seeds caused the loudspeaker to behave percussively, with the seeds bouncing off each other and hitting the speaker surface.

5) Choreographed assembly of a performance structure

As the performance progressed, a scaffolding structure was erected on the stage by two of the performers, and musical instruments – electric guitar, bass guitar and drums – were installed. This construction process was highly choreographed, so that the movements of the 'builders' were in keeping with the overall, gestural-percussive pattern (Figure 4.15).

6) Performance by guitar, bass and drums

While the signer brought the audience in and out with their gestural hocket, the three other performers took up their instruments and played a piece of music that fit in with the gestural rhythm (see Figure 4.17). This piece of music had memorable melodic and harmonic content (rich, chopping guitar chords), as well as a strong groove (a syncopated, staccato bass line). Audience members later described it as 'lyrical funk'.

Figure 4.18 The signer performs the gestural rhythm while the 'backing' ensemble fits into her groove [still image from video footage, (Higgs, 2016)].

7) Smoke rings; rhythmic and arhythmic

The signer shot smoke rings across the venue from a vortex cannon (see Figure 4.18; see vortex cannon description in Instrument Technologies, Section 4.2). These smoke rings occasioned a rhythmic dichotomy: i.e., they could be ejected rhythmically but their movement across the venue was temporally independent, giving the effect of an expressive, ghostly rubato. It should be mentioned that the smoke rings constituted not only visual and sonic expressions (by the sound of the cannon being struck). They were also tactile, by virtue of the smoke rings palpably striking the audience.

Figure 4.19 Smoke rings fired across room and at audience [still image from video footage, (Higgs, 2016)].

8)Shadow-play semaphore

The piece culminated with the signer lowering a sheet, and performing semaphore signs with her body. Back-lighting caused her form to be in silhouette, thus creating a shadow-play dance (see Figure 4.19). The idea here was to investigate if the audience found the two-dimensional semaphore silhouettes more or less expressive than the three-dimensional signs, which included facial expression. Non-manual features such as facial expression have a pivotal role in the grammar of sign languages (Leeson & Saeed, 2012).

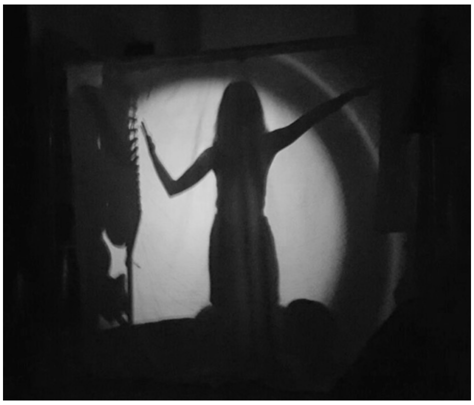


Figure 4.20 Shadow play semaphore: the signer performs semaphore signs behind a sheet with backlighting [still image from video footage, (Higgs, 2016)].

All of these techniques were carefully orchestrated to work together in a crossmodal harmony. A sense of how this harmonic integration was approached is given in Figure 4.20.

Figure 4.21 Excerpt adapted from score showing crossmodal harmonic relationships, giving the sense of how the gestures related to the diverse other musical techniques described above. This excerpt does not correspond with a single section of the score, but is a combination of several sections.

The diagrams on the following pages (Figures 4.21 – 4.24) detail the structure of the study, which comprised 4 stages:

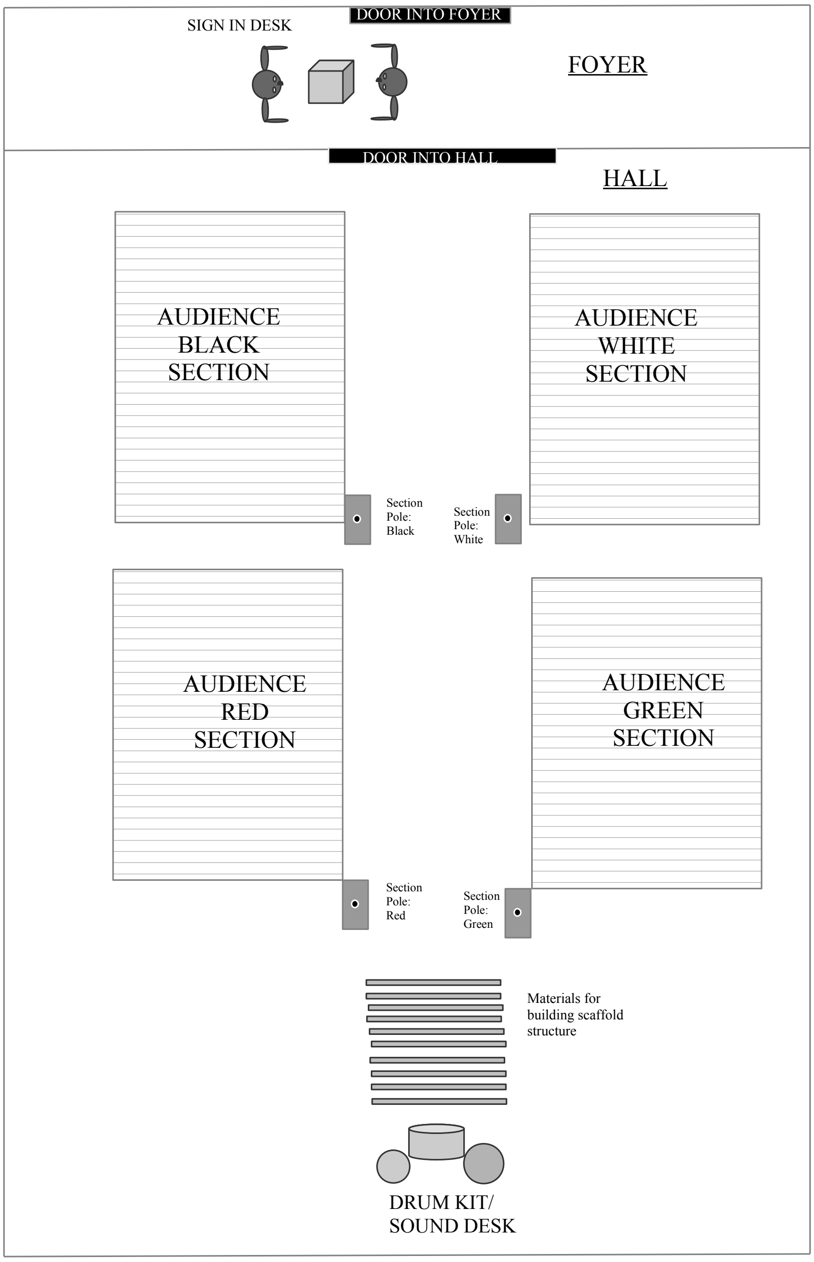


Figure 4.22 Stage 1 of *Sense Ensemble, Study #1*: The signer teaches participants signs as they enter the venue. The signer gives participants a seed whose colour is related to their sign and the audience section they are meant to sit in. The audience members find this section by means of poles with coloured flags corresponding to the colour of the seed they have been given. As the audience enters the venue, the researcher/drummer is operating a sound desk which is sending low-frequency vibrations through a subwoofer at the far end of the hall, 4 bass shaker speakers placed strategically in the venue and two bare loudspeaker drivers placed on the floor.

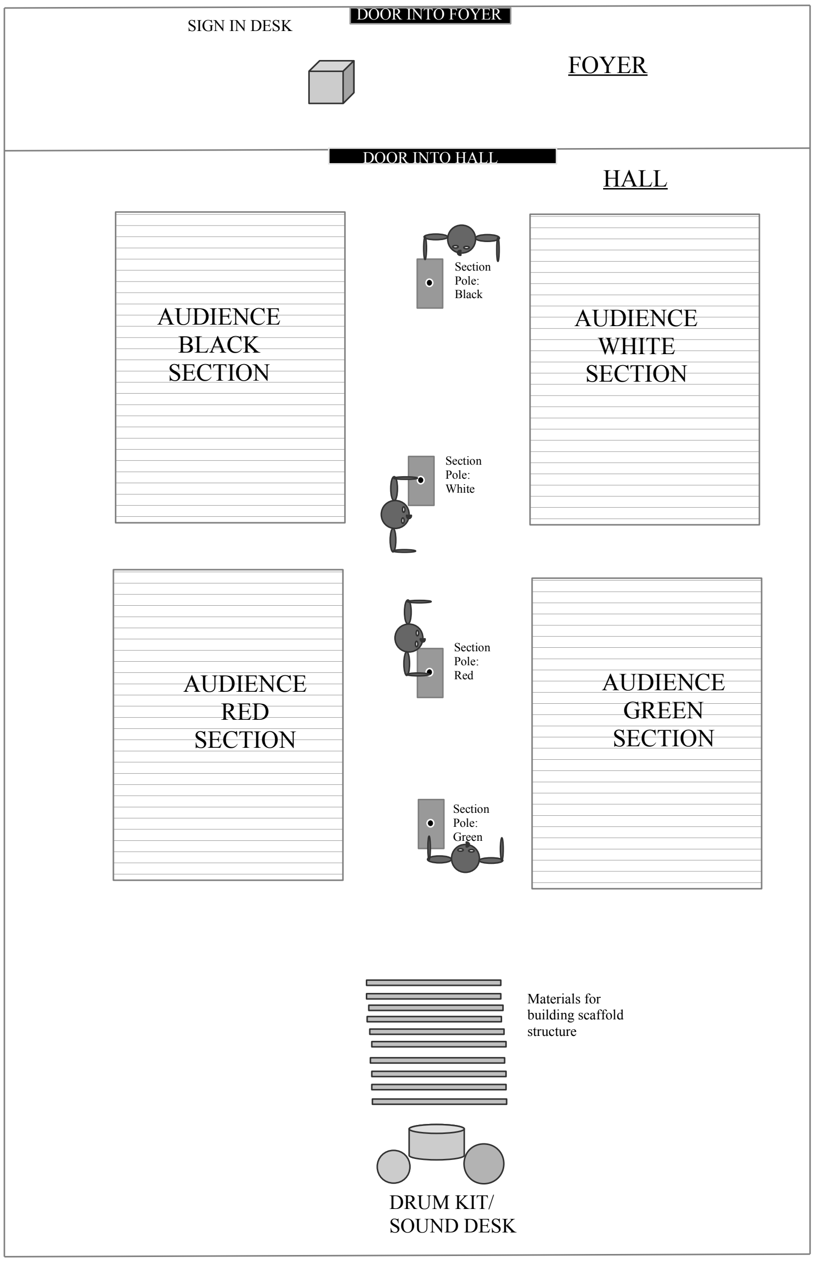


Figure 4.23 Stage 2 of *Sense Ensemble, Study #1*: Once the audience is seated, the four performers each take one of the four poles marking the audience sections and stand along the centre aisle. The flag colours (red, green, white and black) correspond to the seating sections, the seed the audience members have been given, and the colour of the performers' clothes. The performers execute a rhythm by stamping the bases of the poles on the floor of the venue. The rhythm is based on the fundamental pattern for the composition, and is presented as a hocket divided between performers.

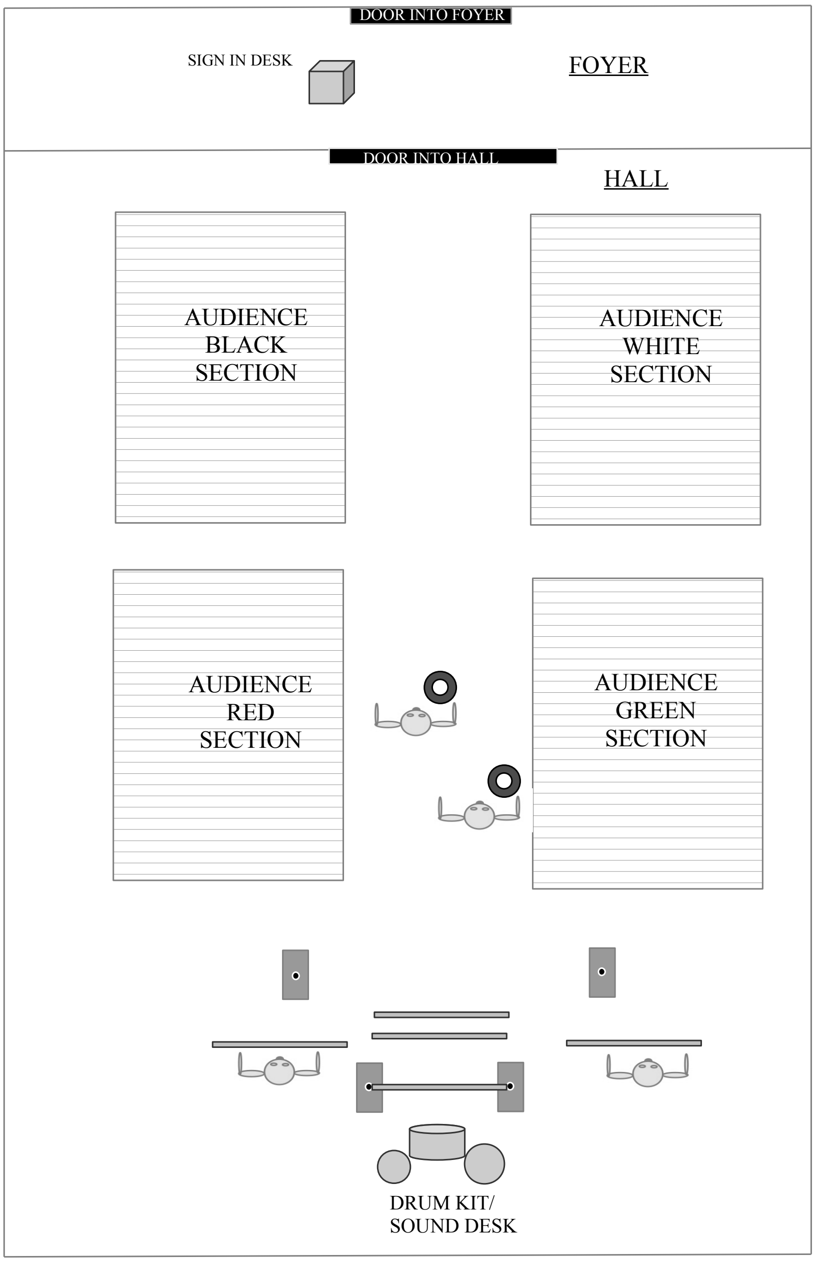


Figure 4.24 Stage 3 of *Sense Ensemble, Study #1*: Two of the performers (guitarist and bassist) begin a choreographed assembly of the scaffold structure and instruments in the stage area (at the far end of the hall). The other two performers (signer and researcher/drummer) carry the bare loudspeakers, which are emitting a steady pulse of low-frequency vibrations, around the venue. They invite audience members to place the coloured seeds they were given into the loudspeaker. Each seed is caused to vibrate percussively in the loudspeaker. As more seeds are added to each loudspeaker, the sound builds up to an impressive level as the seeds vibrate together.

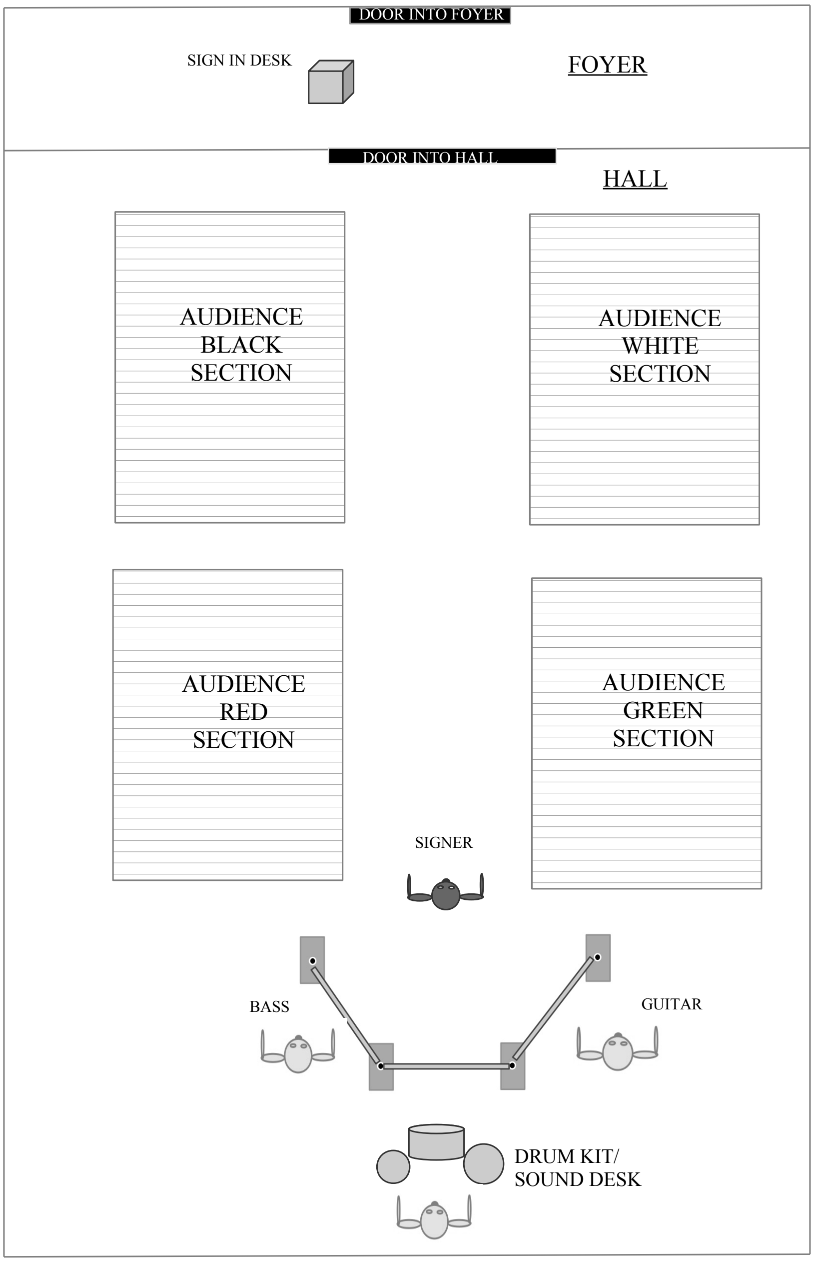


Figure 4.25 Stage 4 of *Sense Ensemble, Study #1*: This final stage involves several smaller stages:

a)The signer, bassist and guitarist teach the individual sections of the audience how to execute their signs as a patterned hocket.

b)The musicians begin performing a composed piece on the scaffold structure based on the gestural pattern. The signer performs the signs as part of the music.

c)The signer fills the vortex cannon with smoke and sends smoke rings across the venue and into the audience.

d)The signer brings down a sheet, and concludes the performance with a shadow play in which she performs semaphore signs in 2-dimensional silhouette.

4.4.4 RESULTS

Overview

Each audience member individually filled out an anonymous questionnaire immediately following the performance, and then all stayed behind for a Q&A led by the researcher. Teachers attending from St Mary's School for Deaf Girls acted as ISL interpreters for deaf participants, helping translate any problematic terms in the questionnaires for the deaf audience members. This discussion began with specific questions by the researcher addressing audience experience, and later broadened into an open conversation concerning the performance and musical experience in general. The Q&A was captured on video, and transcribed later by the researcher. The text was analyzed using a conventional content analysis technique (Hsiu-Fang & Shannon, 2005).

The overall response, both through questionnaire and discussion, was that the audience felt connected to the musical performance – irrespective of hearing ability – and had an awareness of the different senses working in combination in their musical experience.

QUESTION	Yes	No	Abstain
Are you deaf or hard of hearing?	15%	85%	-
Did you feel musically engaged by the performance?	100%	-	
Did you feel a heightened awareness of senses beyond hearing for your experience of the music?	92%	-	8%

Table 4.1 Initial audience survey questions and their results. The full questionnaire can be found in Appendix 4.5.

The responses to the initial questions (Table 4.1) clearly confirm both deaf and hearing being musically engaged, and being more aware of non-auditory expressions of music. This was overwhelmingly reinforced in the post-performance discussion. Here are example comments from two separate hearing participants:

> *'The lack of speech meant I was ready, senses engaged, and open to what came next.'*

> *'Having to interact in a new way without preparation immediately turned on a section of my brain to do with communicating that is normally switched off. I was alert from then on, and everything I saw became more important.'*

Gestures

The audience's success at performing their individual gestures as part of a group constituted a vital form of intersubjective feedback, i.e., the signer communicated a pattern successfully to the participants who in turn performed the pattern as a coordinated group. Additional feedback on post study questionnaires offered key insights as to the intersubjective and crossmodal awareness of participants (Table 4.2). The majority of participants felt the signs were musical in nature, and also felt themselves members of their seating section by virtue of their shared gestural function in the overall rhythm.

QUESTION	Yes	No	Abstain
Did you feel the gestures the signer was performing were musical in nature?	96%	-	4%
Did you feel yourself to be a member of your section (where you were sitting) when you were performing your signs?	96%	-	4%

Table 4.2 Audience survey questions concerning gesture and their results.

The post-performance interviews gave a more thorough sense of the audience reaction to the gestures. The researcher asked whether the audience would consider the gestures to be a form of voice. The reaction by hearing participants was overwhelmingly in the affirmative, with the specific comment being made: 'I felt I was listening to the signer's movements; I'm even talking about the stuff you couldn't hear.' Both hearing and deaf members of the audience agreed that the signer's gestures constituted a clear rhythm. As it was mentioned in an earlier section, the silent sign (Figure 4.12) came to be appreciated as somehow the most audible; being described as a 'sweeping sound'.

Other Musical Techniques Relating to Gestures

In the post-performance discussion, the researcher asked members of the audience to comment on the success of the other compositional techniques that were informed by the gestures (Table 4.3). It is clear that the subwoofer was highly effective in offering the audience a tactile experience of the low frequency pulses, while the bass shaker speakers could not cover the large floor area. Furthermore, the table indicates that participants were moved by both the performance with the poles and the ensemble of bass, guitar and drums. As for the former, the audience felt the pole rhythm's direct relationship with the gestural rhythm (see score excerpt, Figure 4.20) helped reinforce the pattern in their minds. The audience were moved by the ensemble musicians' performance, especially the manner in which their individual movements related to the gestures of the signer. An interesting fact that the table accounts for is the audience reaction to the shadow-play semaphore. Many commented that the movements of the signer's silhouette were emotionally potent, but lacked the communicative essence of her earlier signing. As one hearing participant described it:

> *'I felt the signs in person* [not shadows] *were really talking, or even singing to me. The shadow forms were beautiful, but didn't speak in the same way.'*

TECHNIQUE	PRINCIPAL MODALITY	RESULT
Low frequency vibrations; bass shaker speakers	tactition	-floor area too large -all of audience did not seem to feel these
Low-frequency vibrations; subwoofer speaker	tactition	vibrations felt throughout the venue by all
Colour coordination: seeds/flags/seating sections	vision	audience highly aware of these connections
Section poles stamped on floor	vision, tactition, audition	crossmodal awareness very strong
Vibrating objects in speakers	vision	intersubjective aim clear to audience
Construction of performance edifice	vision	audience oblivious to rhythms in building
Performance by bass/guitar/drums	vision, audition	-audience reported strong connection with gestures
Smoke rings	vision, tactition, audition, olfaction	-audience felt moved by rhythms of the rings
Shadow-play semaphore	vision	-reported to be powerful but less communicative than signs

Table 4.3 Response to other techniques in post-performance discussion.

The most surprising feedback, however, concerned the use of the vortex cannons. The audience was not merely taken with the smoke rings as a novelty feature, but also reported delight at seeing the rings shot from the cannon in time with the music and the impact of the rings on their faces. They were cognizant of the rings' rhythmic duality mentioned earlier: i.e., the rings' being projected in strict time from the cannon by the signer, but thereafter adopting their own rhythm across the venue. The audience were effusive on the subject, with one individual coining the phrase, *'the smoke's poetry of movement'*.

4.4.5 DISCUSSION

Sense Ensemble Study #1 presents one model for a multimodal experimental method, and offers results that support the hypothesis that all music has a crossmodal, intersubjective potential which can be appreciated by audiences irrespective of hearing ability. Several important issues arose in the analysis of the feedback and questionnaire. First it would have been preferable to use a professional signer to assist the deaf participants in understanding the questionnaire. Second, even with a professional signer, examining the notion of voice in the presence of both hearing and deaf participants is problematic. It is one thing to ask a hearing participant if he or she might be willing to regard gestures as a form of voice. On the other hand, the issue is raised as to how one discusses 'voice' with a deaf person. Since a deaf person does not have the same vocal experience as a hearing person – e.g., a sonic and vibrotactile (via bone conduction) identity developed over a lifetime of hearing oneself speak – the notion of 'voice' for each group is likely to be very different. This is not to fault the hypothesis of the study, which was to encourage an audience think of gesture in musical terms as a voice, but to critique the way in which this aim was shared linguistically with deaf and hearing groups. Suffice it to say, this issue needed to be addressed with more consideration.

Further studies would be recommended that might 1) attempt to take a more detailed look at the successful techniques used in this study for crossmodal musical composition, 2) work with larger audience numbers and 3) consider the notion of voice more rigorously.

4.5 *THE SENSE ENSEMBLE, STUDY #2*

Study #2 comprised a compositional study performed in The Beckett Theatre, Trinity College Dublin, October 23, 2016, which further developed a selection of the multisensory techniques used in *Study #1*.

4.5.1 INTRODUCTION

The study was advertised as part of a performance to mark the 20th anniversary of Music and Media Technologies, Trinity College Dublin (see concert programme, Appendix 4.6). The researcher was invited to compose a piece of music for the anniversary show, and chose it as an opportunity to develop further some of the techniques employed in *Study #1*. As detailed in the previous section, *Study #1* experimented with a range of devices for addressing multiple senses: subwoofers, vibrotactile transducers, sign language rhythms, a shadow play and vortex rings. The fundamental interest concerned gesture in its broadest sense: how a sense of bodily movement is fundamental to our understanding of music. The present study continues this exploration, focussing on the use of ostensibly visual signals to establish a musical sense, and then playing with the combination of senses that enter into the experience of these signals.

It is worth noting the following differences in performance circumstances between *Study #1* and *Study #2*:

1) Larger venue: The Samuel Beckett Theatre used for *Study #2* is 4 times the volume and seating capacity of the Printing House Hall used in *Study #1*. The Samuel Beckett Theatre has a maximum seating capacity of 205. The size of the audience on the night of the performance was approximately 200.

2) Stage machinery: The Samuel Beckett Theatre, unlike the Printing House Hall, is equipped with dedicated stage machinery, including an extensive lighting rig with a wide range of lamps and an excellent sound system with bass bins.

3) Participation by an established string quartet: The CRASH Ensemble string quartet, the foremost contemporary classical ensemble in Ireland, was hired to perform at the event. The quartet's leader, cellist Kate Ellis, showed a willingness to participate in the gestural activity inherent in the research aims for *Study #2*.

4) A combination of adapted instrument technologies and conventional instruments: The researcher aimed to find a rapport between his adapted instrument technologies (see Instrument Technologies, Section 4.2) and conventional instruments provided by The CRASH Ensemble string quartet.

5) Bodily gesture and extended technique for conventional instruments: The CRASH string quartet were open to inserting scored bodily gesture into their performance, as

well as performing a type of extended technique known as the bluegrass 'chop' (see below, 4.5.2 Method).

6) Participatory research strategy on a larger scale: The interactive feedback approach used in *Study #1* would be further explored in *Study #2* on a larger scale (by virtue of the larger venue and audience).

7) An olfactory addition to smoke ring cannons: The fluid in the smoke machines was treated with a vanilla oil which gave the smoke rings a conspicuous fragrance as they were sent through the auditorium.

4.5.2 AIMS AND HYPOTHESIS

Thus, the overall aim of Study #2 was to refine select techniques used in *Study #1* and to assess their effectiveness under the altered circumstances specified above. Similar to *Study #1*, the hypothesis was that these techniques would be effective in demonstrating that music has a multimodal potential appreciable by audiences irrespective of hearing ability.

4.5.3 METHOD

Participants

The overall audience on the night of the performance comprised:

-60% ex-students of the Trinity College Dublin Music and Media Technologies Master's Programme

-40% people from outside the college with an interest in contemporary music

-1% (2) deaf individuals that the composer had invited to the performance. The deaf individuals were women, both twenty-years-old.

Due to the size of the audience and venue, *Study #2* did not involve the use of audience-wide questionnaires or post-performance Q & A to the extent that Study #1 had. Instead, the results of the study were measured primarily through 1) participatory feedback, which was then assessed in a post-performance meeting by seven individuals acting as consultants and 2) use of the 2D and 3D documentation which was captured in performance (see Higgs, 2016). The consultants included:

1) SP 1 and SP 2,

2) the cellist in the CRASH Ensemble quartet and

3) 4 audience members, 2 of whom were profoundly deaf. The deaf individuals both wear ALDs. It was decided that they would turn them off during the musical performance, but turn them on for the introduction of the piece.

Ethical approval had been granted for the participation of vulnerable adults in advance of this research (see Chapter 2, Section 2.4 ETHICAL ISSUES for details and APPENDIX 2.1 for all related documentation). All participants (i.e., the 7 acting as consultants) were asked to read an Information Sheet (PIL) and sign a consent form in advance of the performance. After the performance, each participant was also given a debriefing sheet.

Design

The researcher composed a study for 1) string quartet and 2) two signer/percussionists (SP 1 and SP 2), the latter performing ISL patterns as well as playing the vortex cannons (see Study #2 score, Appendix 4.7). In its notes, the score makes clear designations for stage machinery, specifically lights and audio system. In performance, the score was to provide the conditions for 8 minutes of music. As a documentational aspect, the researcher worked closely with Trinity College Dublin researcher Dr Enda Bates, whose work comprises surround sound and 3D video[5]. Dr Bates was interested in capturing the performance for his own academic pursuits, and the researcher felt the surround sound and 3D video document would prove a valuable resource for post-performance evaluation (see video link: Higgs, 2016).

ISL Signs

Because *Study #2* would use a larger venue with a raked seating area, the researcher decided to replace two of the signs used in *Study #1* in order to ensure communication with the audience. It was felt that signs 1 and 2 (Figures 4.11-4.12) would be too nuanced considering the large variety of perspectives available in the Samuel Beckett Theatre, specifically: 1) a

[5] Dr Bates and the researcher are both members of the Spatial Music Collective, a group of composers who collaborate on surround sound performances around Ireland.

wider venue meant more perspectives on the horizontal plane 2) the raked seating area meant more perspectives on the vertical plane and the 3) the depth of the seating area meant that overly nuanced signs might be ambiguous to those at the back of the auditorium.. The new signs, while ambiguous in terms of their ISL meaning, were chosen for their simplicity (Figures 4.25-4.26). These new handshapes sometimes referred to as ‘classifier predicates (Leeson & Saeed, 2012; Leeson, Saeed & Grehan, 2016; O’Baoill & Matthews, 2000).

Figure 4.26 *Study #2*, Sign 1 (silent): This is not an ambiguous ISL sign. Open left palm open is presented at chest level (both photos by author, 2018).

Figure 4.27 *Study #2*, Sign 2 (silent): This is an ambiguous ISL sign. Open left palm open is presented at chest level.

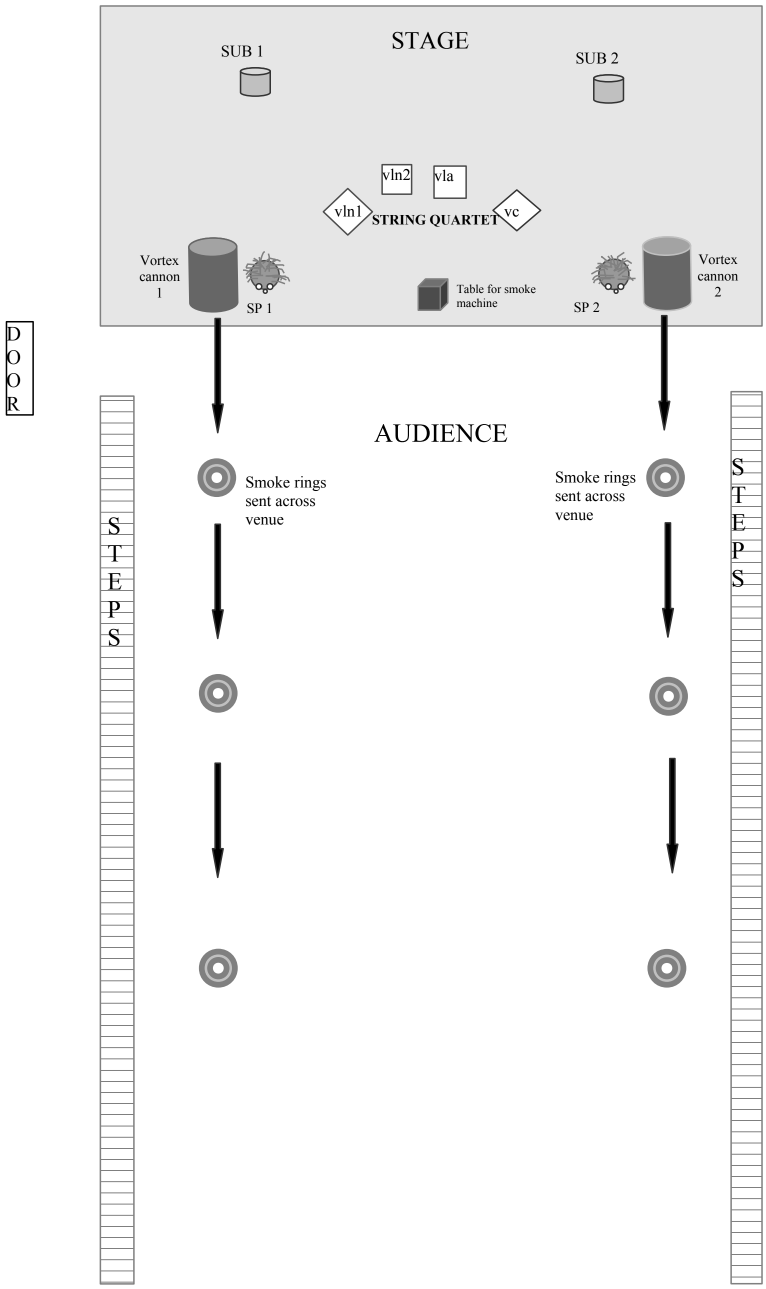


Figure 4.28 Plan of the Samuel Beckett Theatre, Trinity College Dublin, and layout of stage for *The Sense Ensemble, Study #2*. The stage is pre-set with string quartet and smoke machine. SP 1 and SP 2 enter, teach signs to audience and quartet and cue the quartet to begin their tremolando sections by sending smoke rings across the venue (See Plan of *Study #2* on next page for full details).

While a detailed account of the study is given in the "Plan of *Study #2'* notes below and the score, the following techniques feature in the methodology:

1)Two of the ISL gestures used in *Study #1* and two new signs are used to inform the composition as a lyric (Figures 4.25-4.26, 4.14 – 4.15).

2) SP 1 and SP 2 teach the audience the signs, and SP 2 teaches the quartet the signs. This interaction serves to bind the performers and audience together, and reinforce a sense of intersubjective awareness.

3)The members of the string quartet take their cues from the vortex cannons: beginning their tremolando (bar 38) when the cannons are struck and using the smoke rings' progress across the auditorium to time their rallentando (bars 39-41)[6].

4) The string quartet employ the following extended techniques: 1) the bluegrass 'chop' when emulating the ISL signs and 2) the use of visible, bodily movement suggested in the score. These techniques allow a fresh perspective on conventional technologies, suggesting a different way for them to be inhabited (Heidegger, 1982/1991).

Plan of *Study #2* (section letters correspond with score, see Appendix 4.7)

Section A:

The stage is pre-set with the string quartet arranged in an arc at centre stage (see Figure 4.27). Downstage centre is a table with a smoke machine on it. SP 1 and SP 2 enter the venue from stage left, and face each other in the middle of the stage between the string quartet and smoke machine. After a very deliberate and conspicuous gestural count-in of 4 beats (Figure 4.29), SP 1 teaches SP 2 the predetermined pattern of hand gestures, some of which have percussive qualities (Figure 4.28). After the pattern has been repeated 3 times, SP 1 indicates for SP 2 to stop. SP 1, still silently counting, turns to the audience in preparation to teach them the signs, while SP 2 turns and moves upstage to teach the signs to the string quartet. After a pause of 2 bars, SP 1 repeats the gestural four-beat count in, and begins to show the signs to the audience, encouraging them through eye contact and body language to imitate[7] (Figure 4.30). SP 2 meanwhile teaches the gestures to the

[6] Tremolando refers to a trembling effect, in this case a rapid reiteration produced on the strings by moving the bow quickly back and forth. Rallentando refers to a gradual decrease in tempo, in this case coming to a complete halt.

[7] This involved engaging all members of the auditorium with the gaze, as well as turning the body towards different areas of the auditorium by way of invitation to participate.

string quartet (Figure 4.31). The quartet, rather than using their hands, interpret the gestures using their instruments as scored in bars 25 through 28 (Figure 4.32). Each member of the quartet takes a different sign, thus they hocket the gestural rhythm.

Figure 4.29 *The Sense Ensemble, Study #2*: SP1 teaches SP2 the ISL gestural pattern, or motive (Photo: Tristram Miles-Dalton, 2016).

Figure 4.30 *The Sense Ensemble, Study #2*: SP1 uses a deliberate count-in to cue the audience in and out of the gestural pattern (Photo: Tristram Miles-Dalton, 2016).

Figure 4.31 *The Sense Ensemble, Study #2*: The audience imitate the gestures shown by SP1 (Photo: Tristram Miles-Dalton, 2016).

Figure 4.32 *The Sense Ensemble, Study #2*: SP1 teaches the audience the gestures, while SP2 teaches the quartet. The quartet use scored bowing techniques to imitate the pattern, rather than hand gestures (Photo: Tristram Miles-Dalton, 2016).

Figure 4.33 *The Sense Ensemble, Study #2*, bars 25 - 28. The manner in which the string quartet is scored to interpret the signs demonstrated by SP 2.

Section B :

This section involves the vortex cannons being struck by SP 1 & 2, and the string players using the movement of the smoke rings from the stage to the back of the auditorium as cues (Figures 4.33 – 4.34). The string players are cued to begin their tremolando (e.g., bar 38) when the vortex cannons are struck. The quartet are advised in the notes to use the score as a guideline, but correspond their rallentando in the ensuing bars (e.g., bars 39-41) as much as possible with the smoke rings, which slow down in their progression across the large chamber. As indicated in the score, the quartet bow a series of double stops using tremolando with decreasing speed and increasingly clear articulation (for the latter, note the contrast between tremolando in bar 38 with the articulated notes in bar 39 and finally the staccato notes in bars 40 and 41). The change from semi-legato to clearly articulated notes is gradual, and not governed directly by the bar lines in the score. In fact, it is preferable that each member of the quartet make the change at slightly different times. That said, it is important that the rallentando is coordinated strictly between the players, even if the articulation shift is not. The cellist is musically in the best position to cue this, as she is decisively punctuating the beat with crotchets. The score note in bar 39, 'nod on beats', prescribes a method for keeping the tempo change together. At the cellist's lead, the quartet are instructed to synchronise the rallentando throughout the section by this nodding.

Figure 4.34 *The Sense Ensemble, Study #2*: SP2 sends a smoke ring from the stage with a vortex cannon. The striking of the vortex cannon, the journey of the smoke ring across the auditorium and its deceleration served as cues for the string quartet's tremolando and rallentando (e.g., bars 30-33, see score, Appendix 4.7) (Photo: Tristram Miles-Dalton, 2016).

Figure 4.35 *The Sense Ensemble, Study #2*: SP1 sends a smoke ring from the stage. SP1 and SP2 alternated sending smoke rings during Section B of the composition (Photo: Tristram Miles-Dalton, 2016).

Finally, this section introduces the use of more percussive bowing, even on notes which are pitched. This percussive aspect is meant to provide a vibrotactile association with the ISL signs by virtue of greater friction of the bow on the strings. Thus, in the final bar (or bars in certain cases) of the rallentando sections there is a direction for *au talon* (bar 41) [8]. This move toward the frog of the bow is meant to increase the percussive quality of the notes due to the greater hair tension. Furthermore, it is recommended that this *au talon* shift as well as the simultaneous rallentando is accompanied by an increase in pressure of the bow on the double stop[9]. In this way, the sound produced can be more like a 'pluck' effect than a bowed sound; the result of creating significant bow tension, and then releasing for a sharp attack. This technique – putting pressure on the strings and playing close to the frog – is essential to the chop, which is discussed below in Section C.

Section C:

This section involves the string quartet developing a narrative around the motive presented by the gestural pattern. SP 1 and SP2 are positioned stage right and left respectively where they cue the audience in and out with the sequence of signs (Figure 4.35).

Figure 4.36 *The Sense Ensemble, Study #2*: SP1 and SP2 are positioned stage right and left respectively as they cue the audience in and out of the gestural pattern during Section C of the composition (Photo: Tristram Miles-Dalton, 2016).

This section uses a considerable amount of ‘chopping’, a percussive bowing technique. The use of the chop in *Study #2* has a multisensory aim. First, it delivers a rich timbre which is appreciable in a vibrotactile manner through the bass bins even in the case of higher notes on the

[8] *Au talon* is a direction for the string player to bow using the area of hair near the frog, which is the end of the bow nearest the bowing hand.
[9] Double stop, for a string instrument, refers to a two-note chord formed by bowing/plucking two strings simultaneously.

viola and violin. This low-end response through the subwoofer loudspeakers is especially pronounced on the cello. Second, it is gesturally significant, requiring very sudden, jerking motions of the arm and elbow. Here are a few points on the technique:

-Bow area: All chopping is executed *au talon*. Rosin should be liberally applied to this area of the hair.

-Muting strings: The fingerboard hand should mute strings during the chop.

-Bow hold: The thumb should be straightened so that the plane of the bow hair is at an angle to the stings.

-Basic chop:

Down bow chop: Bring the bow down on muted strings at an angle to produce a ‘scratch’ sound.

Up bow chop: Lift the bow up from muted strings at an angle to produce a scratch sound.

-The scratch sound can greatly vary in intensity, ranging from a subtle non-pitched sound to quite a strident sound. A sound falling somewhere in between is recommended for this study.

-Two strings are generally chopped at the same time. Different strings produce a different timbre of chop, and the score generally indicates which strings to chop on.

-All notes with an 'x' notehead specify a chop. The pitches notated generally indicate which open strings should be chopped.

Some Additional Performance Notes for *Study #2*

Notation

While x-shaped noteheads were used for string quartet parts in order to distinguish percussive chops from pitched notes, it was decided that the gestural motive for SP1 & 2 would be scored with round noteheads. While of no significance to the audience, it was thought that for the performers this might help to identify the 'notes' as gestures with multimodal potential, rather than abstract percussion symbols. The same practice had been adopted for *Study #1*.

Body signs

In addition to emulating the ISL gestures as scored, the score invites members of the string quartet to reinforce their own playing through corresponding body movement (Figure 4.36). To be more specific, in certain places, such as Section B where the players are all sharing an even fundamental rhythm, this bodily movement is meant to accent each beat of the bar. In all other places with a greater degree of polyrhythm, each player should make an effort to emphasize their metrical accents in a way that is natural to them.

Figure 4.37 *The Sense Ensemble, Study #2*: The players were instructed by the score to amplify the movement of their bodies in keeping with the rhythms played on their instruments (Photo: Tristram Miles-Dalton, 2016).

Sound Engineering

In the performance of *Study #2*, the string quartet was miked with a combination of close and ambient transducers. Each instrument had its own pickup installed, a stereo pair of ambient mikes was positioned above the entire quartet and Dr Bates' surround sound microphone-array was positioned downstage of both the quartet and SP 1 & 2. The Samuel Beckett Theatre is equipped with a pair of Nexo LS 1200 Watt Sub Bass Bins, powered by a Crest Audio 1200 watt power amp. The researcher worked with the sound engineer to filter the signal coming from the quartet, specifically to boost the low C cello fundamental frequency: 65.4 Hz.

Lights

Lighting design and cues are provided as supplements to the score, being crucial for the nuances of the vortex rings. For the Samuel Beckett performance, lighting provisions involved:

> 1) two 15/30 Profile lamps to focus on the vortex cannon percussionists with R-371 gels.
>
> 2) (x8) Fresnels: positioned on either side of the auditorium above the seating, using both forward and rear lighting rails. These Fresnels (using R-742 gels) are meant to capture the smoke rings in motion as they progress from front to back.

The supplemental score notes indicate that the Fresnel intensity should be dynamic (the profiles maintain intensity), with intensity shifting from forward lighting rail to rear rail as the smoke rings move from the front to the back of the theatre. The smoke rings are sent from the stage, move quickly at first, then slow down to waver and fall off their linear course and finally disperse. The score indicates that this dynamism should be captured by the change in Fresnel intensity (see score, Appendix 4.7, bar 39).

4.5.4 RESULTS

As mentioned in the Participant Section, results were established by two means: a) post-performance meetings with audience consultatnts and b) analysis of the video documentation. In the meeting after the performance, the consultants were asked to comment on 1) audience interaction with the SP's gestures, 2) the extent to which they believed the ISL gestures constituted a musical expression, 3) their awareness of a strong performer/audience bond (collective sense), 4) the quartet's interaction with the smoke rings (from their own perspective), 5) the rest of the audience's awareness of the quartet's interaction with the smoke rings and 6) whether the string players were gesturally involved in their own performance (using enhanced bodily actions) and 7) anything the consultants personally noticed to be of significance during the performance. The researcher made an audio recording of the meeting, and transcribed it for conventional qualitative content analysis. An ISL interpreter was present for the meeting. The video documentation was reviewed by the researcher using conventional qualitative content analysis.

It was confirmed by the consultants and the video documentation that the audience successfully participated in the hocketted ISL rhythmic patterns. This feedback confirms what was already demonstrated in Study #1, but furthermore shows that such an intersubjective sharing of rhythms can function with a larger audience in a much larger venue. Assessment specifically by the 4 audience consultants confirmed their awareness of the string players' interaction with the smoke rings in terms of cuing. Specifically, both the cuing of tremolando by the vortex cannons being struck (bar 38) and rallentando being cued by the smoke rings' journey across the venue (bars 39-41) were apparent to these audience consultants. The consultants furthermore commented that most of the audience seemed to share the same awareness. The consultants reported a strong collective sense of the audience as a whole, one commenting that the music 'held all the people in the room together'. One of the deaf consultants mentioned specifically the vibrotactile effectiveness of the vortex cannons in this regard. Observing the other audience members having the rings of smoke hit their face, and then experiencing the rings hitting her face gave her a sense of 'being connected'. Additional comments were made about 1) the vanilla fragrance being noticeable, 2) the sense of play that was apparent to the audience and 3) the feeling that 'a story was being told with musical actions . . . without words'.

One aim of the study which seemed not to have made a significant impact on the audience was the use of bodily gesture by the members of the quartet. The audience consultants did not report awareness of the string players being gesturally involved to a greater or lesser extent than they might be in any other performance.

4.5.5 DISCUSSION

Study #2 adapted techniques from *Study #1* for use in a larger venue with greater audience numbers. Successful audience participation, and reporting by select observers, supports the hypothesis that the multisensory techniques used in *Study #2* were equally effective in presenting gesture as a conspicuous musical expression with intersubjective potency. Both studies beg important methodological questions around research through performance. Due to the number of variables in a live performance, ungovernable by controlled conditions, the researcher raises the issue of reproducibility. *Studies #1* and *#2* used comparable methods but under significantly different circumstances. Thus, the researcher proposed a new study under more controlled conditions which might enable it to be effectively replicated for verification purposes (see Section 4.6; *The Sense Ensemble, Study #3).*

4.6 *THE SENSE ENSEMBLE, STUDY #3*

Sense Ensemble Study #3 is an experiment comprising the performance of a music composition with specific research aims under controlled, empirical conditions. This experimental study was held in The Trinity Long Room Hub, March 23, 2017 and was based on the 'Sound Induced Flash Illusion' and the 'Touch Induced Visual Illusion' (Shams *et al.*, 2002; Shams *et al.*, 2005).

4.6.1 INTRODUCTION

Research has demonstrated a visual illusion induced by sound: a single flash on a screen is perceived as 2 flashes when the stimulus is accompanied by 2 beeps (Shams *et al.*, 2002). Further research has demonstrated a visual illusion induced by tactition: a single flash on a screen is perceived as 2 flashes when the stimulus is accompanied by two brief tactile stimuli (Shams *et al.*, 2005). These studies show that when conflicting information is received in separate modalities, one modality can consistently dominate over another to reconcile the perceptual conflict.

4.6.2 AIMS AND HYPOTHESIS

The aim of the study is to merge the visual illusion induced by sound with the visual illusion induced by tactition in order to explore modal dominance (crossmodal correspondence) in the case of conflicting information. This study is an attempt, moreover, to investigate such crossmodal correspondences on the level of harmony with a view to harnessing their potential for multisensory musical expression. The study involves a composition that presents combinations of different numbers of visual flashes, sonic beeps and vibrotactile pulses. Predictions based on the literature will be made as to perceptual conflicts in the reporting of the number of visual flashes by the participants, due to conflicting numbers of beeps and pulses (see Method below).

The hypothesis is that crossmodal correspondences between visual, sonic and tactile illusions can be predicted and demonstrated through an experimental, multimodal musical composition for deaf and hearing audiences. The researcher surmised that being able to predict such illusions would suggest new multisensory compositional techniques.

4.6.3 METHOD

Participants

Participants were recruited through a combination of poster advertisement, email and social network invitation (see *Study #3* poster, Appendix 4.8). 28 participants subscribed in total, with 17 of them being deaf individuals.

Ethical approval had been granted for the participation of vulnerable adults in advance of this research (see Chapter 2, Section 2.4 ETHICAL ISSUES for details and APPENDIX 2.1 for all related documentation). All participants were asked to read an Information Sheet (PIL) and sign a consent form in advance of the performance. After the performance, each participant was also given a debriefing sheet. All documentation was presented to deaf participants in ISL by staff from St Mary's School for Deaf Girls.

Design, Materials and Process

The researcher created a composition to be presented to individual participants (see below, Design of Composition; also see *Study #3* score, Appendix 4.9). Each participant was met in reception, and brought to a conference room where they were shown to a seat at a large conference table (see diagram, Figure 4.37). A computer monitor was positioned in front of the participants, two loudspeakers were hidden from view at either side of the monitor and a subwoofer was positioned under the table 75 cm in front of the chair. A miniature proscenium had been fashioned for the computer monitor, with a piece of fabric around it to cover the edges of the proscenium and the speakers at either side (Figure 4.38). This served both to reduce glare and to create a more relaxed atmosphere.

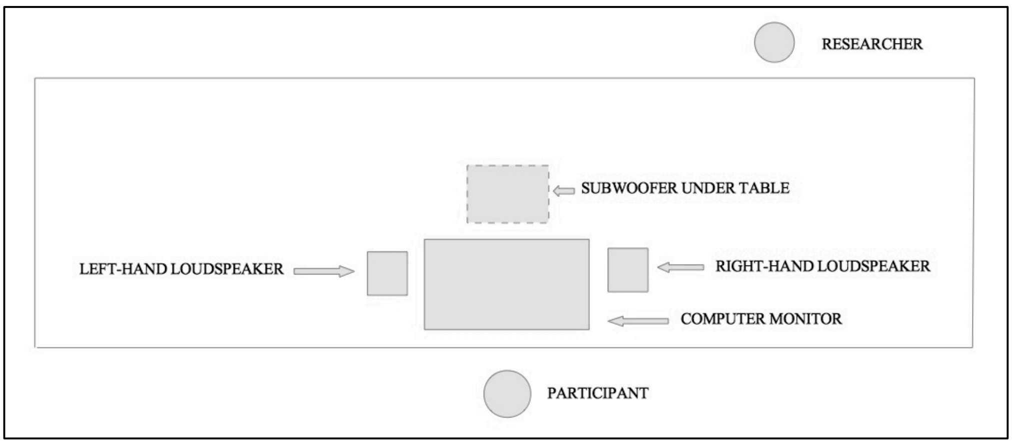


Figure 4.38 Layout of study in the conference room. The participant is seated at the table with a computer monitor and speakers (enshrouded by a miniature proscenium with a fabric covering it). Under the table, 75 cm in front of the chair, is a subwoofer.

Figure 4.39 Participants were seated at a conference table with a screen in front of them, two speakers hidden to each side and a subwoofer under the table in front of their legs (photo by author, 2017.

Subjects were asked to read a briefing sheet and sign a consent form granting permission for any results to be used anonymously. The participants were then told that a four-minute multisensory music composition would be played for them, and that the composition would consist of flashes on the screen, sounds from the speakers and audible/tactile vibrations from the subwoofer. It was explained that at regular intervals during that time they would see either 1 or two flashes (in very quick succession) appear on the screen. They were told that it was their task to indicate the number of flashes on the screen with their fingers each time the flashes appeared. Specifically, they were instructed to hold up one finger if they perceived one flash, and two fingers if they perceived two flashes. Participants were given further instruction on how to represent '1' and '2'with the fingers[10].They were assured that there was not necessarily a right or wrong answer, and that they should simply report what they saw. Subjects were asked to confirm that they understood the procedure. Deaf participants were asked to either remove or turn off their ALDs. Just before the composition began, subjects were asked to sit up straight, so that their eyes would maintain an approximate distance of 50 cm from the screen. As the composition played, the researcher (seated across the table) documented the number of flashes reported by participants. After the composition was played, each participant was given a debriefing form and thanked for their participation.

[10] It was shown in trials that there are a wide variety of ways to represent one and two with fingers. For some, '1' is represented by the thumb, and for others the index finger. '2', for some, is represented by the thumb and index finger and for others by the index finger and middle finger. Delays occurred when participants became flustered moving between '1' and '2'.

Design of Composition (see *Study #3* score, Appendix 4.9)

The four-minute-long composition consists of a Pure Data patch run on a Macbook Pro computer, triggered remotely by the researcher using a MIDI keyboard[11]. Occurring every 4 seconds throughout the composition are simultaneous combinations of visual flashes, sonic beeps and tactile pulses, with a total of 60 such instances (Figure 4.39). Each instance comprises a predetermined combination of one or two flashes, one or two beeps and one or two pulses. 10 combinations were chosen from the total number of available permutations (see Table 4.4). The first 30 seconds of the composition involves only these instances of flash/beep/pulse. After 30 seconds, however, there is additional thematic development in parallel with these instances, involving 4 different parts delivered as both sonic and vibrotactile expressions. When fully developed, the composition presents a reasonably involved, multisensory fabric.

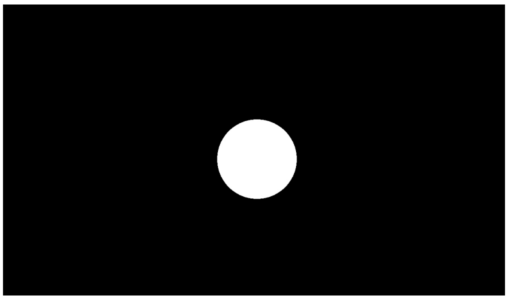


Figure 4.40 The white disc which was presented as a flash (screenshot by author, 2017).

PERMUTATION	# VISUAL FLASHES	# SONIC BEEPS	# TACTILE PULSES
I	1	1	1
II	1	1	2
III	1	2	2
IV	2	2	2
V	2	2	1
VI	2	1	1
VII	2	1	2
VIII	1	2	1
IX	2	0	0
X	1	0	0

Table 4.4 Study #3, Details of 10 permutations presented in the course of the composition, each six times.

[11] Pure Data is a graphical programming environment closely related in design and origin to MaxMSP.

It is worth considering the different permutations and how their combinations of flash/beep/pulse relate to the aims and hypothesis of this study (Table 4.4). Based on existing studies, certain combinations would be expected to produce a perceptual conflict (i.e., cause the participant to report a number of flashes that does not correspond to the number presented), while others would not be expected to create a perceptual conflict. The permutations in the composition include both, with the conflict permutations scattered randomly amongst the non-conflict permutations throughout the four-minute piece. Based on the literature, any permutation with 2 flashes (IV, V, VI, VII and IX) would not be expected to involve a perceptual conflict influencing the reported number of flashes. That is to say that, while there is a presentational conflict in some of these permutations, the literature shows that the presentation of 2 flashes is generally perceived as 2 flashes even when a 1 beep is presented simultaneously (Shams *et al.*, 2002). Should the results of this study prove otherwise in a statistically significant manner, it would be advisable to 1) question the experiment design, 2) consider the possibility in the case of V and VI that 1 pulse has a greater influence than 1 beep on the presentation of 2 flashes or 3) consider the possibility of a peculiar harmonic interplay at work; e.g., an emergent percept resulting from the specific combination of multimodal stimuli.

Naturally, those permutations with a single flash and either 1 beep/1 pulse or no beep/no pulse (I and X) would not be expected to involve a conflict (Shams *et al.*, 2002).

Thus, the 3 permutations which might be expected to involve a conflict are II, III and VIII. For hearing individuals, permutations III and VIII (having 1 flash and 2 beeps) have consistently been shown in the literature to receive a report of 2 flashes; thus, indicating a conflict (Shams *et al.*, 2002). For deaf individuals, however, the sonic beep would not be expected to influence the reported number of flashes. For deaf participants, on the other hand, permutations II and III might present a perceptual conflict due to the conflicting number of pulses.

The predicted results to the study are presented in Tables 4.5 and 4.6 below, and in simplified form in Table 4.7.

Deaf Results, Predicted

PERMUTATION	# VISUAL FLASHES	# SONIC BEEPS	# TACTILE PULSES	1 FLASH REPORTED	2 FLASHES REPORTED
I	1	1	1	x	
II	1	1	2		x
III	1	2	2		x
IV	2	2	2		x
V	2	2	1		x
VI	2	1	1		x
VII	2	1	2		x
VIII	1	2	1	x	
IX	2	0	0		x
X	1	0	0	x	

Table 4.5 *Study #3*, Predicted results of deaf participants, indicating the expected report (by means of an 'x') of 1 flash or 2 flashes for each of the 10 permutations of 1 or 2 flashes, 1 or 2 beeps and 1 or 2 pulses presented.

Hearing Results, Predicted

PERMUTATION	# VISUAL FLASHES	# SONIC BEEPS	# TACTILE PULSES	1 FLASH REPORTED	2 FLASHES REPORTED
I	1	1	1	x	
II	1	1	2		x
III	1	2	2		x
IV	2	2	2		x
V	2	2	1		x
VI	2	1	1		x
VII	2	1	2		x
VIII	1	2	1		x
IX	2	0	0		x
X	1	0	0	x	

Table 4.6 *Study #3*, Predicted reports hearing participants, indicating the expected report (by means of an 'x') of 1 flash or 2 flashes for each of the 10 permutations of 1 or 2 flashes, 1 or 2 beeps and 1 or 2 pulses presented.

Hearing and Deaf Predicted Results (simplified)

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
DEAF	+	-	-	+	+	+	+	+	+	+
HEARING	+	-	-	+	+	+	+	-	+	+

Table 4.7 *Study #3*, Predicted reports hearing and deaf participants, with a "+" indicating an accurate response (i.e., in which the reported number of flashes corresponds with the actual number of flashes presented) and a "-" indicating an inaccurate response (i.e., a perceptual conflict).

The stimuli of flashes, beeps and pulses are characterised as follows:

1)Flashes

a) Shape: Flashes are consistently solid discs.

b) Size:

Flashes 1-24 are discs with an area of 15 cm^2.

Flashes 25-27 are discs with an area of 1.2 cm^2.

Flashes 28-31 are discs with an area of 15 cm^2.

Flashes 55-60 are discs with an area of 75 cm^2.

c) Colour: Flashes were a solid colour presented against a black background.

Flashes 1-48 are white.

Flashes 49-55 are blue.

Flashes 56-60 are red.

d) Duration: Each flash lasts 33 milliseconds.

e) Delay between flashes: When there are 2 flashes, there is a 47 millisecond delay between.

f) Position: The flashing discs are in the centre of the screen.

2)Beeps

a) Frequency: Beeps are 1280 Hz sine tones.

b) Duration: The envelope of each beep comprises a 3 millisecond attack, a 30 millisecond sustain and a 3 millisecond release.

c) Delay: When beeps are repeated, there is a 30 millisecond delay between.

d)Volume: Beeps are rated at 75 dB SPL.

3)Pulses

a) Frequency: The pulse consists of a blend of a 40 Hertz sine tone with a 60 Hertz sine tone. It was found that this tactile ‘chord’ was more effective in terms of its attack than a single low frequency tone.

b) Duration: The envelope of each pulse comprises a 30 millisecond attack, a 50 millisecond sustain and a 30 millisecond release.

c) Delay: When pulses are repeated, there is a 50 millisecond delay between.

d) Volume: The SPL is difficult to gauge due to the low frequency of the pulse, but it is set as close to 75 dB SPL as possible.

4.6.4 RESULTS

Data Analysis

This is a preliminary study, and the number of participants was limited. The percentages of accurate versus inaccurate reports of the number of flashes give a clear picture of significance for both deaf and hearing groups.

Deaf Results

For deaf participants, the results for all permutations show a high percentage of accurate reports; i.e., the reported number of flashes agreed with the actual number of flashes presented (Table 4.8).

DEAF RESULTS (n=17)

PERMUTATION	# VISUAL FLASHES	# SONIC BEEPS	# TACTILE PULSES	1 FLASH REPORTED	2 FLASHES REPORTED
I	1	1	1	94% (16/17)	6% (1/17)
II	1	1	2	88% (15/17)	12% (2/17)
III	1	2	2	82% (14/17)	18% (3/17)
IV	2	2	2	12% (2/17)	88% (15/17)
V	2	2	1	6% (1/17)	94% (16/17)
VI	2	1	1	12% (2/17)	88% (15/17)
VII	2	1	2	24% (4/17)	76% (13/17)
VIII	1	2	1	82% (14/17)	18% (3/17)
IX	2	0	0	12% (2/17)	88% (15/17)
X	1	0	0	82% (14/17)	18% (3/17)

Table 4.8 Study #3, Results of 17 deaf participants, giving the percentage (fraction) of participants who reported 1 flash or 2 flashes for each of the 10 permutations of 1 or 2 flashes, 1 or 2 beeps and 1 or 2 pulses which were presented.

Hearing Results

For hearing participants, all permutations show a high percentage of accurate reports with the exception of permutation III and permutation VIII, which show a high percentage of inaccurate reports.

HEARING RESULTS (n=11)

PERMUTATION	# VISUAL FLASHES	# SONIC BEEPS	# TACTILE PULSES	1 FLASH REPORTED	2 FLASHES REPORTED
I	1	1	1	90% (10/11)	10% (1/11)
II	1	1	2	81% (9/11)	19% (2/11)
III	1	2	2	10% (1/11)	90% (10/11)
IV	2	2	2	10% (1/11)	90% (10/11)
V	2	2	1	19% (2/11)	81% (9/11)
VI	2	1	1	10% (1/11)	90% (10/11)
VII	2	1	2	10% (1/11)	90% (10/11)
VIII	1	2	1	19 % (2/11)	81% (9/11)
IX	2	0	0	10% (1/11)	90% (10/11)
X	1	0	0	90% (10/11)	10% (1/11)

Table 4.9 Study #3, Results of 11 hearing participants, giving the percentage (fraction) of hearing participants who reported 1 flash or 2 flashes for each of the 10 permutations of 1 or 2 flashes, 1 or 2 beeps and 1 or 2 pulses which were presented.

COMBINED RESULTS

As would be expected, combined reports show a high percentage of accuracy except in the case of permutations III and VIII, which show an ambiguous result.

COMBINED RESULTS (Deaf and Hearing; n = 28)

PERMUTATION	# VISUAL FLASHES	# SONIC BEEPS	# TACTILE PULSES	1 FLASH REPORTED	2 FLASHES REPORTED
I	1	1	1	93% (26/28)	7% (2/28)
II	1	1	2	86% (24/28)	14% (4/28)
III	1	2	2	54% (15/28)	46% (13/28)
IV	2	2	2	11% (3/28)	89% (25/28)
V	2	2	1	11% (3/28)	89% (25/28)
VI	2	1	1	11% (3/28)	89% (25/28)
VII	2	1	2	18% (5/28)	82% (23/28)
VIII	1	2	1	57% (16/28)	43% (12/28)
IX	2	0	0	11% (3/28)	89% (25/28)
X	1	0	0	86% (24/28)	14% (4/28)

Table 4.10 Study #3, Results of all 28 participants, giving the percentage (fraction) of participants who reported 1 flash or 2 flashes for each of the 10 permutations of 1 or 2 flashes, 1 or 2 beeps and 1 or 2 pulses that were presented.

SIMPLIFIED RESULTS

	P-I	P-II	P-III	P-IV	P-V	P-VI	P-VII	P-VIII	P-IX	P-X
DEAF	.94	.88	.82	.88	.94	.88	.76	.82	.88	.82
HEARING	.9	.81	.1	.9	.81	.9	.9	.19	.9	.9
DEAF & HEARING	.93	.86	.54	.89	.89	.89	.82	.57	.89	.86

Table 4.11 Study #3, Simplified results of deaf, hearing and combined groups, showing percentage of accurate reports for each permutation (P-I = Permutation I, etc.)

4.6.5 DISCUSSION

	P-I	P-II	P-III	P-IV	P-V	P-VI	P-VII	P-VIII	P-IX	P-X
DEAF PREDICTED	+	-	-	+	+	+	+	+	+	+
DEAF ACTUAL	+	+	+	+	+	+	+	+	+	+
HEARING PREDICTED	+	-	-	+	+	+	+	-	+	+
HEARING ACTUAL	+	+	-	+	+	+	+	-	+	+

Table 4.12. Predicted results versus actual results for deaf and hearing participants. with a "+" indicating an accurate response (i.e., in which the reported number of flashes corresponds with the actual number of flashes presented) and a "-" indicating an inaccurate response (i.e., a perceptual conflict).

Table 4.13 compares the predicted results with the actual results for deaf and hearing participants for each of the permutations (P-I through P-X). The actual results for deaf individuals show a high percentage of accurate reports for all permutations. Contrary to the predicted results, the presence of conflicting pulse stimuli in permutations II and III did not significantly affect the perception of flashes.

Rather than draw any conclusions from this result, he researcher feels the choice of vibrotactile stimuli should be reconsidered due to the resolution limitations of the subwoofer with respect to the flash and beep stimuli. To illustrate these limitations, Figure 4.30 shows the envelopes for flash, beep and pulse. The flash has a 30 ms sustain, no detectable attack or delay time (i.e., less than 1 ms), making it more or less an impulse. The beep has a 30 ms sustain, only a

3 ms delay to prevent distortion and a 3 ms release. This flash/beep combination is very similar to the literature, particularly Shams (2002), with whom the researcher was personally able to discuss the issues around relative timing of flashes and beeps. Unlike the flash and beep, however, Figure 4.40 shows a lack of temporal correspondence for the pulses, which, due to the large speaker driver of the subwoofer, required a 30 ms attack, and a 30 ms release, with a 50 ms sustain between. The researcher experimented with many variations of the vibrotactile envelope, and any shorter attack/sustain/release combination created either distortion or no pulse at all. Clearly, the lack of temporal correspondence will affect the possibilities for illusion, as Shams (2002) points out in the case of flash and beep. The issue is even more severe in the case of two pulses, where the lag between flash/beep and pulse becomes even more pronounced: 130 ms. Shams (2002) makes it clear that such a serious delay, almost one fifth of a second, will fail to produce a perceptual conflict between modalites.

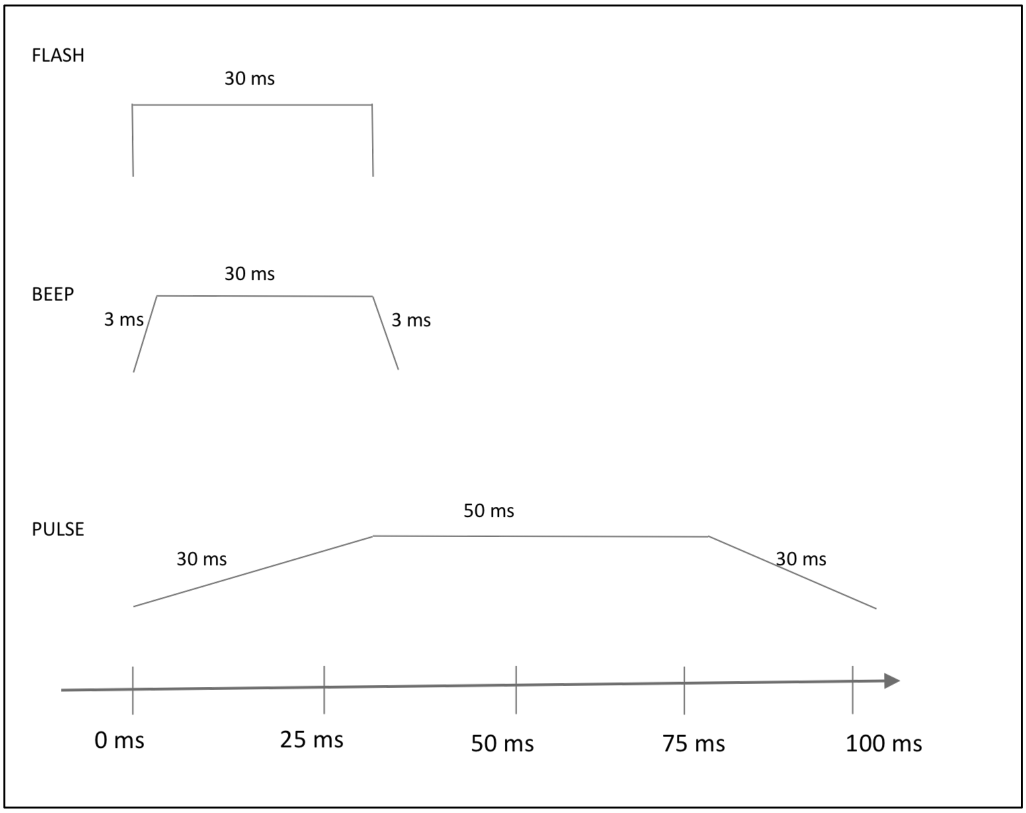


Figure 4.41. A comparison of multisensory stimuli, showing ADSR (Attack-Delay-Sustain-Release) envelopes for flash, beep and pulse.

In contrast to the deaf participants, the hearing participants' actual results did reflect the predictions in the case of both P-III and P-VIII. For a significantly high percentage of hearing participants, permutation II was the only instance in which a predicted result differed from the actual result; i.e., as with the deaf participants there seemed to be no influence of tactile pulse on the perceived number of flashes (Table 4.8). Once, again the researcher feels the vibrotactile pulse lacked the necessary resolution to create the conditions necessary to create an illusion, as indicated in Shams (2002).

The combined results in Table 4.9 indicate agreement between deaf and hearing participants except in the case of permutations III and VIII. This discrepancy can clearly be attributed to the fact that the presence of 2 beeps did not have the same influence on the perception of deaf participants that it did on hearing participants..

Just as there was no evidence that the vibrotactile stimuli influenced either visual or auditory perception, changes in the size and colour of the disc do not appear to have influenced the number of flashes perceived. After the composition had ended, a number of participants claimed that the change in disc size and colour was a source of confusion. Participants also found it awkward to report their perception of the number of flashes by holding up 1 or 2 fingers. Furthermore, they reported the general feeling of being rushed; i.e., there was not enough time between flash/beep/pulse combinations.

While the hypothesis for this study was supported by the accurate prediction of visual illusions induced by sound, these were merely a confirmation of illusions that are already well-documented in the literature. Predictions of visual illusions induced by touch were not upheld. As suggested before, these results should be treated with caution due to the limitations of the vibrotactile stimulus employed.

Further studies could thus be considered with the following changes:

1) Fewer variables are presented, i.e., the complexity of the musical composition could be more balanced to allow for participant concentration in such a task-oriented study.

2) A haptic device with greater resolution might be a better choice for presenting a vibrotactile stimulus (Hopkins *et al*. 2016).

3) A more defined method for participants to report the number of flashes perceived could be devised. This could be either through speech (the participant saying "one" or "two") or using two buttons on the table in front of the computer monitor.

4) There could be a greater delay between the presentation of flash-beep-pulse combinations; perhaps 8 seconds rather than 4.

4.6.6 CONCLUSION, *THE BALLOON STUDY*

Study #3 involved the performance of a music composition with specific research aims under controlled conditions. Specifically, the study aimed to experiment with a variety of crossmodal illusions, or conflicts, to explore their usefulness in multisensory composition. The responses of hearing and deaf participants were markedly different in areas of particular interest. While the sound-induced visual illusion was demonstrated for hearing participants, deaf participants, not surprisingly, did not exhibit a conflict between sonic and visual stimuli. The influence of vibrotactile stimuli on visual and auditory perception was not clearly present for either group. It could be surmised that this was due to the nature of the vibrotactile stimulus; a subwoofer incapable of necessary resolution and spacing between pulses of air. Moreover, the change in disc size for the flashes was potentially a distraction to the participants. In general, it is speculated that the complex nature of the composition possibly made concentrating on the perception of the flashes challenging. Furthermore, the spacing between flash/beep/pulse combinations could be increased to give participants adequate response time.

Study #3 provided valuable insights for the researcher in terms of composition as a form of research in a controlled setting. The fact that the performance comprised an 'audience' of one (the participant), and that the researcher was observing this lone audience member closely from across a table, is worth remarking on. It should even be said that this single audience member became a performer in the composition, with the researcher acting as a highly critical audience; scribbling the hasty reports of the participants into his notebook. The significance of this scene is by no means negligible. While such a situation of participant and observer is common in experimental studies, with subject and scientist acting in analogous roles, it is quite unlike most performance settings. It stands in stark contrast to *Studies #1* and *#2*, which had the audience performing as a group. Furthermore, in these earlier studies the researcher was performing along with the audience, rather than coldly observing and recording their reactions to his composition.

Arguably, a research 'event' that blends the conventions of performance and experimental study sheds light on both. In truth, controlled studies do indeed consist of a performance, though it is not often addressed as such. Equally, performance involves a complex form of study, in that an audience studies the 'quality' of the performance, and the performers study the reaction of the audience to the performance. An in-depth analysis of the performer/audience relationship is beyond the scope of this thesis, but has been addressed by others (Schechner, 2017). The literature for considering scientific study as a performance is not as common, however (Jacob, 1990). Moreover, examinations of the two working together are rare indeed, if not non-existent. The researcher suggests that merging experimental study and performance offers a powerful methodology for studying the nature of musical experience, and is worth further exploration.

4.7 CHAPTER 4 CONCLUSION

This chapter has presented a series of workshops and three studies which explored approaches to multisensory composition for deaf and hearing audiences. The four workshops produced a variety of techniques which the researcher was able to employ in the composition of the studies. Study #1 was an investigation into the musical use of gesture. Specifically, the study treated ISL gestures as the voice, or lyric, of a composition and used this lyric to create a multimodal and intersubjective narrative. The study provided positive results for a number of techniques by means of participatory audience feedback. Study #2 refined a few of these techniques under altered performance circumstances: a larger performance space and audience. The results of Study #2 show the techniques of Study #1 to be successful under these different circumstances. Finally, Study #3 involves the performance of a music composition with specific research aims under controlled conditions, investigating the use of crossmodal illusions in multisensory composition. The results offer insights into performing music compositions under controlled conditions, and suggest areas for future research.

The controlled and performative methodologies used in these studies will be further evaluated in Chapter 6. First, Chapter 5 consolidates some of the positive results of these studies in order to present an overall approach to music composition for deaf and hearing audiences.

. . . .

CHAPTER 5

⚄

A COMPOSITIONAL APPROACH FOR DEAF AND HEARING AUDIENCES ALIKE: CROSSMODAL HARMONIC TECHNIQUE

5.0 CHAPTER 5 INTRODUCTION

While Chapter 4 presents workshops and studies which explored multisensory approaches to music composition, Chapter 5 proposes a specific compositional technique based on these studies: crossmodal harmonic technique. The chapter is presented as follows:

> **Section 5.1** carefully examines the act of musical composition and the indirect nature of its relationship to the musical experience.
> **Section 5.2** proposes a crossmodal harmonic technique, identifying physical gesture as its starting point, and how that physical gesture can be represented in multimodal ways.

5.1 RECONSIDERING COMPOSITION

This thesis centres on an approach to music composition for deaf and hearing audiences. In the spirit of defining terms, while the nature of deafness has already been examined to a certain degree (Chapter 2), it remains to consider, or possibly re-consider, the nature of music composition. It is often taken for granted that a composer's job literally involves composing music. Closer examination reveals, however, that the act of composition has only an indirect relationship with the musical experience. Strictly speaking, the task of the composer is to prescribe some of, but far from all, the conditions for a musical experience. The most conventional example of this prescriptive process involves the creation of a musical score; that is, a set of instructions for performers to execute. Those composers working largely or entirely in the digital realm similarly work towards the creation of instructions which a performance machine – potentially a computer, sampler or some digital apparatus – can interpret for the musical experience of an audience. While Lukas Foss has criticised the distinction between composer and performer as 'a division as nonsensical as the division of form and content', this researcher sees the distinction as crucial (Foss, 1963, p.45). At a more nuanced level, it might be argued that Foss is positing that the division of labour between composer and performer became too extreme over the course of the 19th and 20th centuries. Foss asserts that a composer should be encouraged to operate as a performer, a vital aspect of his own practice as well as this researcher's, and thus bring the two roles closer together. Nonetheless, while it may sometimes be beneficial for a composer to act also as the performer of his or her instructions, the composition and performance of these instructions are nonetheless distinct activities[1]. As Samuel Feinberg puts it:

> . . . the composer is not always a perfect instrumentalist. Creation of a composition and its concert performance are two different aspects of the musical art. Therefore it shouldn't be surprising if a composer relegates the interpretation of his work to another musician with a greater mastery of the instrument. (Feinberg, 1958, introduction).

Composers are creators of experiential possibilities rather than realities, and the difference between a score on paper and a score in performance can be considerable; whether or not the composer is involved in both. While it can be argued that a score is indeed an experiential reality for a composer, it is not one which his or her audience will likely ever know. The audience are invested in the musical experience, for which the score, however real it may be in the private act of composition, provides only the conditions.

Considering the chasm between score and audience experience, one of the most important tools a composer can have is a flexible imagination concerning the fate of the conditions set out in a score: instrumentation, notes for instruments, tempo, metre, dynamics, articulation, extended techniques, arrangement of musicians on stage and numerous other specifications. While the composer can be extremely precise around the instructions given for performance, many of the conditions providing the actual musical experience cannot be controlled, and are moreover impossible to predict. The composer might have a preference for the selection of performers, and even insist on a certain ensemble, but these are always subject to change. Who the performers are, how well they perform on a given day as individuals, how well they perform as an ensemble and the manner in which they choose to interpret the music; all these factors are fundamental to providing a musical experience, and all are largely beyond a composer's control.

Finally, the execution of the composer's score in performance does not by itself result in a musical experience. The crucial remaining element is the audience, and the myriad conditions which enter into an audience's experience[2]. While many composers are fully aware of this, there is often a surprising lack of comprehension of the differences between the conception of a work and an audience's perception of it in performance. Witness Karlheinz Stockhausen:

> I found [in working on *Kontakte*] for the first time ways to bring all the properties under a single control. I deduced that all differences of acoustic perception can be traced to

1 Improvisation presents a different case, which will not be considered here (see Bailey, 1992, p. 72).
2 This includes the performer as his or her own audience.

> differences in the temporal structure of sound waves . . . If nowadays, it has become necessary to find one general set of laws to govern every sphere of musical time itself, that is simply the result of a condition imposed by electronic music that each sound in a given work must be individually composed. (Stockhausen, 1962, p. 40)

This notion of Stockhausen's regarding the fundamental role of time in all musical parameters is well-known, but as stated here reveals certain flaws. Whatever truth may exist to the concept that all acoustical wave phenomena is predicated on time, Stockhausen confuses his own, crystal-clear conception of his famous work, *Kontakte*, with the necessarily different experience of each member of its audience. He speaks of tracing back 'all the differences in acoustic perception' to a single temporal principle, but these perceptual differences include a host of additional elements that are not governed by Stockhausen's 'single control'. An audience does not hear acoustical waves directly from an instrument or audio recording, but an interpretation of these waves by their own bodies. Before these waves even interact with an individual body, they are influenced by many environmental factors that are unique to each performance and the status of the individual within that environment. On a purely sonic level (that is, ignoring the multisensory aspects of the experience), the venue must be considered: 1) the nature of the acoustics and 2) the presence of unintentional noise (public transportation outside, people coughing, *etcetera*). As one example of the significance of the performance environment, Jukka Pätynen and Tappio Loki have recently demonstrated that emotional response (measured by heart rate, blood pressure, body temperature and skin conductance response) is significantly different for audiences in venues with superior lateral reflections (Pätynen&Loki, 2016). Whatever the venue characteristics, every member of the audience will moreover be positioned differently in this environment: some at the back, some at the front, some in the centre and some at the sides. In certain cases, the performance of a score might only have one person in the audience, which for certain performers, such as the pianist Glenn Gould, would be considered ideal. The Canadian virtuoso more or less gave up live performance and devoted his life to studio recording because he felt frustrated by the lack of homogeneity in the live concert hall experience (Bazzana, 1997; Menuhin, 1987). His wish was that everyone occupy the 'sweet spot', positioned strategically either with respect to a live performer or to their hi-fi system. Even obsessiveness such as Gould's, however, cannot ensure that every listener has an identical experience.

In the final analysis, a composer may attempt to dictate as many performative elements as possible and then a very insistent performer may demand certain conditions, but one element remains entirely outside the control of either: the audience themselves. Who are the members of the audience, or in the case of Glenn Gould's solitary, idealised experience: who is the listener? The unique morphology of each individual – from the pinnae to the cochlea – further transforms the identity of the initial waveforms leaving the instruments or speakers. The age of each listener will have a bearing on many aspects of the sonic interpretation: e.g., the effects of presbycusis on the basilar membrane (Kelly, 1939). The cognitive realm is exponentially more complicated in terms of variable factors. At the most basic level, each individual possesses a different musical background (enculturation) and level of intelligence that will be brought to bear in what the music ‘sounds like’ (Morrison *et al*., 2008). In addition to this, as Chapter 2 highlighted, music cognition does not exclusively involve processing sonic stimuli, but a crossmodal interplay at both the level of the single neuron and neuronal clusters (Calvert, 2004). Thus, environmental factors perceived by other modalities during the performance – visual and tactile stimuli – will greatly influence the cognition of the music. Even having each audience member’s head fixed in a stereotaxic device would not prevent eyes from attending to different areas of the performance, or ignoring it completely.

Many other factors remain, but one more will be mentioned here; the role of attentiveness in experience, which has become the subject of increasing interest in the past 20 years. Patricia Flowers, for one, has demonstrated clearly that the attention paid to a piece of music fluctuates considerably as it is performed or played, and the nature of these fluctuations can greatly affect a listener’s reaction to the music in question (Flowers, 2001). Attention can be affected by many unaccountable variables specific to the occasion, but some consistently reported factors include level of fatigue, the mental state of the listener entering the performance and the condition of health. In sum, a piece of music can seem very different depending not only on how much someone wishes to pay attention to it, but how much they are able to pay attention to it.

Thus, a composer’s score is not the music, any more than the map is the territory, the blueprint the building or a general’s strategy the battle. This thesis instead considers music as a whole-body experience created by composer, performer, listener and the performance environment coming together as an event. Nonetheless, in musical analyses over the past two centuries the ephemeral nature of this encounter has often been overshadowed by the concept of a ‘piece of music’ – whether score or recording - suggesting a static object, existing independently of the human body and mind, that can be performed repeatedly (Goehr, 1992). Variations in each performance, whether welcome or unwelcome, are often viewed as deviations from the composer’s intentions; or the ‘authentic’ work (Sherman, 1998). This abstract conception of music not only impoverishes the richness of the experience; it quite simply overlooks reality. Music may be represented in abstract form by means of a score, but this is only a representation. As Joseph Kerman comments:

> Music is a process, action, activity: but once it is written down it yields up an object (a score) and is itself on the way to becoming objectified. The concept of a musical work or composition, to say nothing of a canon, depends on such objectification, at least to some extent – on writing, which is not a musical but a graphic mode. (Kerman, 1998, p. 34)

It is worth noting that the reading of a score is nothing more than an internalised musical performance. It can be argued that a composer's ability to experience a score internally can lead to a dangerous belief that such an internal experience is the 'correct' one. Reference should be made here, however, to the work of Helmut Lachanmann, whose musique concrete instrumentale scores 'emphasizes the way sound is produced rather than how it should be heard, thus reversing traditional hierarchies" (Orning, 2012, p.12). Lachanmann's work Pression is particularly notable in that it can be viewed "not as a work (self-) contained in a score, but as a live object, as performance, action and embodiment" (Orning, 2012, p.12).

While Simone de Haan does not inveigh against the composer/performer distinction to the same extent as Lukas Foss, de Haan does argue that music became increasingly objectified from the start of the Classical period to the present:

> During this period [Classical] there was an increasing desire by composers to control the performance parameters within the initial composition process itself. As a consequence, performers were no longer asked to have the same level of creative input as had been the case in the Baroque period. The performance element was seen to be a re-creative rather than directly creative function and the performer was no longer considered a collaborative partner in the creation of the music by the composer. This separation in roles, together with other major changes in musical practice which occurred at about the same time, created a fundamental shift in the attitude to music-making. The more experiential parts of the musical process appeared to give way to the presentation of pre-determined musical objects. (de Haan, 1998)

Music is both an intimately personal and vitally interpersonal experience. At the most basic level, music is personal because it does not exist unless an individual hears it, feels it or sees it. Music is not an objective reality existing independently of human experience; it is experience itself (Johnson, 2007). Vibrations, for one, only become sound when they reach human ears and are interpreted as such. The personal nature of this experience goes deeper, insofar as the ultimate perception of music occurs differently for every individual. The qualia will not only be unique to each person, but more or less remain impossible to represent accurately for someone else.

On the other hand, music is inevitably interpersonal for at least two reasons. First, while music perception is unique to an individual, it is not hermetically contained within that individual, often involving other individuals in performance, or at the very least a shared environment. Second, and more importantly, our development of meaning is fundamentally intersubjective, as Chapter 2 discusses in some detail. That is to say, in the course of meaningful experience, we do not comprehend the world in isolation to others, but carry all the interpersonal experiences of our lives into each encounter, musical or otherwise (Stern, 1985). As Hans-Georg Gadamer put it, our experience is a 'fusion of horizons'. The simultaneously personal and interpersonal nature of musical experience should not seem a paradox, but a vital relationship collectively mediating our embodied experience of this world. The Cartesian dualism prevalent for so long in the scientific and general understanding of human experience saw mind and body as separate entities, and thus introduced innumerable, irresolvable paradoxes into self-perception (Merleau-Ponty, 1945). The personal experience is established by interpersonal, or intersubjective, meanings starting in neonates (Trevarthen, 2010). This intersubjective process of meaning-making does not end with childhood, however. As Mark Johnson puts it, 'Adults are big babies' (Johnson, 2007, p. 33). Johnson's playful wording is deliberately self-reflexive, since development is based on the act of play as an intersubjective process that continues throughout a person's life in all of his or her meaningful encounters.

It might seem the above argument – that composers only create the conditions for a musical experience rather than the experience itself – threatens a composer's sense of importance in the musical process. Certainly, it does debunk any notion of absolute authority a composer might have been presumed to command. The reality of the musical experience – where composer, performer, audience and environment commingle across time and space – is far richer and collectively rewarding than the idea of a performance being judged by its authenticity in relation to a static work of art, e.g., a score. In any case, by controlling the design of such an experience, the composer exercises a huge degree of influence over the outcome, whatever the vagaries of performers, audience and venue. A composer must after all mediate between the personal and interpersonal through a score's imaginative engagement with performer, audience and venue. Perhaps, as a last word in this section, it can be suggested that such mediation constitutes what is more often called empathy; which this researcher would submit lies at the heart of the composer's craft.

5.2 CROSSMODAL HARMONIC TECHNIQUE

Rather than a strict codification, what is presented as technique in the following section is really an attempt to consolidate some of the findings from Chapter 4 for effective music composition approaches for deaf musicians and audiences. 'Crossmodal and intersubjective harmonic technique' might be a more appropriate name (albeit lengthy), as the intersubjective aspect is equally important in considerations of reaching audiences whether deaf or not. However it is referred to, the technique is predicated on the idea that music involves patterns of physical activity experienced by the whole body, whose meaning is constituted by intersubjective correspondence; i.e., relationships between individuals within an ensemble, individuals within the audience and the ensemble/audience as an entity. It might finally be added that the word technique is most usefully, as mentioned in Chapter 4, regarded in the Heideggerian sense: as 'a mode of being, or of revealing . . . an event to which we belong' (Blitz, 2004, p. 71).

5.2.1 THE BUILDING BLOCKS OF MUSICAL MEANING; GESTURES AND MOTIVES

Conventional Notions of Musical Materials

If it is agreed, as Section 5.1 argues, that a composer does not compose music, but rather the conditions to allow for a musical experience, what are these conditions? That is, what are the building blocks that allow for the musical experience? In the past, many prominent theories have focussed to this end on either 1) the abstractions of language or 2) musical notation as an objectified expression of music. In the former case, Mark Johnson explains it this way:

> According to the Music as Language metaphor, passages in music are conceived as sentences, with individual notes or clusters of notes taken to be the equivalent of words. This metaphor thus gives rise to terms like musical ideas, musical sentences, propositions, punctuation, musical questions, and other quasi-linguistic phrases.
>
> However, if you start with the popular assumption that only language has meaning and that meaning is primarily referential, then music comes off looking semantically impoverished, since it is not typically regarded as having substantial referential meaning.
>
> (Johnson, 2007, p. 235)

Brandt *et. al* reinforce Johnson's objections to this metaphor in a study showing that rather than language being the basis for music, the opposite would appear to be the case:

> Language is typically viewed as fundamental to human intelligence. Music, while recognized as a human universal, is often treated as an ancillary ability – one dependent on or derivative of language. In contrast, we argue that it is more productive from a developmental perspective to describe spoken language as a special type of music. A

> review of existing studies presents a compelling case that musical hearing and ability is essential to language acquisition. In addition, we challenge the prevailing view that music cognition matures more slowly than language and is more difficult; instead, we argue that music learning matches the speed and effort of language acquisition. We conclude that music merits a central place in our understanding of human development. (Brandt *et al.,* 2012, p.1)

The second tendency of musical materials being seen as notation – i.e., ledger lines, noteheads, rests, bpm, *etcetera* – is addressed in the previous section, but it is worth adding some additional observations by Simone de Haan:

> In contemporary Western art music practice, notation is generally perceived as the starting point in the creation of the music, rather than as a code of representation which enables music-making to take place . . . In current practice, notated medium is therefore widely considered as the music, rather than as a component part in a more complex and interactive process between participants. (de Haan, 1998, p. 6)

De Haan goes on to say:

> . . . they [musicians trained in Western art music tradition] tend not to distinguish between the 'symbols and signs' as represented in the score and the music's essential nature – its 'sounding' form, which can only be produced in performance. In current Western art music practice the composer is considered solely responsible for the creation of the music (as represented in its notated form) and the performer no longer a partner in its creation, but an interpreter of a fixed and pre-determined object. (de Haan, 1998, p. 7)

Gesture as Musical Material

This thesis maintains the view that the building blocks of music are physical actions rather than representations of the actions through either language or music notation. The following quote by composer Roger Sessions makes an eloquent case for physical actions being a reasonable starting point for an approach to any musical composition:

> It seems to me that the essential medium of music, the basis of its expressive powers and the element which gives it its unique quality among the arts, is time, made living for us through its expressive essence, movement . . .
> Time becomes real to us through movement, which I have called expressive essence; and it is easy to trace our primary musical responses to the most primitive movement of our being – to those movements which are indeed at the very basis of animate existence. The feeling for tempo, so often derived from the dance, has in reality a much more primitive basis in the involuntary movements of the nervous system and the body in the beating of the heart, and more consciously in breathing, later in walking. Accelerated movement is, from these very obvious causes, inevitably associated with excitement, retarded movement with a lessening of dynamic tension. The experience of meter has the most obvious and essential of its origins in the movement of breathing, with its alteration of upward and downward movements. The sense of effort, preparation, suspense, which is the psychological equivalent of the up-beat, finds its prototype in the act of inhalation, and the sense of weight, release and finality produced by the down-beat corresponds most intimately to the act of exhalation. (Sessions, 1941, p. 105, p.108)

It is not reasonable to assume from Session's observations that each and every action could be described as immediately musical. As Sessions points out indirectly, it is not so much single actions but the relationships between actions that provide music's 'expressive essence'. Thus, the inhalation might not exist meaningfully without the exhalation, as might not their musical analogues of up-beat and down-beat (Sessions, 1941). An action generally features as part of a sequence to have meaning, which philosopher Roger Scruton refers to floridly as a relationship of diachronous unities, a rubric borrowed from geology (Scruton, 2010). Scruton's typology warrants a brief digression. His list of diachronous unities is extensive, including melody, rhythm and motifs; more commonly referred to as the horizontal aspect by music theorists. Such diachronous unities, Scruton reasons, stand in contrast to synchronous unities such as chords and counterpoint; usually referred to as the vertical aspect. Scruton is indeed working like a geologist; painstakingly exhuming layers of musical history, and identifying their content in terms of neat lexical stratifications. When the dust has settled, however, the question remains as to what such flourishes of classification accomplish; other than to apply yet another cumbersome nomenclature to an experience that in any case presupposes linguistic classification, according to Johnson and Brandt (Johnson, 2007; Brandt *et al.*, 2012).

5.2.2 GESTURE BASED MOTIVE

The aim of this thesis is not to perform a self-contained theoretical study of the subject of music composition. The refined question that has gradually emerged from the initial aims of this research - to explore approaches to composition for deaf audiences with a notion to broadening compositional approaches for all audiences (p.1 of this thesis) – is as follows: what compositional strategies can be adopted to alert and sensitize a mixed deaf and hearing audience to the physical, multisensory and intersubjective potential of the musical experience? If crossmodal harmonic technique is to offer anything useful to this researcher or other composers, a method for presenting actions and their relationships in multisensory composition must be clarified.

One such method is to regard actions in the same manner that sounds are traditionally accounted for in music theory. Actions can be grouped into memorable and identifiable units, just as the sounds they create are grouped into conventional units according to a unimodal approach to music. These units are generally referred to as motifs, or motives. Arnold Schoenberg's writings identify the motive as the 'smallest common denominator' (Schoenberg, 1911, p. 25). His student, Anton Webern, similarly describes the motive as 'the smallest independent particle in a musical idea' (Webern, 1944, p. 26). While seen in traditional music theory as a group of musical tones, this technique employs the motive as a group of actions with multimodal potential. Such an expanded definition – extending the scope of the word 'motive' to comprise a more active element - is in keeping with its etymology, being derived from the Latin *motivus*, 'to move' (Lewis, 1879).

Chapter 4 presented two studies which employed such a motive: 4 hand gestures. Those used in *Study #1* are featured again here in Figures 5.1 - 5.4.

Figure 5.1 *Study #1* ISL Sign 1 (percussive): '*Beat*' Left hand in a fist, right palm moves left to right striking top of right fist

Figure 5.2 *Study #1* ISL Sign 2 (silent): '*Hour*' Right hand in letter 'H', palm facing body, moves swiftly anticlockwise in a circle

Figure 5.3 *Study #1* ISL Sign 3 (percussive): '*What*' Palms to self in 'L'; alternately snap fingertips in one hand off fingertips in the other

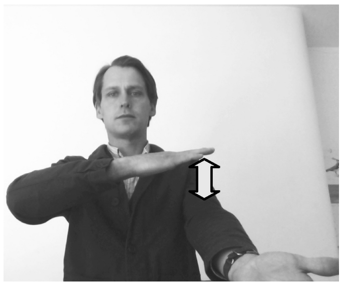


Figure 5.4 *Study #1* ISL Sign 4 (percussive): '*Walk*' Tap right fingers on left forearm twice. This sign has been adapted, as the arm position of the non-dominant hand is not correct for the "walk" sign.

While these ISL signs are conventionally recognised as semantic gestures, their multimodal potential was harnessed in *Study #1*. Rather than being presented in their customary roles as signifiers, the gestures came to represent sonic, visual and tactile expressions with musical significance. More specifically, they were arranged to create a rhythmic pattern constituting a motive. Figure 5.5 represents these signs as such, abstracting them into musical notation.

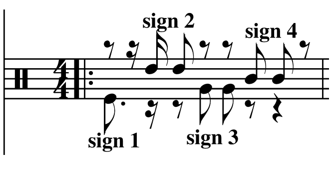


Figure 5.5 The basic gestural motive produced by the ISL signs in Figures 5.1 – 5.4.

This single motive contains the potential for a multimodal narrative. As stated in Chapter 1, this researcher subscribes to the view that all composition avails of a narrative strategy (Section 1.2). This does not refer to narrative in the literary sense, but one that presupposes language itself, insofar as narrative is fundamental to meaning-making (Stapleton & Wilson, 2016). Musical narrative, like any embodied meaning, involves pattern making, and playing with expectations of pattern variation and repetition (Meyer, 1956). Thus, the basic pattern, or motive, shown in Figure 5.5 can be varied and repeated in order to develop such a narrative. The early stages of narrative development in *Study #1* are shown in Figure 5.6, where the basic motive of bar 14 is repeated in bar 15, and then varied in bars 16 and 17.

Figure 5.6 Narrative development of a motive with multimodal potential: the motive in bar 14 is repeated in bar 15, and varied in bars 16 and 17.

In *Study #1*, the section poles first adumbrate this motivic development when they are stamped percussively on the floor of the venue (Figure 5.7). These section poles are topped with flags whose colours correspond with 1) one of the four colours of seed each participant is given when entering the venue, 2) one of the colours each of the performers is dressed in and 3) one of the four sections audience members were seated in (Figure 5.8). This initial presentation of the motive, which is more of a prefatory statement, is then given more detail by the signer in bars 14-17 (Figure 5.6). The initial statement of the motive by the section poles has a number of aims:

1) to give the audience a sense of being involved in the rhythm by their association with a specific pole (by virtue of its colour as well as its marking their seating section),
2) to foreshadow the more detailed expression of the motive by the signer in bars 14-17 and
3) to announce the motive in a powerful and percussive manner[3].

[3] The action of the poles being stamped on the floor produced a thunderous sound, and a powerful vibrotactile reverberation through the wooden floor.

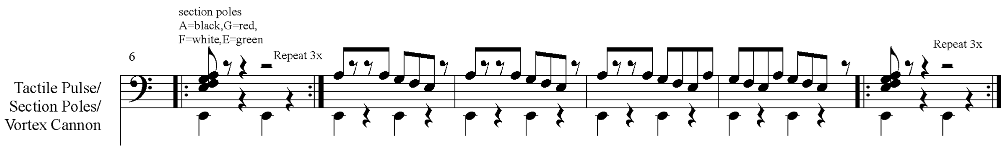


Figure 5.7 *Study #1*, bars 6 – 11. The section poles outline the gestural motive in a hocket between the four musicians. Each musician is scored to 'play' a different pole (represented by notes A, G, F and E) which he or she stamps on the ground to contribute to the rhythm. The notes are assigned to one of 4 colours –black, red, white and green – worn by the signer, bassist, guitarist and drummer (researcher) respectively.

Figure 5.8 The section poles outline the gestural motive in a hocket between the four musicians. Each musician has a different pole (represented by notes A, G, F and E) which he or she stamps on the ground to contribute to the rhythm. Each musician is dressed in a different colour – black, red, white and green – that corresponds to the flag colour atop the pole they are stamping as well as the colour of the seed given to each participant in that section. As well, these musicians are linked to the same section by the gesture they are later to use within the audience hocket (photo from video footage, Higgs, 2016).

It is worth acknowledging that conventional music theory would likely designate Figure 5.6 as a 'theme'; that is, an introductory idea created from smaller units, e.g., the motive (Figure 5.5). Admittedly, it is a challenge to articulate musical development without adopting a similar language-based musical perspective to that examined in Section 5.1. While such practices should not be regarded as anathema, it should be pointed out that what constitutes a theme, or a motive for that matter, is as ever subject to debate. Schoenberg vacillates between micro and macro conceptions of motive in his theoretical works; suggesting at times that a motive can be a single note, and then insisting that a motive needs far greater breadth for coherence; up to 8 bars even (Schoenberg, 1911). This researcher feels this issue is not nearly as relevant as the simple fact that a pattern is being set up that can be repeated and varied in ways that will generate a sense of narrative. The limits of the units within such a pattern are a matter of opinion and an attempt to fix these limits rigidly by name would seem unproductive in the context of this thesis.

5.2.3 MULTIMODAL DEVELOPMENT; NARRATIVE TECHNIQUES BEYOND EXPOSITION

Whether referred to as the exposition of a theme or an extended motive, the gestural narrative begun in Figure 5.6 can be further developed in ways which are both crossmodal and intersubjective. In *Study #1* this occurs when the signer teaches the gestural pattern to the audience as a hocket, with different audience sections performing specific gestures in coordination with each other as part of the larger pattern (*Study #1*, bars 14-17). This technique is clearly intersubjective in that it identifies a relationship between the performers and the audience, as well as between the members of the audience themselves, by means of the gestures they perform. The word 'identify' is most apposite here, for while such performer/audience relationships arguably exist in any performance situation, they are often not identified. As much as it is an intersubjective identification, this shared gestural pattern is equally crossmodal. Initially, the audience observes the signer performing the gestures (a visual experience) and also hears the percussive aspects of the gesture (an auditory experience). Once the gestures have been taught to the audience and they begin to perform them, the gestures also become a sensorimotor experience. That is to say, the audience become aware of themselves performing the gestures as proprioceptive and vibrotactile realities. In fact, this is again a matter of identifying what would exist in any situation if one is to accept the mimetic theories of cognition (embodied simulation) propounded by both Arnie Cox and Vittorio Gallese (Cox, 2000; Gallese, 2009). Such theories, as Chapter 2 describes, see all communication as an intersubjective reality; in that an individual's perception of a gesture being performed by another individual involves an imitation of that gesture in either an overt manner (by actually imitating the gesture outwardly) or a covert manner (through embodied simulation at the level of motor neurons).

Like *Study #1*, *Study #2* has the signers teaching the gestural pattern to the audience, but with a slight, intersubjective twist. In this case, the pattern is also taught to the string quartet who use a different gestural technique for the same motive. To be more precise, while the audience perform the gestures manually as shown by SP 1 & 2, the string quartet adapts the gestures to their instruments (Figure 5.9). What is notable here is that the audience are adapting their gestures, too, without necessarily being aware of it. This happens at several different levels. First, it is a conscious decision by the researcher to have SP 1 enact the gestures in reverse perspective (i.e., mirrored) rather than in the same left hand/right hand relationship that he intends the audience to use. In other words, if SP 1 wants the audience to sign with their left hands, he should demonstrate the gesture with his right. This can be clearly seen in Figure 5.10, where SP1 is using his right hand to enact the gesture, and SP2 (playing the role of the audience) is using his left hand to mirror the gesture. Thus, the audience is immediately making an adaptation to the signer's demonstration, or personalising the gesture, by using a different hand to SP 1. This adaptation is analogous to the quartet using their bows and strings instead of their hands to imitate the gestures in Figure 5.9.

Figure 5.9 *The Sense Ensemble, Study #2*, bars 25 - 28. The manner in which the string quartet is scored to interpret the signs demonstrated by SP 2. Note that violins 1 and 2 maintain their pattern throughout the four bars, while the viola and cello follow the motive faithfully.

Figure 5.10 *The Sense Ensemble, Study #2*: SP1 teaches SP2 the ISL gestural pattern, or motive. It can be seen here that SP1 (facing and standing) is using the reverse left hand / right hand approach to SP 2 (facing away and seated). This technique, of teaching gestures to a group in reverse fashion, has a long history in performance; but it can be seen in the work of Dalcroze and Laban. What is significant here is that SP2 is serving as a model for the audience to mimic SP 1.

This gestural personalisation happens in a second and more fundamental way. Imitation, of course, can never be a perfect representation and must always involve adaptation (Meltzoff & Decety, 2003). Even an individual performing the same action repeatedly is re-presenting the gesture at a different time, therefore adapting to changed circumstances at some level. Needless to say, the physical differences between individuals make perfect imitation of gestures impossible; one is always performing adaptations to imitate another person's gestures. Nobody waves the same way, or shakes hands in precisely the same manner; although everyone attempts to represent a shared sense of the gesture. Arguably, the imitation becomes a form of approximation, or even possibly an appropriation. Far from an idle observation, this fact is central to any kind of intersubjective study, for it is the approximate quality of this socially connective endeavour which lies at the heart of musical, and all interpersonal, communication (Anderson, 1999). There can be no true replication of one person's meaning transferred to another person through music, gesture or language, only a sort of adaptation of meaning suited to purpose; or something the pragmatists might say, with deceptive simplicity, 'works' (James, 1907). In the case of crossmodal harmonic technique, the audience are merely engaging deliberately in a process which all musicians take part in: an effort to collaborate in the performance of a collective pattern. Again, it is a form of participation available to audiences in any musical performance, whether or not they choose to recognise it.

The question needs to be raised: what is the distinction between conventional performance instances where an audience's intersubjective engagement is momentarily identified – as when a singer encourages an audience to clap, wave or sway to the music – and crossmodal harmonic technique? Perhaps there is no essential distinction between any situation where an audience is invited to participate, since each is identifying a connection between performer and audience. Having said that, these conventional instances are normally brief, and situated in a larger performance context where the audience commonly behave as witnesses to a performance rather than participants. The technique described in this chapter is instead an explicit attempt to code an entire piece of music for multi-modality and intersubjectivity, so that an audience's awareness of the multiple dimensions of experience is maintained consistently throughout the piece. Crossmodal harmonic technique, more than anything else, is an attempt to draw awareness to the *ongoing* presence of an intersubjective reality.

Moving on from the hocketted gestural pattern, the motive can be re-presented in a variety of other multimodal ways. *Study #1*, for example, has the drummer repeat the motive in bars 18-21. While this repetition is faithful from a rhythmic point of view, it is transferred to another instrument and thus involves adaptation. This adaptive technique is very similar to the transfer of a motive from one instrument to another in any compositional or performance situation, except that the initial motive – created by the ISL signs - is conspicuously gestural[4]. The strategic re-presentation of this gestural motive on the drum kit has two aims: 1) to confirm the musicality of the ISL gestures for the audience by performing them on the drum kit (commonly recognised as a musical instrument, *per se*) and 2) to emphasize the gestural quality of the drum performance in the act of repeating signed rhythms. In other words, by juxtaposing the different modes of re-presenting the motive, the researcher is compositionally demonstrating what they have in common (in terms of rhythmic similarity), and how they complement each other with their differences in musical qualities (timbre, colour, pitch quality) and gestural qualities (amplitude, speed and character of movement).

Moreover, this faithful repetition of the motive by the drummer, as well as the variations to the motive in bars 22 – 25, provide the means to establish a crossmodal harmony between the drummer, the signer and the audience. Specifically, the interplay between the gesture, sound and feeling of the ISL signs and the gestures and concomitant sounds of the drummer create a crossmodal harmonic fabric. The drummer is instructed in the score to direct his gaze to specific sections of the audience as he plays the part of the rhythm relating to the ISL gesture assigned to that section; i.e., the one they were taught when entering the venue (Figure 5.11). For example, if the drummer accentuates the dotted quaver at the beginning of bar 18 (which is the rhythmic equivalent of sign #1), he directs his attention to the green audience section (who are performing sign #1). During the repeated four bar section in bars 26 - 29, the signer is meant to monitor the rapport between the drummer, audience and her own signs. When she feels the rapport has been firmly established (in terms of relationship between ISL signs and rhythmic identification on the drums), she cues the move to bar 30. This technique was very effective in the performance in May, 2016, and only needed to be repeated 3 times. During the Q & A after the performance, the audience participants commented on this element, and their awareness of this harmony between audience, signer and drummer (see Q&A excerpt below).

4 This is such a common technique, examples seem too numerous to cite. Nonetheless, a very well-known instance is in *Beethoven*'s *Symphony No. 9*, Movement 4, when the strings state the famous theme (bars 92-104) which the baritone will later repeat (bars 242-254).

Figure 5.11 *Study #1*, bars 18 – 21 When repeating the gestural motive, the drummer is instructed to accent certain parts of that motive and direct his attention to the relevant section of the audience; i.e., the section performing that specific part of the motive as a hocket.

5.2.4 HARMONY AND TECHNOLOGY IN CROSSMODAL HARMONIC TECHNIQUE

To identify harmony in relationships between gesture, sound and tactition is unorthodox from the point of view of musical theory, and perhaps warrants further explanation. To this end, it is worth breaking down the latter terms in crossmodal harmonic technique, and taking a closer look at the concepts of harmony and technology. Technology has been discussed already in this thesis, from an essentially Heideggerian perspective (Chapter 4, Section 4.2). More will be said on this presently, but first, it is important to consider the notion of harmony; a surprisingly elusive term whose meaning is largely dependent on cultural and historical perspectives (Whittall, 2003). Within the tradition of Western music, for example, harmony and counterpoint have long been the subject of theoretical debate, with some insisting on a distinction between the two and others regarding them as necessarily interrelated. In support of the latter belief, Carl Dahlhaus comments:

> Bach's tonal counterpoint is surely no less polyphonic than Palestrina's modal writing . . . harmony comprises not only the ('vertical') structure of chords but also their ('horizontal') movement. Like music as a whole, harmony is a process. (Dalhaus, 2017)

Because the word harmony comes from the Greek *harmos* (*ἁρμός*), meaning 'a joining', the tendency for some theorists to dissect it aggressively might seem ironic (Liddell *et al*., 1843). Whatever the outcome of these theoretical performances, the term clearly implies a union, or a coming together, of different elements. Based on a number of examples (e.g., Western choral music, counterpoint, African polyrhythm, Gamelan and phase music), this researcher considers harmony to be the practice of simultaneously presenting independent musical phenomena, which in combination represent an emergent, interdependent identity. Of course, most existing concepts of musical harmony involve auditory stimuli exclusively: e.g., the combination of two or more notes to produce a chord. Crossmodal harmonic technique, however, proposes to enlarge the scope for harmony to encompass multimodal expressions; thus, creating 'chordal' analogues by the union of gestures, sound and tactition.

In fact, it might be counter to the interests of this thesis to circumscribe the notion of harmony to involve only its musical aspect. Moreover, rather than treating harmony and technology separately, the idea of merging this expanded sense of harmony with the Heideggerian sense of technique, or technology, would even seem appropriate. As Heidegger puts it:

> According to ancient doctrine, the essence of a thing is considered to be *what* the thing is. We ask the question concerning technology when we ask what it is. Everyone knows the two statements that answer our question. One says: Technology is a means to an end. The other says: Technology is a human activity. The two definitions belong together. For to posit ends and procure and utilize the means to them is a human activity. The manufacture and utilization of equipment, tools, and machines, the manufactured and used things themselves, the needs and the ends that they serve, all belong to what technology is. The whole complex of these contrivances is technology. Technology itself is a contrivance, or, in Latin, an *instrumentum*. (Heidegger, 1977, pp. 2-3)

In *The Question Concerning Technology*, Heidegger is not taking issue with technology itself – that is, seeing it as something intrinsically evil - but addressing the limitations of humans' awareness concerning their relationship with it; or in fact that technology itself essentially constitutes a human relationship. Phenomenologists such as Heidegger are not alone in proposing a return to 'the essence of things'. Arguably, this has ever been an implicit aim of the arts, which themselves all represent an inherently technological endeavour. Having said this, art is just as capable as science, or any other discipline that falls into conventional modes of practice, of operating only with an awareness of the first definition of technology that Heidegger refers to here: 'a means to an end'. For example, when the musical experience is objectified – whether as an audio recording or as a score – humans are operating under the kind of limited awareness which Heidegger wishes to alert his readers to. Such objectification is natural, even perhaps unavoidable at times, by Heidegger's own admission; constituting what his teacher Edmund Husserl refers to as the 'natural attitude' (Husserl, 1982, p. 5).

In effect, Heidegger's statement points to the aim of this thesis and all the work that led to it: to engage with the many instrument technologies as essential, harmonious activities. Similar to Husserl's method of phenomenological reduction getting 'back to the things themselves', this thesis attempts to get music back to the human activities themselves (Husserl, 2001, p. 168). Heidegger does not object to humans seeing technology as a 'means to an end', as long as those humans are at times capable of appreciating it essentially as a 'human activity'. As he writes, 'the two definitions belong together'. This conceptual union, argues Heidegger, is a kind of harmony necessary to the well-being of humanity; without which it risks being overcome by nihilism (Blitz, 2014). Music should be regarded no differently. It can be beneficial to humans only with this same kind of perceived harmony between purpose and activity. For, beneath it all - the centuries of theory, major shifts in style, the commercialism and the fashion – music is essentially an activity of human togetherness. Far from being a fanciful or wistful notion, this awareness is crucial to comprehending music's vitality. It must be taken very seriously if any understanding of the phenomenon is to be achieved. All the rigorous analysis in the world is meaningless if this essential feature is overlooked: that the activity of music-making is the means to an end, and the end itself.

It is worth recalling that the research aim of *Study #1* was to use actions, or more specifically gestures, as the voice of the composition in place of a lyric. Addressing that idea here is an excerpt from the Q & A that followed the performance of *Study #1*:

> **Participant 1** (hearing)**:** Even though nobody talked during the show, I really felt things were being said. You know, by what you were doing . . . your actions, I mean.
> I presume I wasn't the only one. (looks around the room) We all probably just understood different things.
>
> **Researcher:** Interesting you should say that. It's true we made a pretty strict rule that no speech would be used by the performers. And while we obviously couldn't tell anyone in the audience not to speak, we would make it clear from the minute they entered the venue that all communication would be carried out using non-verbal gestures.
> Funnily enough though, I remember trying to give Caoimhe [the ISL signer] helpful advice during rehearsals on how to perform the signs. I told her to imagine she was saying to the audience, 'This is not what *I* do; this is what *we* do'. 'We' meaning you (points to the audience).
>
> **Participant 1:** And *we* did! (laughs) I mean we did what she did. She did the signs, and so did we.

Participant 2 (hearing)**:** And *you* did, too. (points to researcher). On the drums.

Researcher: Exactly. And there was another level I saw in that. It has to do with something called embodied simulation, which is . . . let's see . . . it's more or less the idea that when you see someone doing something, you are actually performing the action yourself . . . internally. Or when you hear a sound, you imagine yourself making that sound.

Participant 2: What if you don't know what the sound was? Or what made the sound?

Researcher: Good question. But I guess that's the beauty of it. Your mind, or body, or whatever you are going to call it, comes up with some kind of action, some kind of approximate action, that might have made the sound.
In any case, I was hoping for Caoimhe to say to all of you, by not saying to all of you (laughs), 'when you see what I'm doing, you're doing what I'm doing. And when you hear what I'm doing, you're also doing it . . . even if you're not doing it!'
The same goes for touch, and all the other senses for that matter . . . all the time. Or so I'm starting to believe.
(Transcribed from video recording of *The Sense Ensemble, Study #1*, Q&A)

This conversation identifies the overall aim of *Study #1* and *#2*, and indeed crossmodal harmonic technique. The audience is not simply asked to listen to the music, they are invited to participate consciously in the activity; to become involved in the event rather than serving merely as an 'audience', in the strictest sense of the word. Thus, the compositions attempt to demonstrate relationships between all the activities which occur within them, and all the people witnessing and participating in those activities.

5.2.5 SECONDARY MOTIVES AND OTHER TECHNIQUES TO REINFORCE MULTISENSORY AWARENESS

While the initial gestural motive (Figure 5.5) serves as a three-dimensional musical action from which a multitude of narrative developments can arise, there is no reason for the composition to remain fixed on that motive alone. As with many traditional compositions, there is the possibility of introducing successive motives (or themes) which can be treated in much the same way as the first. In *Study #2*, the B section introduces a new motivic approach: one which departs from manual gestures (i.e., ISL signs) and relies on the interplay between the string quartet and SP 1 and 2 sending smoke rings to the back of the auditorium with the vortex cannons. As Chapter 4 explained, the string quartet take their cues from the smoke rings both to begin their tremolando and to govern the rate of rallentando, as can be seen in (Figure 5.12). The action of the smoke rings travelling both above and into the audience as the string quartet follow their movement helps to reinforce the sense of unity between the different parts of the auditorium in the compositional world.

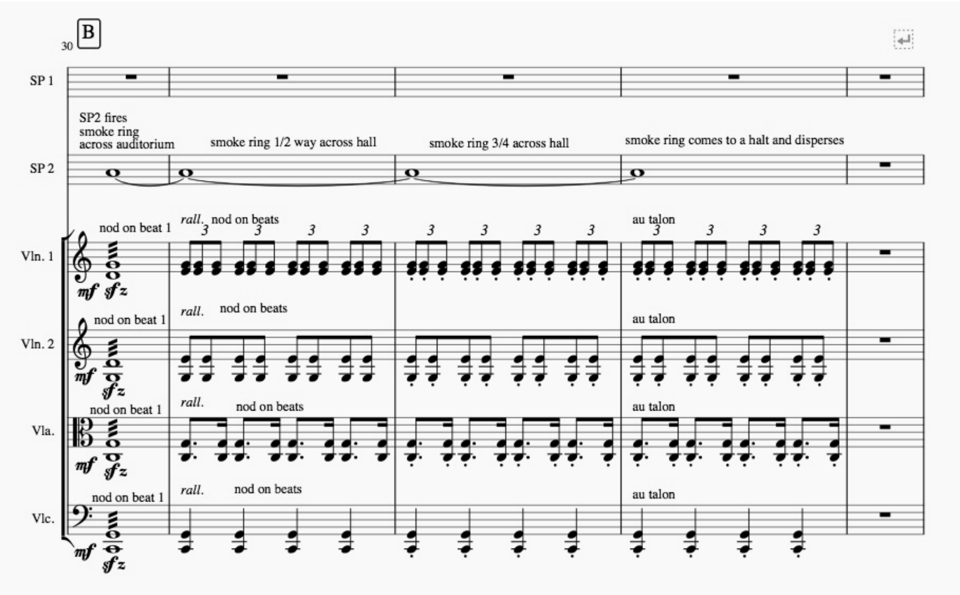


Figure 5.12 *Study #2*, bars 30-34. SP 2 fires a smoke ring across the hall. The string quartet get two of their cues from the smoke ring: 1) when to begin their tremolando and 2) how to pace their rallentando over the course of bars 31-33 (NB: excerpt from an earlier score, so bar numbers don't correspond with full score in Appendix 4.7).

The smoke rings are a rich and interesting subject of study in themselves. As well as providing expression to multiple senses, they have a ludic element which is effective from an intersubjective point of view. Besides the fact that audiences find them a novelty, the rings introduce a sense of playfulness and unpredictability that, rather than undermining the impetus of the music, seems to complement it. The rhythmic duality of the smoke rings was already discussed in Chapter 4. As another example, in *Study #1* the signer hits the members of the audience with the smoke rings in a provocative way; blowing back their hair and ruffling their clothes (*Study #1*, bars 79-89). In *Study #2* this is taken a step further when SP 1 and 2 blow the string quartet's sheet music off the music stands at the end of the performance; potentially a whimsical gibe at the objectification of music (*Study #2*, bars 72-75).

5.3 LIMITATIONS OF STUDIES IN CONDERATION OF CROSSMODAL HARMONIC TECHNIQUE

Studies #1 and *#2* achieved positive feedback from participants in terms of musical engagement with gesture. It should be said, however, that in retrospect certain aspects in both studies could be improved in terms of maintaining a connection between multimodal gesture and other musical aspects. In *Study #1*, for example, the connection is very strong up to bar 37; i.e., there is a strong sense of crossmodal harmony[5]. Thereafter, the connection between the instrumentalists' musical actions - specifically the guitarist, bassist and the signer's performance - is not made explicit. The bassist in fact employs a figure which the signer engaged with reasonably well through improvised gesture in the performance, but this relationship could be reinforced in the score by 1) instructing the signer and bassist to amplify their gestures and 2) instructing the signer to face the bassist. The guitarist, meanwhile, plays a figure - a rhythmic ostinato which continues throughout the piece - which is not addressed whatsoever by the signer through gesture (*Study #1*, bars 38-39). This could very easily be matched by the signer enacting the rhythmic equivalent in gestures, such as Figure 5.13 suggests.

Figure 5.13 *Study #1* proposed improvement (bars not in score). In order to maintain a gestural connection with the guitar part, the signer could perform gestures with a rhythmic equivalent to that notated here. There is license here for ellipsis, i.e., the gestural motive need not be slavishly mimicking the guitar line.

Study #2 can at times be accused of the same disconnect between the string quartet and the signers. While the connection is very strong in both the A and B sections, Section C features the string quartet executing a strong rhythmic motive that, while it is complemented by the SP 1 and 2's gestures, does not have a sufficiently clear connection. SP 1 and 2 are resting during some of

[5] Because of the number of repeats, bar 37 is actually a considerable way into the composition.

the string quartet's most pronounced bursts of activity in Section C, until those moments when the signers resurface with the original gestural motive (Figure 5.14). As with *Study #1*, this could be rectified simply by scoring a gestural motive for SP 1 and 2 to perform which is responsive to the rhythmic character of the string quartet's activity. Rhythmic mimicry of the accented first, fourth and seventh beats of each bar (as shown in bars 151-154 for the 1st and 2nd violins) would be one option for this gestural motive.

Figure 5.14 *Study #2*, bars 151 - 154. SP 1 and 2 are observing the string quartet perform; the case for a considerable portion of Section C. To maintain a gestural connection, it is suggested they perform a new rhythmic gestural motive related to the string quartet's insistent rhythm. The cello part would likely be the best choice, with its accented double stops. The accented first, fourth and seventh beats of each bar (as shown in bars 151-154 for the 1st and 2nd violins) would be one option for this gestural motive.

In spite of any limitations, the feedback to both *Study #1* and *Study #2* was overwhelmingly positive in terms of engagement between performers and audience on an gestural level. Moreover, as it has been shown in this section, the shortcomings in each study can be improved by a more rigorous application of crossmodal harmonic technique. More than a vindication of the two studies, this fact is instructive for those who may wish to adopt the technique for their own compositional purposes.

5.4 CHAPTER 5, SUMMARY AND CONCLUSION

To summarise, crossmodal harmonic technique suggests the following steps and alternatives:

1) Establish a motive with multimodal potential through gesture.
   Exampl*e, Study #1*: Section poles (bars 6 -11) and then the ISL signer (bars 14 -17) present the gestural motive.

2) Invite the audience to participate in the expression of the gestural motive.

This approach allows the gestural motive to be divided between different members of the ensemble and/or the audience by means of a hocket to underline the intersubjective relationships.

Example, *Study #1*: Audience are assigned sections of the gestural rhythm as part of a hocket (bars14 – 17).

3) Repeat and vary the gestural motive on another instrument (i.e., adaptation).

Example, *Study #1*: Drum kit re-presents, or adapts, the gestural motive (bars 18 -21).

4) Allow the original gestural motive to co-exist with variations on the motive, and adapted versions (in other modalities), thus producing a multimodal harmony.

Example 1, *Study #1*: Drummer repeats and introduces variation to the gestural motive, accentuating specific parts of the pattern while directing his gaze at the audience section performing that part (bars 18 - 29).

Example, *Study #2*: SP 1 & 2 perform ISL gestures while string quartet adapts the original motivic gestural expression (bars 134-141).

5) Have the motive return to its original gestural expression.

Example, *Study #2*: SP 1 & 2 bring the audience back into the ISL signs (bars 174 - 177).

6) Introduce secondary gestural motives.

Example 1, *Study #1*: The signer presents a range of other signs which the drummer and musicians interact with (bars 34 – 61).

Example 2, *Study #2,* Section B: Tremolando and rallentando are cued by vortex cannons and smoke rings (bars 30 - 33). This relationship constitutes a new motive.

7) Use gestural techniques which complement the continuing development, and emphasize a multisensory experience

Example, *Study #1 and Study #2*: Use of vortex cannon and smoke rings.

8) Provide strategies to emphasize audience involvement, connecting them to the fabric of the composition in a physical manner.

> Example 1, *Study #1*: The percussive stamping of the gestural motive by section poles draws attention to the correspondence between the individual audience sections, the colour of the flags atop the poles, the colours of seed given to each audience member and the gesture identified with each section and seed colour (bars 6 – 11).

. . . .

As well as reconsidering the notion of composition, this chapter presents an approach to music composition for deaf and hearing audiences – crossmodal harmonic technique – based on the studies accounted for in Chapter 4. The technique identifies physical gesture as its starting point, and involves a gestural motive being presented and re-presented using multimodal and intersubjective narrative strategies. Such an approach is not the last word on music creation of this kind; nor is it strictly speaking the first (see Chapter 2, Section 2.3). It might be argued that the technique does not so much offer a new kind of music as a novel means of identifying multisensory and intersubjective potential in all music. Most importantly, it is the hope of this researcher that this technique will provide a starting point for other composers to move further in this direction.

CHAPTER 6

SUMMARY, EVALUATION AND CONCLUSION

6.1 SUMMARY

This thesis explores approaches to music composition for deaf and hearing individuals alike. Chapter 1 details how these investigations were inspired by time the researcher (a composer) spent working in a school for deaf girls in Dublin, Ireland between 2010 and 2013. Previous to this experience, he shared a commonly held belief that deaf individuals cannot experience music, and that music is for the hearing alone. Working in the school not only revealed to him that deaf people can engage with music, but that music has an extra-auditory potential, for both deaf and hearing individuals, which is often ignored. The researcher undertook 3 years of formal studies in the Music and Media Technologies activity of the Department of Engineering in Trinity College Dublin (supported by an Irish Research Council Fellowship) to explore harnessing this potential compositionally. This thesis documents the results of these efforts.

Chapter 2 begins by examining the many degrees, types and configurations of deafness, and demonstrates that the condition comprises a broad, multi-layered continuum between ability and disability. While members of a Deaf community may share a sign language specific to the region in which they live, every deaf individual's condition, and moreover his or her experience of deafness, is unique. For this reason, any assumption that deaf people are categorically capable or incapable of musical engagement is without foundation. The chapter goes on to argue that music, rather than being exclusively for the ears, is in fact a whole-body, crossmodal and intersubjective experience. Many forms of evidence, from clinical studies in the field of neuroscience to testimonies of deaf and hearing individuals, are presented to support these premises. The fact that music is not for hearing alone, as well as the reality that most deaf individuals have some degree of hearing, suggests a case for deaf participation in musical activities. The chapter concludes by citing numerous historical and contemporary examples of deaf individuals being musically engaged.

Chapter 3 discusses possible reasons for the widely held belief that music is a uniquely auditory experience. Neuroscientific studies have shown that multisensory awareness is problematic. This is due to the fact that multisensory stimuli are generally resolved into a unified percept, with an individual's awareness presenting in the dominant modality (Deroy *et al.*, 2014; Calvert, 2004). Further research in the fields of social psychology and phenomenology shows that the culture around music, specifically the audio-centric nature of the language used, has a decisive effect on limiting or increasing the scope of an individual's experience (Heidegger, 1971; Kahneman, 2011). To whit, if music is approached as an auditory experience, it becomes an auditory experience. The chapter concludes with the presentation of a vibrotactile study the researcher carried out, *The Balloon Study*, which suggests a way for people to extend awareness concerning the musical experience into modalities other than hearing.

Chapter 4 begins by outlining the background to this research, which was stimulated by three years working as composer-in-residence in a school for the deaf and by a number of public music performances with students from the school. The chapter continues by itemizing the instrument technologies devised and employed by the researcher for the purposes of investigating the crossmodal and intersubjective nature of musical experience. The chapter then provides a detailed account of 4 workshops and 3 compositional studies (*The Sense Ensemble, Studies #1 - #3*) carried out in the course of this research to explore different approaches to composition for deaf audiences with a view to learning how to extend composition strategies for hearing audiences. These activities provided methods and results. Based on what was learned during the 4 workshops, *Study #1* was an experiment in using gesture as the 'voice' of a composition, testing a number of different techniques for alerting an audience to the whole-body and intersubjective potential of musical experience. The study aimed both to encourage the audience to perceive the gestures as musical, and to have them participate in the performance of the gestures in a musical fashion. Results from participatory feedback, questionnaires and post-performance Q&As unequivocally show both deaf and hearing participants to have perceived the gestures (ISL signs) as a form of musical expression, and to have participated successfully in the performance of these gestures.

Study #2 took this use of gesture a step further with a performance involving 1) a larger venue, 2) a mixture of conventional and adapted instrument technologies (e.g., string quartet and vortex cannon) and 3) a refined use of selected techniques from *Study #1*. The study demonstrated the gestural interaction to be equally successful in the larger venue, and that again the audience perceived the gestures as musical. Moreover, the vortex cannons were integrated more thoroughly into the performance. Specifically, the string quartet took the smoke rings emerging from the cannons as their cue to begin a furious tremolando, and then governed the rate of rallentando by watching the rings gradually slowing down as they drifted across the auditorium and into the audience.

Chapter 4 concludes with *Study #3*: an attempt by the researcher to perform a composition under more clinical circumstances. *Study #3* is based on examples from the literature which demonstrate sound induced visual illusions, and visual illusions induced by vibrotactile stimuli (Shams *et al.*, 2002, 2005). The study aims to investigate such crossmodal correspondences with a view to exploiting them in composition. To be more precise, participants are instructed to report the number of flashes appearing on a screen while conflicting auditory and vibrotactile stimuli are presented as part of a multisensory composition. Overall, Study #3 provides valuable methodological insights in terms of composition as a form of research in a clinical setting. The results confirm sound induced visual illusions, while the influence of vibrotactile stimuli on either visual or auditory perception was uncertain in this case. Further studies are recommended.

Chapter 5 consolidates the results from the studies in Chapter 4 into a compositional approach – **a crossmodal harmonic technique** – the aim of which is to alert an audience to the whole-body, multisensory and intersubjective potential of music. First, the act of musical composition is acknowledged to be merely an initial step in the creation of a musical experience, necessarily followed by performance and audience interaction in an intersubjective event. Crossmodal harmonic technique is then outlined, its fundamental building block being a motive with multimodal potential, i.e., a gestural pattern that can be repeated and varied for the attention of other modalities. The chapter goes on to suggest ways of developing a multisensory narrative using this motive. Harmony and technology are then collectively considered in terms of human relationships, and their vital role in the musical experience. The chapter concludes with a clear outline of crossmodal harmonic technique, with the aim of providing others with a foundation on which to develop such methods further.

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6.2 EVALUATION OF ACHIEVEMENTS AND FUTURE RESEARCH

This research has been motivated by passion, curiosity and a deep love for this most mysterious of phenomena: music. It has provided insights into how an audience can be alerted to the whole-body experience of music through a compositional technique that foregrounds intersubjective and crossmodal relationships in performance. Many of the features of this technique are based on existing musical conventions – e.g., theme and variation, hockets, polyrhythms – but serve to extend these conventions into multimodal presentations. The researcher welcomes others to experiment with the technique and to develop it further. It is worth listing some of the areas of this research that are ripe for future exploration:

1) The Live Experience versus Recorded Media
This thesis mostly explored music composition as it relates to live performance. Even in the case of *The Balloon Study* and *Study #3*, there was a live interaction between researcher and participants. A contrasting area of study involves multisensory compositions that can be experienced through, for want of a better term, recorded

media. Such studies are useful in exploring intersubjectivity between a living individual (the listener) and the mechanical expression of a living individual (playback of recorded media). Such recorded multisensory compositions arguably represent a vital, humanization of technology, as stated by Heidegger (1977), and can take (and have taken) many forms, including:

a) Multisensory expressions of music using a variety of media technologies (video, audio and vibrotactile),

b) VR technology which immerses participants in a world which is not only multisensory, but can also represent a more verisimilitudinous extra-musical narrative (Serafin *et al*., 2016)

and

c) Suggestions of multisensory experience brought about by unimodal expressions (e.g., audio recordings which suggest visual and tactile experience, e.g. Kaija Saariaho's Japanese Gardens)[1].

2) Studies in Increasing Vibrotactile Awareness

More work should be carried out to further what was investigated in *The Balloon Study* (Chapter 3, Section 3.2). This study points to novel avenues of research into how vibrotactile awareness can be heightened for an extended period of time, alerting listeners to an ever-present, but often latent, dimension of musical experience. As the conclusions to the study pointed out (Chapter 3, Section 3.2), further research could have the following aims:

a) To examine deaf participants' responses more comprehensively by i) engaging with a larger sample group and ii) more rigorously comparing deaf participants with and without ALDs. Larger groups would provide much more reliable data, which could be further tested statistically. The comparison of participants with and without ALDs is crucial in

[1] While this last option would not be of interest deaf people who evaluated as having a severe or profound hearing loss, it is worth mentioning as a way for hearing individuals to expand their sensory horizon in terms of musical experience.

understanding the duality in the listening experience of many deaf individuals.

b) To use brain imaging techniques to investigate a correlation between reported awareness and neural activity in relevant cortices (Gallese & Cuccio, 2015). Techniques such as fMRI could be employed in variations on *The Balloon Study* to find correlations between the reported vibrotactile awareness of participants and the areas of their brains that show corresponding activity.

c) To engage a more gender-balanced, deaf participant group (this study had a larger proportion of female participants). The significance of gender in Irish Deaf Studies can be identified, for one, in the linguistic differences created by the separate schooling of deaf girls and boys in Ireland (Matthews, 1996).

d) To mix different orders of Likert scales (between 5 and 9) into the questionnaire process, to see if there is a statistical difference in terms of response. Preston *et al.* (1999) have shown that there is a trade-off for increasing or decreasing the number of choices on any rating scale - respectively greater choice or greater simplicity – which can be productive or counterproductive for participant engagement. It would be worth considering what number of choices best suits *The Balloon Study*.

3) Musical Performance as Experimental Study

This research involves studies which attempt to marry an experimental approach with performance. *Study #1* and *#2* are compositions with embedded research aims, and the performance of these compositions provided empirical results through audience feedback. While *Study #1* and *#2* involved medium and large audiences respectively, *Study #3* reduced the audience to either one or two participants under more controlled conditions in the interests of reproducibility. *The Balloon Study* (which took place after the 3 Sense Ensemble Studies) took this controlled approach even further by radically reducing the musical stimulus in order to gauge the participants' awareness of a very specific perceptual aspect.

The results of these studies beg many new research questions concerning methodology. While the challenge of importing scientific methods into a performance vocabulary must be acknowledged, both *Study #1* and *#2* (the more performance based of the four studies) have produced results relevant to the research aims. The researcher regards the issue of merging musical performance with controlled, experimental study as a potent area for future investigation; allowing for insights into both performative and scientific methodologies.

4) Eurythmics and Multisensory Composition

Eurythmics is an educational method, developed by Swiss composer Emile Jaques-Dalcroze, predicated on the connection between movement and music. It encourages the use of bodily movement to represent musical phenomena (Dalcroze, 1913; Frego, 2009). It is beyond the scope of this research to address Dalcroze's methods in any detail; as this thesis focusses on composition while Dalcroze's concerns are largely pedagogical. Nonetheless, a comparative study of eurythmics and multisensory composition might be warranted due to the embodied foundation common to both.

For now, the researcher would like to set down some concrete observations on a method for a movement-inspired sense of harmony which he established with the Sense Ensemble Workshops 1-4.

Embodied Harmonic Technique

This is an embodied crossmodal harmonic approach which involves a series of perspectives of increasing compass, including 1) an individual striking a single percussion instrument once, 2) an individual striking a single percussion instrument with a two-bar pattern, 3) an individual dividing their struck pattern between two percussion instruments with different mass to introduce melody (i.e., pitch), 4) two or more individuals striking related melodic patterns simultaneously to introduce harmony and 5) introducing changes to the combined result to introduce structure.

The approach is presented below in more detail.

<u>Perspective 1: Introducing the single strike</u>

Striking a single percussion instrument.

In striking a single percussion instrument – for example, a cow bell – one should focus on:

1) the grip on the beater,
2) the movement of the hand towards the instrument,
3) the body's supportive pose,
4) the resistance of the object (i.e., the object striking back),

5) use of this resistance (that is, to incorporate it into the player's rhythm),

6) the tangible nature of the action for the player,

7) and an awareness of this tangible experience being evident to an audience through embodied simulation (i.e., the audience can 'feel' it, too).

Perspective 2: Introducing rhythm

Striking a single percussion instrument with a pattern of 2 - 4 bars.

In striking the pattern, one should focus on:

1) the sense of a series of striking actions being grouped (rather than the sense of an abstract pattern),

2) the pattern itself as a set of bodily actions and

3) the fact that while the manner of striking the pattern can be varied (e.g., different accents), the pattern essentially stays the same.

Perspective 3: Introducing melody

Dividing the struck pattern between several percussion objects – e.g., two cow bells of different dimensions – to generate a contrasting response.

It is useful to be aware of the following:

1) These contrasting responses can be perceived through:

i) Hearing (pitch, colour, tone, timbre),

ii) Sight (alteration in posture, direction of strike, rebound) and

iii) Touch (mass of object, density of object; in short, the object's reaction to being struck).

2) The vocabulary of melody is thus extended beyond pitch to include tactile and visual elements, and melody takes on a gestural significance.

3) Hearing ability becomes unimportant in that there are multiple forms of entry for these patterns, and they can be experienced in different ways.

Perspective 4: Introducing harmony:

Developing an awareness of the pattern of strikes as part of a larger body of actions; that is, the ensemble.

It is useful to be aware of the following:

1) How the members of the ensemble depend on each other, e.g., changes in one body can affect the larger body;
2) The need to watch each other, listen to each other, feel each other;
3) The connectedness of the rhythms, e.g., feeling not only what the others are doing but also the emergent properties of the musical organism represented by the group; and
4) That harmony is achieved, i.e., a combination of distinct elements which can be appreciated both independently and as a coherent whole.

Perspective 5: Introducing structure

Developing an awareness of the harmonic organism.

It is useful to be conscious of:

1) The larger body of actions (made of smaller ones) acting as an entity and
2) The ability to use different coordinated techniques (rests, crescendo, accelerando) to introduce structure.

5) Voice Leading in Crossmodal Harmonic Technique

Jane Clenndinning describes voice leading as the linear progression of lines and their harmonic interaction with each other (Clenndinning, 2013). The technique presented in Chapter 5 could be greatly expanded to involve a more rigorous sense of multimodal voice leading; especially taking into account recent scholarship like that of David Huron (Huron, 2016). Rather than imposing rules, it would be productive to explore different perspectives regarding how multisensory stimuli act in parallel (horizontal movement) and in combination (vertical relationships).

6) Workshops in Multisensory Composition

It is hoped that this research can be valuably used to inform workshops on techniques for multisensory composition with other composers. It had been the researcher's intention to include this as a component of this Ph.D., but ultimately it became clear that this would have to represent a separate project. Such workshops could involve a demonstration of the approaches represented in this thesis, as well as inviting new ideas from participants.

NB: It is worth considering any adaptation of facilities necessary to such workshops. This researcher benefited from conducting workshops in facilities tailored for deaf participants. For more information, see United Nations (2006).

6.3 CONCLUSION

This research was originally motivated by a desire to learn about deaf people's experience of music. Work in a deaf school quickly showed the researcher, however, that neatly defining a deaf experience of music was no more reasonable a proposition than defining a hearing one. First, as has been said, the condition of deafness and the condition of hearing vary widely from person to person. It is not possible for two deaf people to have exactly the same personal circumstances (physiologically, cognitively or environmentally) for experiencing music, nor is it the case that any two hearing individuals share the same circumstances. Second, an individual's physical ability is only a small part of the perceptual canvas. More important, arguably, are the preconceptions which an individual brings to the musical experience. What is meant here by preconception is not necessarily the notion of a negative prejudice, but a functional, cognitive agency that necessarily presupposes concept (Gadamer, 1989). To comprehend music, or any other set of patterns, humans depend on preconceptions (Wiercinski, 2011).

It is typically assumed that music exists as an objective reality; an inviolate phenomenon occurring somewhere in space outside of the individual. In fact, music can only ever be encountered as an embodied perceptual experience. Vibrations may occur in inanimate objects, but music requires a living being if it is to 'exist' at all. What music means to each individual, beyond the point of initial stimulus in one or more modalities, begs an even more complex set of cognitive questions. Such questions involve intersubjective relationships that fundamentally inform the manner in which an individual experiences the world (Merleau-Ponty, 1945; Gallese & Cuccio, 2015). Exploring such an intersubjective dynamic is a principal ingredient in music-making; although this is not evident in most day to day musical interactions. Working with deaf musicians, however, makes this normally latent intersubjective relationship more prominent, due to the fact that communication between deaf musicians requires techniques unlike those used in conventional music-making between hearing individuals. These techniques, some of which this thesis has investigated, can serve any individual – whether hearing or deaf – and produce a novel experience. Thus, as is suggested in the thesis introduction, exploring music for deaf audiences is in fact an exercise in better understanding music for all audiences.

'What's in a name?' In the context of musical experience, the answer would seem to be 'everything'. As Martin Heidegger put it, 'Language is the house of being' (Heidegger, 1971). The names commonly used to describe musical interaction – listening, hearing and other audio-centric terms - carry inveterate assumptions which decisively influence the experience of those that use them. People do not determine their musical experience as free agents, but are born into a cultural contract of sorts; inheriting and absorbing much more than they will likely ever know, or possibly wish to admit, through language, tradition and exposure. Yet, while preconceptions must exist in order for individuals to comprehend music, many assumptions about the musical experience are subject to reinterpretation. The contract can be renegotiated, and people need not think of their relationship with tradition or language as a form of experiential slavery. After all, tradition and language are generated by people themselves in an intersubjective Ouroboros that encircles and connects all of human history. It is not a matter of escaping the hermeneutic circle, but of finding a way to negotiate it (Fry, 2009). Rather than being rigid, conventions are as flexible as their adherents choose them to be. Musical conventions, despite all the theoretical dogmatism that peppers their history, have in fact proved extremely plastic. Traditions are in constant flux, as the people that follow them adapt to new technologies and ideas, providing new names and new approaches.

In sum, there is much to learn about music from those who cannot hear, and it is hoped that this thesis will offer some encouragement for others to investigate the area further, and above all to listen.

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APPENDICES

APPENDIX 2.1 ETHICAL ISSUES

A) Letter of Approval from the School of Engineering Research Ethics Committee of Trinity College

COLÁISTE NA TRÍONÓIDE, BAILE ÁTHA CLIATH | TRINITY COLLEGE DUBLIN
Ollscoil Átha Cliath | The University of Dublin

December 17, 2015

To Whom It May Concern:

George Higgs' Ph.D. research proposal 'An Approach to Music Composition for the Deaf' has been approved by the School of Engineering Research Ethics Committee of Trinity College Dublin.

Sincerely,

Luiz DaSilva

Luiz A. DaSilva

Professor of Telecommunications
Director of Research, School of Engineering
Trinity College Dublin

B) Application to the School of Engineering Research Ethics Committee of Trinity College, including forms (PIL, Consent Form, etc.) 17 pages.

2015/2016

School of Engineering Research Ethics Committee
Application Checklist

Name of applicant: Mr George Higgs

Date: November 17, 2015

Please read through the checklist below and tick the relevant boxes provided to ensure that each required item has been included with your application. Please put 'N/A' against items that are not relevant to your application. Applications submitted without a completed checklist will not be reviewed by the Committee.

Application Inclusions:	≥	**N/A**
Letter of approval from medical/hospital/specialist ethics committee *No hospital or clinical procedures are involved*	N/A	**N/A**
For studies involving minors (i.e., participants under age of 16 years), form for obtaining written consent to participate from parent or legal guardian.	N/A	**N/A**
Signed 'working with adults' signed declaration form (if submitted with previous application, please state date of submission ______________________)	X	
Signed 'statutory declaration' form when working with minors (if submitted with previous application, please state date of submission __________________)	N/A	**N/A**
Letter from clinically responsible person agreeing: to host study; provide access to sufficient numbers of participants; provide appropriate psychological/medical support in the event of distress being experienced by participants	N/A	**N/A**
Letter of permission from the organisation/industry/institution hosting the study	N/A	**N/A**
Application form (Section 23) states that data will be stored for a minimum of 10 years in line with Trinity College's data retention policy. **N.B. Ticking this box is not sufficient, you must state clearly on Section 23 of the application form that you will implement this specific data storage procedure**	X	
Applicant's and supervisor's signatures on final page of application form	X	
Participant consent form and study information/debriefing sheet	X	
Is this a retrospective study/clinical audit and/or is it a study which uses data from secondary sources? (ensure Section 24 of form is fully completed)	**N/A**	**N/A**
Provision of any advertising material that will be used for the purpose of recruiting participants (e.g., posters)	**N/A**	**N/A**
Study information/debriefing sheet containing contact details of psychological support services that participants may avail of should they experience any	**N/A**	

distress. Procedure for dealing with/minimising any possible psychological distress in participants to be specified on application form (e.g., in Section 18-21).		**N/A**
Study information/debriefing sheet containing Trinity College work contact details (phone number, e-mail and postal address) of applicant and supervisor.	X	
Study's procedure, design and methodology described on application form (Sections 1-4).	X	
Study's consent and debriefing procedures described on application form (Sections 8-11, 22).	X	

PLEASE NOTE FOLLOWING REASONS FOR AUTOMATIC REJECTIONS**:**

APPLICATIONS WILL BE REJECTED WITHOUT FURTHER CONSIDERATION IN THE FOLLOWING CIRCUMSTANCES AS APPLICABLE:

1. Failure to submit 3 complete copies of the application form. This means 3 copies of the current application form with checklist and 3 copies of all supporting documentation. Copies not bound together properly will also be rejected.
2. Failure to submit by the scheduled application deadline.
3. If ALL sections of the form are not completed (1 – 24 inclusive). If a section does not apply to your study it is not acceptable to leave blank/write n/a – you must explain in brief why it does not apply.
4. Submission of a hand-written application.
5. The application is without the following signatures: applicant signature or research supervisor signature (applicable for student applications). If the supervisor is not available to sign the application form please attach an email of consent from him/her. In cases where the project supervisor is not a member of the School of Engineering, a School project supervisor is also required
6. Failure to submit a signed statutory declaration form witnessed by a Commissioner for Oaths in the case of a study involving minors, i.e., any person under 18 years of age.
7. Failure to submit a signed declaration form of the Guidelines when Interviewing or Testing Adults.
8. Failure to submit a properly composed participant information sheet, consent form and debriefing sheet. Forms will be rejected if:
   - The participant and/or supervisor's FULL work contact details are omitted, i.e., phone number, email address and work postal address (the address for both the researcher and supervisor must always be as follows: School of Engineering, Museum Building, Trinity College, Dublin 2).
   - Any study which may cause distress to participants must provide full contact details for psychological support services that participants may avail of on the information/debriefing sheet.
   - Consent form must include spaces for participants to both print and sign their name.

N.B., Any application that is rejected due to any of the reasons above must be amended to comply with the instructions as set out above and resubmitted by the applicant in time for the next scheduled application deadline. <u>You will not receive feedback on the cause of rejection as it is the responsibility of the applicant to identify the omissions/error(s) from the list above.</u>

2015/2016

School of Engineering
Research Ethics Committee

Application for approval

Handwritten applications will be not be accepted.
Please note that you may exceed the space provided if necessary.

Name of applicant	Mr George Higgs
Date	November 17, 2015
Contact details (TCD e-mail)	ghiggs@tcd.ie
Status (e.g., Staff, Postgraduate)	Postgraduate
Brief project title (6 words max.)	Approach to Music for the Deaf
Academic Supervisor/Principal Investigator (if applicable)	Dr Dermot Furlong
Proposed start date	October 1, 2015

Study Design & Methods

1. Specify the research question/s to be addressed (30 words max.)

What are the cognitive connections between sight, touch and hearing, as they relate to the experience of music? How can an understanding of these connections be used in order to create multi-sensory musical compositions and design instruments to perform these compositions?

2. Describe the research design and briefly outline the methods that will be used

1)I will research studies on embodied cognition; specifically inter-modality processing, i.e., the connections between sight, touch and hearing.
This research will serve to inform my investigations into techniques for multi-sensory composition (see Method #2), and provide a background for presenting my investigations and compositions in my dissertation.

2)I will conduct a series of investigations in my first year into techniques I have conceived for multi-sensory performance. I will develop these techniques in order to design instruments and to begin composition by the second year of my Ph.D.

a)Technique # 1: Use of vortex rings to create multi-sensory musical phenomena. I will develop a variety of vortex cannons, capable of producing vortex rings which are 1)visible through the use of smoke, 2)tangible when the impact of the vortex ring reaches the audience and 3)audible in the sound of their production.

Detail: A vortex ring is torus shaped vortex in a fluid or gas, which moves in a direction perpendicular

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to the plane of the vortex, while the molecules within the vortex ring are also moving with a regularity as a result of the inner part of the ring moving at a faster rate than the outer. They are usually invisible in air, unless visible particles are suspended within the vortex (smoke). Examples are smoke rings. By virtue of their rotation, vortex rings can move quite far in a relatively stationary medium.

b)Technique # 2: Development of a five piece string ensemble which can perform around a tuning system based on just intonation for 6 harmonic series: C, G, D, A, E and B. I will model this using software, Pure Data (aka, MaxMSP) and a surround speaker system to represent the individual components of the ensemble. This software modelling phase will be followed by work with an actual string quintet to perform the piece. Each instrument will me miked, and the resulting signals will be chanelled to vibrating speakers set on a structure to be occupied by audience members.

This just tuning system will predominantly use the natural harmonics of the stringed instruments – essentially pure tones – and will allow me to analyse which harmonic combinations are the most successful in translating to vibrations in the structure.

3)I will put on a number of workshop performances of compositions from the series in the second and third year of the PhD and gather audience feedback from both deaf and hearing individuals.

4)I will use the feedback from the performances to refine my approach for successive compositions.

3. Describe the procedures that participants will encounter during the study. This account should convey, in straightforward language, exactly what will happen to participants in the study.
Please attach copies of all **non-standard** questionnaires, interview schedules, etc. in an appendix (copies of standard/published questionnaires are not required, but their psychometric properties must be stated in the next section).

Participants will be members of an audience witnessing a multi-sensory musical performance; i.e., one that uses auditory, visual, and tactile(through consciously 'felt' vibrations) musical expressions. Before the performance the participants will be asked about their habits and customs around experiencing music.
They will be asked after the performance to give their feedback on how the experience was for them, through the use of specific questions regarding different senses.

4. How will reliability and validity be assessed. If not known, what steps will be taken to establish reliability and validity?

Face validity: This has been checked with my supervisor and staff in the Centre for Deaf Studies, especially regarding the phrasing of questions and the options for response.

Content Validity: With my supervisor I have considered the issues of multi-sensory experience that we feel need to assessed, and ensured that the questions cover all these issues around the performance the participants will be witnessing.

Criterion Validity: This is more difficult as there are not many existing surveys of this kind, i.e., qualitative studies of multi-sensory experience. However, we have done our best to ensure we have asked the proper questions for evaluation of that combined experience.

Test-retest Reliability: Because the response to a performance depends on many contextual issues, it's hard to address this properly. However, one measure we have taken is to ask certain questions before the performance, and certain questions afterwards; so as to ensure that the performance experience won't influence questions asked on a more general level: e.g., what sort of music do you generally listen to?

Access & Recruitment of Participants

5. How many participants are required?
Approximately 100

B. Age/age-range of participants?
18-65

6. Classification of participants [Tick as appropriate]

A. Students X

B. Other non-clinical/non-medical groups (e.g., participant panel) – specify group in space below ☐

C. Medical group (see section 6.1 on medical groups below) ☐
Inclusion criteria
i) People currently receiving medical treatment
ii) People not 'in remission' from previous medical treatment
iii) People to be recruited because of a previous medical condition
iv) Healthy controls recruited for a medical stud

D. Clinical group (see section 6.2 on clinical groups below) ☐
Inclusion criteria
i) People currently undergoing non-medical treatment (e.g., counselling, psychoanalysis) in treatment centre or similar venue
ii) People diagnosed with DSM disorder

6.1a If study involves a MEDICAL GROUP, has ethics approval from hospital / medical / specialist ethics committee been sought and granted?

Yes_______ / No_____ [Tick as appropriate]

If Yes, supply letter of full (unconditional) approval [Tick to confirm attachment] **N/A**

If No, give detailed explanation why approval cannot/has not been sought and granted

6.1b If study involves a MEDICAL GROUP, does study impact on participant's (including medical and control groups) medical condition, well-being or health?

Yes_______ / No_______ [Tick as appropriate]

N/A

If Yes, supply letter of full (unconditional) approval for hospital / medical / specialist ethics committee. [Tick to confirm attachment]

If No, give detailed explanation of why you consider there to be no impact on medical condition.

Note: If study impacts on participant's medical condition and where no external ethics committee approval exists, applications will be reviewed by Committee's panel of medical experts.

6.1c If study involves a MEDICAL GROUP, (regardless of external ethics committee approval), supply the following two letters:

1. Letter from host institution agreeing to support study [Tick to confirm attachment] **N/A**

2. Letter from medically responsible authority figure at host institution supporting/sanctioning study (should include: support mechanisms for participants who may experience distress; potential risks to participants; access to sufficient number of participants) [Tick to confirm attachment] **N/A**

Note: One letter containing all necessary information may suffice

6.1d People attending for psychoanalysis or counselling but who would NOT normally be regarded as being part of a treatment group. NB. Usual individual consent protocols apply **N/A**

6.2a If study involves a CLINICAL GROUP, has ethics approval from hospital / medical / specialist ethics committee been sought and granted?

Yes_______ / No_______ [Tick as appropriate]

If Yes, supply letter of full (unconditional) approval [Tick to confirm attachment] **N/A**

If No, give detailed explanation of why approval cannot/has not been sought and granted

6.2b If study involves a CLINICAL GROUP, (regardless of external ethics committee approval), supply following two letters:

1. Letter from host institution agreeing to support study [Tick to confirm attachment] **N/A**

2. Letter from clinically responsible authority figure at host institution supporting/sanctioning study (should include: support mechanisms for participants who may experience distress; potential risks to participants; access to sufficient number of participants) [Tick to confirm attachment] **N/A**

Note: One letter containing all necessary information may suffice

2015/2016

7. How will participants be accessed/ recruited? From where will participants be recruited?

This recruitment will be public, mostly through FACEOOK. There will be no strict relationship with any particular institution for recruitment, other than the fact that the research will be carried out through Trinity College Dublin, specifically the departments of Engineering and the Centre for Deaf Studies (Department of Linguistics).

N/a

Note: If recruiting participants from institution/organisation, supply letter of agreement to host study and participant recruitment advertisement/email etc.

[Tick to confirm attachment]

8. Specify how participants will be informed of the nature of the study (e.g., aim, rationale) and what participation entails (attach copy of information sheet, briefing or debriefing forms). Volunteers will be given an information sheet through email, describing the study. [Tick to confirm attachment]	X
9. Specify how informed consent will be obtained (attach copy of consent form). All participants who choose to answer the questionnaire will be asked to sign a consent form. Audience members are entitled of course not to participate in the study; i.e., attending the performance does not constitute participation in the study, filling out the questionnaire does. [Tick to confirm attachment]	X

10. Specify whether the study involves deception or the withholding of information. If so, justify why it is necessary?

N/a

11. If observational research is to be undertaken without prior consent, describe the situation and how privacy, confidentiality and dignity will be preserved.

N/a

Fieldwork/Data Collection/ Testing

12. Where will the study take place? Specify where participants will be tested/interviewed. *In a performance space on campus (TBC); possibly the Printing House.*
13. How long (per participant) will testing / interviewing take? Will participants be offered a break? [if testing period extends beyond one hour, then a break must be offered] *45 minutes.*
14. Will participants be paid? If so, what is the rate of payment?

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Participants will not be paid.
15. Specify how confidentiality of participants will be assured. Feedback given will be ultimately be presented anonymously. We will only require the identity of the participants to ensure they have given their consent. From thereon, the participants' names will not be associated with the information they have given or used in assessing the results of the study.
16. Can participants withdraw from the study at any point without penalty? If so, how will this information be communicated to participants? Yes. It will be made clear that participants can leave the study at anytime without any problem.

Data Storage & Management

23. [For guidelines, see http://www.tcd.ie/foi/] **With reference to the Freedom of Information Act, specify the measures the study will adopt for storing data.** I will keep a copy of all the questionnaires for 10 years, both in hard copy, and digital format. **Will all data be kept for 10 years in line with Trinity's data storage policy?** [Tick to confirm] X
24. For studies involving the use of personal, secondary data (e.g., for clinical audit purposes), describe how the study complies with the policy of the Data Protection Commissioner regarding informed consent and anonymisation [for guidelines, see hhttp://www.dataprotection.ie/docs/A-Guide-for-Data-Contollers/696.htm] n/a

Declaration of applicant *I confirm that I have read and will abide by the School of Engineering Ethical Guidelines and the Psychological Society of Ireland guidelines on Ethical Research.* **Signature of applicant** (GEORGE HIGGS)
Declaration of supervisor (if applicable) *I have read through and approved the contents of this application to the Research Ethics Committee.* **Signature of supervisor**____________________

School of Engineering, Trinity College Dublin

Guidelines when Interviewing or Testing Adults

(See separate guidelines for research with children)

These guidelines must be read by all staff and students carrying out research on human participants in the School of Engineering, Trinity College Dublin. The School's Research Ethics Committee will not accept an application for ethics approval unless a declaration is signed saying that the applicant has read, and will abide by, these guidelines.

1. In the School

Under most circumstances, testing of participants proceeds without incident. Occasionally, however, difficulties arise and these guidelines should be followed by all students and staff.

- If you are interviewing or testing a participant in the School, please make sure that you have a landline telephone number and address for them before they come in. Please telephone in advance to confirm that this is a correct number. Ensure that this is filed in a place known to your project supervisor or to a colleague.
- Make sure that someone knows that you are seeing this person, where, and when you are due to finish. Please introduce the person by name to this colleague.
- Please dress appropriately and somewhat conservatively and not in a way that could make anyone of a different age, background or gender feel uncomfortable.
- Wherever possible, try to ensure that you are seated nearest the door. If practical, leave the door slightly ajar. As some of the testing cubicles do not have telephones, bring your mobile phone with you.

  ƒIf you have any doubts or worries about the person, please terminate the session immediately and inform your supervisor. In some cases, it may be better to leave the room and to let the person finish while reporting the difficulty to your supervisor, the School's Safety Office (Pat Holahan) or the Head of School. Please make sure you inform all of these people of the difficulties after the event, and make sure that the participant panel administrator (Eddie Bolger) is informed so that this person is removed from the participant panel.
- ƒIf you feel under physical threat, immediately leave the room and call security on extension **1999** (**01 896 1999** from a mobile phone or a non-College landline).
- Staff or students testing out of normal office hours should ensure a supervisor, or other suitably nominated person, is also present in the building. Make sure that they know when you are due to finish, and report to them when you have finished.
- Should you see anyone in the building whom you regard as behaving suspiciously, or in the School whom you do not recognise, do not confront but immediately leave the building, seek assistance from any available source and phone security on extension 1999.
- Please note that participant panel members have not been 'vetted' and that people recruited from posters on campus are not necessarily students. Researchers should give out a College landline number or a specific mobile phone provided by the supervisor for the research project rather than a personal mobile phone number.
- Researchers should report any cases of inappropriate or persistent calls or contact from participants to the supervisor, Safety Officer and Head of School.
- If any participant asks for help or advice for psychological or other problems, please say firmly that you are not qualified to give such advice and tell them to contact their GP or go to a local hospital casualty department.

  2. Assessments or interviews outside the School
- For undergraduates, a first home visit must always be made by two people.
- For all other postgraduates and staff, the following precautions must be taken when making a home visit:

o Staff/students must always carry a charged mobile phone.

o There should be a clear 'checking-in' procedure to a member of staff (this includes postdoctoral research fellows) when they have been on a home visit. The member of staff must have a record of the time of the visit, the name and address, and the telephone number. They must also know the mobile phone number of the researcher.

o As part of the introduction to the person being assessed, the researcher should say 'I just have to call my supervisor. The researcher should then ring the designated staff in the presence of the participant and say 'I'm in xxxx's house, and will be finished at approximately xx'.

- o If a researcher fails to ring the designated staff member at the appointed time, that staff member should immediately try to make contact with him/her. Failing that, a more senior member of staff should be contacted, and where appropriate, the relevant emergency services telephoned.
- o Make sure you that are familiar with routes to and location of your destination.
- o See 'Before you Go' leaflet of guidelines for safe practice.

Guidelines for Assessing Brain Damaged or Psychiatric Patients

- Patients should be well briefed about what to expect of the testing session before the visit in question.
- A first home visit by staff and students to psychiatric or brain damaged people must always be made by two people.
- Ideally, patients should be given the information sheet to discuss with their families at least 48 hours before the first visit.
- If you are using computers, or tests requiring a table, you should make sure in advance that, on a home visit, the facilities exist for you to properly do your testing.
- Quietness is particularly problematic when testing in the home, and so it is worth discussing whether you will be able to get peace and quiet in a room on your own with the patient for the time you require. Many houses have dogs, doorbells, televisions, and curious relatives sitting watching.
- In general, brain damaged and psychiatric patients should not be tested for more than 50 minutes without a break. A maximum of two 50-minute testing sessions in any one day is reasonable, although there are exceptions such as when people have travelled a long distance.
- People who have suffered a stroke can often develop pain and discomfort when, for instance, being asked to stare for long periods at a computer screen. They should be frequently monitored for pain and discomfort, and testing stopped if necessary. Test results will be quite invalid if people are in pain or over-fatigued.
- There are considerable ethical problems about paying patients for participation in studies. Patients should be given reasonable travel and out-of-pocket expenses if they travel from home (e.g., taxi fares, refreshments).
- Where patients are coming into the School, you should make sure that they are able to go to the toilet on their own, or if they are not, that someone is accompanying them who can take them to the toilet.
- Many patients with brain damage are at increased risk of epilepsy, even though they may not yet have had an epileptic seizure. If your study includes visually-demanding or flickering screens, you should take appropriate advice before running it.

Declaration

I declare that I have read and understood the document '***Guidelines when Interviewing or Testing Adults'***. I agree to abide by these guidelines, and acknowledge that if I breach these guidelines then ethics approval for the study by the TCD School of Engineering Research Ethics Committee will be nullified.

Name (Print) ...GEORGE HIGGS... Signature...[illegible]............ Date...NOV 17, 2015...

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Department of Electronic and Electrical Engineering
Aras an Phiarsaigh
Trinity College
Dublin 2

Study Information Sheet

Title of Project:	The Sense Ensemble; An Approach to Music Composition for the Deaf	**Ethics Approval Number:**	
Investigator(s):	George Higgs	**Researcher Email:**	ghiggs@tcd.ie

Aims of the Study: To explore multi-sensory expressions of music by 1) performing compositional studies to both deaf and hearing volunteers and 2) getting their anonymous feedback on the effectiveness of the multi-sensory expression

Eligibility Requirements: Participants must be at least 18 years of age. There are no other requirements aside from an interest in exploring new approaches to music

What you will need to do and time commitment: There will be up to 3 performances over a three year period, each lasting 45 minutes.

Risks/Discomforts involved in participating: There are no risks involved in participating in this project, and no discomfort.

Confidentiality of your data: All participation will be treated with the utmost confidentiality. Audience feedback used in the resulting research will be treated without reference to the identity of any of the participants.

Remember that participation in this research study is completely voluntary. Even after you agree to participate and begin the study, you are still free to withdraw at any time and for any reason.

If you would like a copy of this consent form to keep, please ask the researcher. If you have any complaints or concerns about this research, you can direct these, in writing, to the Chair of the Engineering Research Ethics Committee by email at: dasilval@tcd.ie. Alternatively, you can contact us by post at: Ethics Committee Chair, School of Engineering, Trinity College Dublin, Dublin 2.

Contact Information for Researcher:

George Higgs, School of Engineering, Museum Building, Trinity College, Dublin 2

email: ghiggs@tcd.ie

phone: +353(0)872995264

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Department of Electronic and Electrical Engineering
Aras an Phiarsaigh
Trinity College
Dublin 2

RESEARCH INFORMED CONSENT FORM

Title of Project:	The Sense Ensemble; An Approach to Music Composition for the Deaf	**Ethics Approval Number:**	
Investigator(s):	George Higgs	**Researcher Email:**	ghiggs@tcd.ie

Please read the following statements and, if you agree, initial the corresponding box to confirm agreement:

	Initials
I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.	
I understand that my data will be treated confidentially and any publication resulting from this work will report only data that does **not** identify me.	
I freely agree to participate in this study.	

Signatures:

Name of participant (block capitals)	Date	Signature
Researcher (block capitals)	Date	Signature

If you would like a copy of this consent form to keep, please ask the researcher. If you have any complaints or concerns about this research, you can direct these, in writing, to the Chair of the Engineering Research Ethics Committee by email at: dasilval@tcd.ie. Alternatively, you can contact us by post at: Ethics Committee Chair, School of Engineering, Trinity College Dublin, Dublin 2.

Contact Information for Researcher:

George Higgs, School of Engineering, Museum Building, Trinity College, Dublin 2

email: ghiggs@tcd.ie

phone: +353(0)872995264

The Sense Ensemble;
Questionnaire

Please answer any questions you can. It is perfectly acceptable not to answer a question if it makes you feel uncomfortable.

Background Questions to be answered before the performance

1)How would you describe your hearing ability.

Full hearing ☐

Partially deaf ☐

Profoundly deaf ☐

2)How often do you listen to music on average? (put an x in the box next to the appropriate answer)

Every day ☐

Three times a week ☐

Once a week: ☐

Less than once a week: ☐

3)When you listen to music, do you you:

sing along? ☐

move your body? ☐

4)What is your favourite type of music?

5)When you listen to music do you experience it only with your ears, or do you feel other senses (i.e., sight and touch) contribute to the experience?

Questions to answer following the performance.
Please answer in 1 or 2 short sentences.

1)Can you describe how this experience made you feel, for example: happy, sad, confused, frustrated, annoyed, wistful.

2)Can you give reasons for the way it made you feel, for example: 'It made me feel confused because I couldn't understand what was going on?'

3)What sense (i.e., touch, sight or hearing) was mostly involved in your experience of today's performance?

4)Can you describe your visual experience of the performance today?

5)Can you describe your tactile (touch) feeling of the performance today?

6)Can you describe your auditory experience of the performance today?

7)Do you find it hard to think of these sensory experiences (sight, touch,hearing) separately, or is do think of them as being very separate?

Contact Information for Researcher:
George Higgs, School of Engineering, Museum Building, Trinity College, Dublin 2
email: ghiggs@tcd.ie
phone: +353(0)872995264

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Debriefing for Sense Ensemble Study

This performance and the questionnaire you were asked to fill out before and after are part of a study on multi-sensory approaches to music composition. It is the belief of the researcher/composer that all musical experience is in fact multi-sensory, but Western culture has encouraged the perception of music as primarily an auditory experience. This conscious perception of music as being mainly to be listened to understandably affects our overall experience. That is to say, even if unconsciously several of our senses are being affected by music(sight, sound, touch), our conscious notions are going to be the ones that govern how we communicate our response to the experience, to friends and even to ourselves on private reflection.

This performance thus involved use of musical patterns consciously directed at other senses, as well as hearing. The use of air being sent rapidly across the room allowed for a simultaneously visual (when used with smoke), tactile and auditory experience. The answers to the questions you were asked will hopefully help shape how these efforts were successful and unsuccessful, and to find ways to improve the approach.

Thank you so much for your cooperation in our study.

Contact Information for Researcher:
George Higgs, School of Engineering, Museum Building, Trinity College, Dublin 2
email: ghiggs@tcd.ie
phone: +353(0)872995264

APPENDIX 3.1 THE BALLOON STUDY RAW DATA

PARTICIPANTS	VIBRO TACTILE AWARENESS						
	1	2	3	4	5	µ	s
1st LISTENING							
Hearing (n=12)	8	3	1			1.25	.81
Deaf (n=3)			1	2		3.6	.58
Hearing Ctrl (n=4)	3	1				1.25	.433
Deaf Ctrl (n=1)				1		4	0
2nd LISTENING							
Hearing (n=12)					12	5	0
Deaf (n=3)					3	5	0
Hearing Ctrl (n=4)	4					1	0
Deaf Ctrl (n=1)				1		4	0
3rd LISTENING							
Hearing (n=12)	3		9			2.5	.905
Deaf (n=3)			2	1		3.33	.4714
Hearing Ctrl (n=4)	4					1	0
Deaf Ctrl (n=1)				1		4	0

Table 1 Study #4, overall results
Middle columns represent levels of vibrotactile awareness. Rows represent frequency of reported awareness for 4 different groups of participants for 3 consecutive listenings.

APPENDIX 4.1 INSTRUMENT TECHNOLOGIES, DESCRIPTION AND IMAGES[1]

List of Instrument Technologies Involved in this Research (in alphabetical order)

Aluminium Friction Rods

These friction rods are made from 12 mm aluminium bar, and cut to lengths that will produce the following pitches: C, D, E, F, F#, G, B♭. The rods are hung vertically by means of a U-bolt passing through a 6 x 1 cm length of wood behind them, to which they are pinned at their centre point (the 2nd harmonic node) when the U-bolts are tightened.

Amplified Tuning Forks

A set of tuning forks - comprising C, G, E and A – are struck on the scaffolding pipe and placed firmly on a resonant box for amplification. By touching and removing the tuning forks from the resonant surface quickly, pulses of varying durations can be produced, and thus rhythms could be generated. The box is fitted with contact microphones (ceramic piezoelectric transducers) that send a signal to a mixer, and then to an amplifier.

Bass Shaker Speakers

Two 100 watt tactile transducers (AuraSound AST-2B-4) with an optimal frequency range of 30 to 48 Hz have been employed regularly throughout the research. These transducers are secured to a wooden board by bolts, and can then either be clamped to seats or placed on the venue floor for effective transmission of the tactile stimulus.

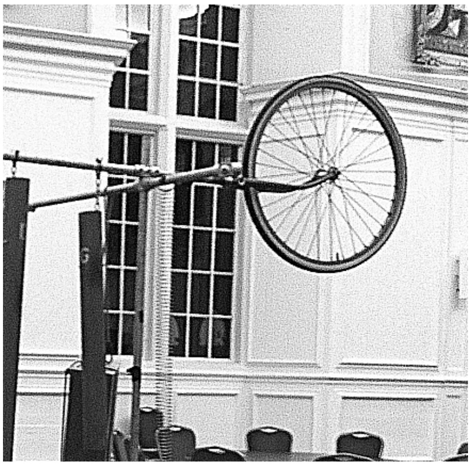
[1] Not pictured: amplified tuning forks, marimba, percussion table and remote hi-hat.

Bell Jar/Percussive Speaker Telegraph Stations

These were prominently used in *The Lost and Found Sound Assembly*. They consist of a telegraph key on a desk, which also has a bare loudspeaker covered by a bell jar. Materials are placed in the loudspeaker which vibrates percussively when infrasonic pulses are sent through the loudspeaker. The telegraph key when pressed produces a sine tone (frequency varied per performance) in the loudspeaker. On the desks there is a Morse code glossary with the help of which the performers can tap out messages. Two deaf musicians can kneel at the station and communicate with each other through a mixture of Morse code and ISL.

Bicycle Wheel

The front forks and wheel have been taken from a bicycle and mounted on the scaffolding frame. The spokes of the wheel can be tuned, rosined and played with a violin bow. The wheel can also be spun and the spokes struck with sticks as they move past, producing a pleasant, percussive sound with a surprising volume.



Copper Pipe Glockenspiel

This instrument has 1.9 cm diameter copper piping cut to different lengths and connected to each other by elasticated string passed through their nodes at either end (4^{th} harmonic). The instrument is played with a teaspoon.

Copper Pot Cow Bell

This is simply an adapted copper pot (diameter = 8 cm, depth = 6 cm) that produces a euphonious, pitched sound when struck (E). A hole has been drilled into the handle of the pot to allow it to be fixed onto the scaffold structure.

DOOR

This is a musical door, endowed with a variety of instruments. Two players can push the door around a space (indoors or outdoors) on its side, set the door aright and perform for an audience. On one side, the door has a cello built into the mullion that is to be played by a standing performer. On the other side, the door is designed to be played by a seated percussionist who can avail of several instruments at his or her feet, and others built into sub-doors which open at head level. The percussion battery comprises 1) a cajon (a wooden box drum) played by a foot-pedal, 2) four slit drums built into the right-hand sub-door, 3) a set of conical bells built into the left-hand sub-door and 4) a set of rectangular bell plates also built into the left-hand sub-door. DOOR was created in St. Mary's workshops for the Cork Midsummer Festival (see video link: https://www.youtube.com/watch?v=3hI3pOdzPqs).

Electronic Multisensory Metronome/Percussion Unit

This instrument is a variation on loudspeaker adaptations the researcher had used in *The Electro Acoustic Exchange* in 2007, and in St Mary's as well (see Chapter 1, Section

1.1). Different objects are placed into a bare loudspeaker driver and allowed to vibrate percussively when infrasonic signals are sent though the loudspeakers. Rhythms can be created, or the unit can be used as a metronome to keep tempo; providing visual, auditory and tactile stimuli.

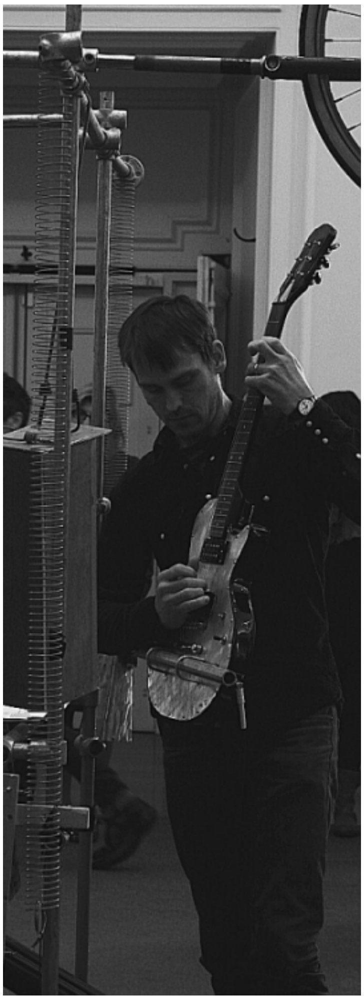
<u>Guitars Mounted on Scaffold Frame</u>

This is often a standard guitar with an open tuning, most often in C (from low to high string: C2-G2-C3-E3-G3-C4). The researcher has also experimented with a guitar adapted to just intonation using fifths, but this remains a work in progress. Whatever the tuning, it is the ergonomic aspect which was most significant. It allows a guitarist a unique perspective on the ensemble by virtue of how the guitar is rigged (into the scaffolding) and how the guitar is played (vertically rather than horizontally).

There are two methods for this rigging to be accomplished:

1) The body of the guitar is fitted with U-bolts which allow the guitar not only to be hung on the scaffold frame, but easily swung in and out of playing position. The guitar is mounted so that it is played vertically.

2) The guitar is played in the vertical position while resting on a shelf built onto a horizontal scaffold pipe at waist level. When the guitar is not being played, it is hung on a guitar hanger built into a horizontal scaffold pipe at 2m height.



Irish Sign Language

Signing has been used extensively in performance. It is worth acknowledging that rather than ISL being used in its recognised capacity for communication, a small number of signs have been appropriated and leveraged in performance for musical expression. This is not merely to suggest a form of dance, but equally as a means of connecting with the audience through a gestural call and response. Curiously, the formal denotation of the signs is often less important than the ability of performer and audience to respond to one another in a purely gestural fashion. For example, the performers enact a brief pattern of signs, and the audience is invited (without spoken language) to imitate the signs; irrespective of their knowledge of ISL. Patterns can be broken apart, involving a kind of hocket where different sections of the audience are performing different parts of the pattern. While signing is clearly a form of visual expression, it is less obviously also capable of generating both sound and vibration. Sounds and vibrations are produced when hands are slapped against each other, or another part of the body.

Marimba (upright) with PVC Pipe Resonators

The bars of the marimba have been cut from 3.8 x 3.8 cm red deal timber. They are all identical in length, but have been tuned by removing mass from their backs around the node (2nd harmonic). They have holes cut into their nodes at the top (4th harmonic) that allow them to be hung vertically. PVC pipe resonators have been cut to appropriate lengths for each marimba bar (the same tuning principle applies here as with the plosive aerophones, see below), and set horizontally at a right angle to each bar. The marimba is played with two dessert spoons, each hanging from a thin chain below the instrument for easy access.

Percussion Table

This is a plywood (1.5 cm) box built around a frame of 4 cm x 4 cm timber, with dimensions: l=1.5 m, w=.75 m, h=.75 m. The box has a hi-hat projecting from its centre which is activated by a remote foot pedal at one end. Next to this hi-hat pedal, a drum pedal has been installed so that the beater strikes the end of the box and resonates throughout. Performers are seated around the box with their knees touching the wood in order to feel the vibrations. As well as its sonic properties, the hi-hat provides a visual stimulus by virtue of its top and bottom cymbals opening and closing. Furthermore, the air being pushed out when the cymbals are brought together produces a sudden current of air on the players' faces, constituting a tactile stimulus.

Plosive Aerophones

PVC piping of different diameters can be struck with a paddle to produce pitched percussive notes with a strong attack, quick decay and a timbre rich in high harmonics. The fundamental frequency of the pipes is closely related to pipe length, but only indirectly related to pipe diameter[2]. The diameter directly affects amplitude, and also influences the useable register of the pipes; e.g., larger diameter pipes are better for lower registers / smaller diameter pipes are better for higher registers. For notes of C2 to C3, 100 mm pipe works best. For notes of C3 to C4, 60 mm works best.

Remote Hi-hat

This is a hi-hat whose pedal is able to be activated from a distance by means of a bicycle brake cable. As is customary, the hi-hat provides its sonic cue by the many ways it can be employed (snapped shut, shut then open to produce a clash, struck with a stick while closed to produce a tight sound, struck with a stick while open to produce a sustained sound, etc.), but also provides visual stimuli (seeing the cymbals open and close, being struck, etc.) and tactile stimuli (feeling the air being pushed out from between the cymbals when the musician's face is in reasonable proximity).

Scaffolding Structure

[2] The pipe supports a slightly longer standing wave than is suggested by its actual length. Thus, the pitch of each pipe must be corrected (i.e., end correction) by trimming it according to a formula based on its diameter: $Le = L + .6(D)$; where Le is the effective length of the pipe(meaning the wave length), L is actual length of the pipe and D is diameter (Hopkins, 1996).

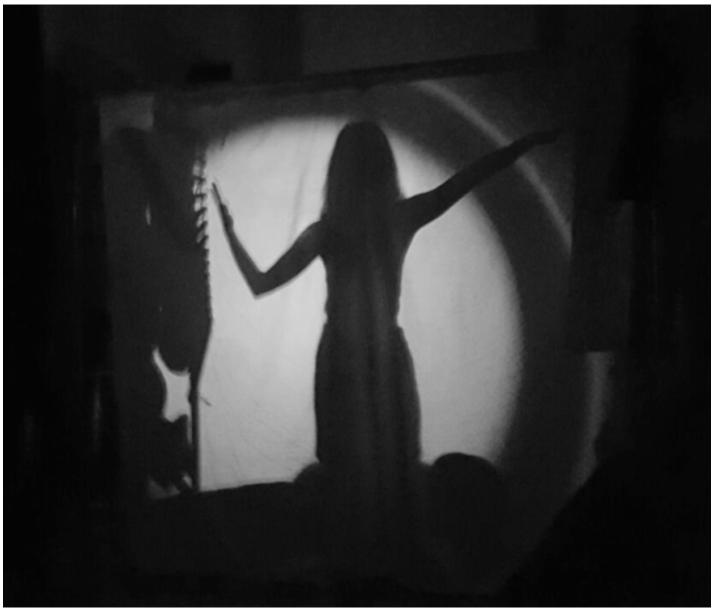
Metzger & Fleetwood (2005) identify eye-gaze as a principal regulator in sign language interaction. Indeed, while at St Mary's the researcher observed that the musicians would have to see each other while they played, and found that a scaffolding frame provided an effective structure around which the musicians could work. This structure has also been used for the Sense Ensemble Workshops 1-4. The scaffolding structure allows: 1) multiple instruments to be hung on the metal scaffolding pipe, 2) the musicians to face each other, 3) the musicians to see each other without too much obstruction and 4) for easy rearrangement into different shapes for performance. The scaffold pipe is 22 mm in diameter and is joined together by couplers using 6mm hexagonal sockets. Assembling and disassembling the scaffolding structure was a group act which constitutes an element of the performance. Using a ratchet with a hexagonal key to loosen/tighten the couplings and sliding the scaffold pipe in and out of the couplers can be a choreographed and coordinated process between performers.

Section Poles

These are 2 metre tall scaffolding poles set into wooden bases (width=50 cm, length=50 cm, thickness=2 cm). The poles are used for the scaffold structure, but can also be used as instruments by lifting them and stamping the floor with the flat bases. This has a visual effect, a strong sonic result and in a room with a wooden floor creates a tactile reverberation.

Shadow Play

This involves a white sheet being attached to a horizontal scaffold bar, a light being projected onto it from behind and a performer moving between the light source and the sheet. The room must be sufficiently dark, and the proximity of the performer to the sheet determines how well-defined the silhouette is. When the performer is close to the sheet, the silhouette is sharp. When the performer moves away from the sheet, the edges of the silhouette become blurred and the body of the silhouette loses contrast.



Slit Drum (two-pitched)

This slit drum is cut with two tongues, the relative size of each producing two pitched notes: F and C. The drum is played with a mallet made from a rubber ball and a piece of 5 mm aluminium rod.

Subwoofers

These are Genelec 7050B Active Subwoofers (70 watts) with a free field frequency response of between 25 Hz and 85 Hz (+/- 3 dB). These subwoofers have been very effective for all stages of the research in delivering an airborne tactile stimulus (as opposed to the tactile transmission through solids provided by the bass shakers, see above), and are designed to function with the high-end Genelec loudspeakers used in all Sense Ensemble studies: Genelec 8010AP and Genelec 1032CPM.

Tactile Walkway

This was a slightly raised platform (10 cm high, 1.5 m long and 1 m wide) ramped on each end to allow audience members to walk across it without impediment. Two bass shaker tactile transducers (see above) have been fitted underneath, hidden from the audience. When the audience members step onto the platform, they can pause and feel the tactile expression of the music. This walkway is often placed in a corridor of the scaffolding through which audience members are invited to pass (e.g., see Section 4.1: *The Lost and Found Sound Assembly*).

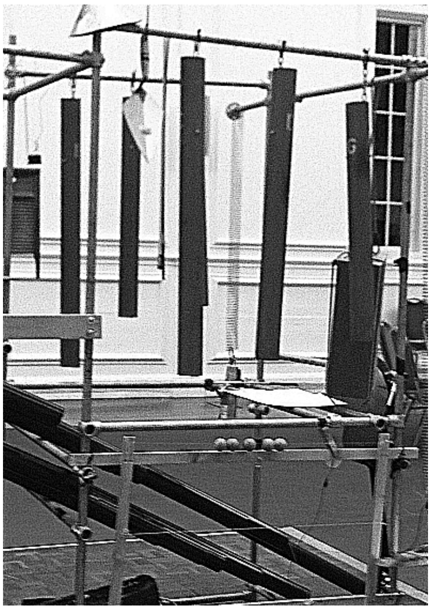
Tension Spring and Cymbal

A crash cymbal is suspended from a 2 m high scaffolding pipe by a long tension spring. At rest, the spring holds the cymbal 75 cm from the ground, but the spring can be stretched so that the cymbal makes contact with the ground and produces a clashing sound. The cymbal then bobs up and down on the spring for a matter of minutes before again coming to rest position. This produces a visual rhythm independent of the other rhythms in the piece of music being played.

Tubular Bells

These are steel pipes cut to lengths to cover the pitches B♭, C, D, E, F and G. The pipes are hung from the scaffold using strings attached through their nodes (4th harmonic).

The bells provide a rich, audible timbre with a strong sustain, but also produce tangible resonance for those playing them.



Washboard

A traditional tin, corrugated washboard set into a wooden frame is used as a scraped percussion instrument.

Wood Block (pair)

These wood blocks are made from two wooden mortars (bowls for crushing seeds) and played with a wooden pestle (the implement for crushing seeds in the bowl), all sourced from a Chinese culinary supplier. The larger and smaller mortar produce semi-pitched notes when struck by the pestle: respectively C and D.

Vortex Cannons

This is effectively a drum that, when struck, produces a toroid shaped vortex (a donut shaped ring) of air. The top of the drum is fitted with an impermeable, elastic membrane. The tension on the membrane should be enough to keep it taut, but still allow the membrane to displace air sufficiently inside the drum. The base of the drum needs to be covered by a rigid membrane with a hole cut into it somewhere between half and one third the diameter of the base. When smoke is put into the drum, a smoke ring is emitted from the hole on the base when the top of the drum is struck. A harness is fitted onto the drum to allow it to be carried by the performer.

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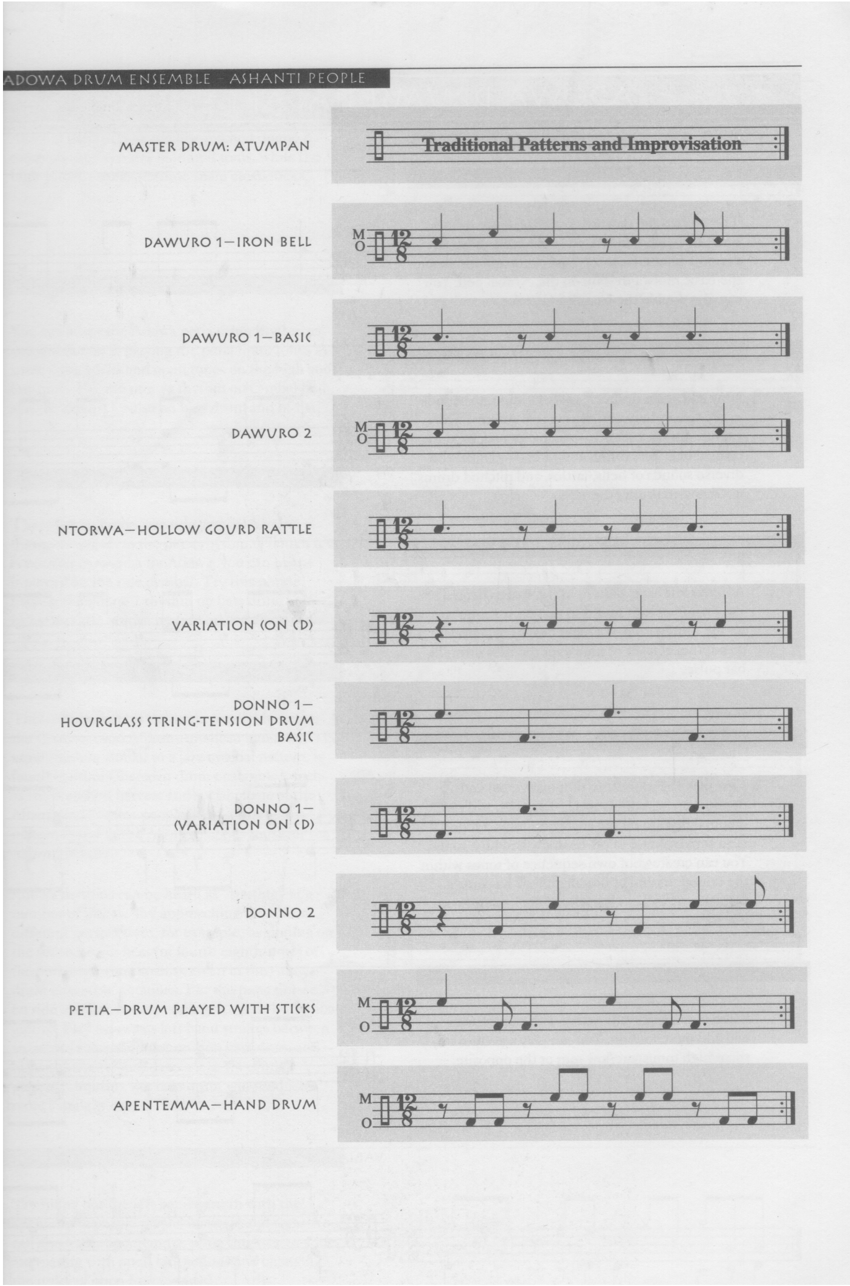
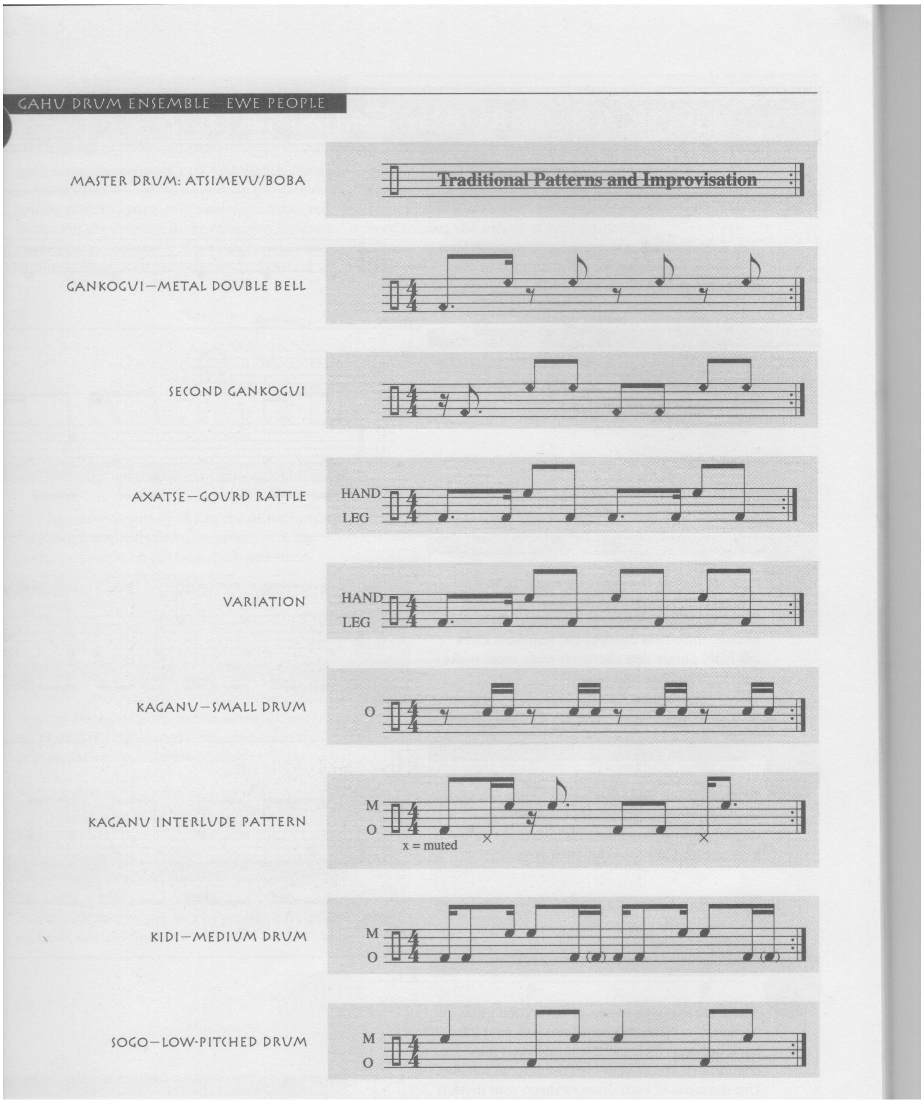
APPENDIX 4.2 GHANAIN RHYTHMS USED IN SENSE ENSEMBLE WORKSHOPS 1 - 4

SIKIYI

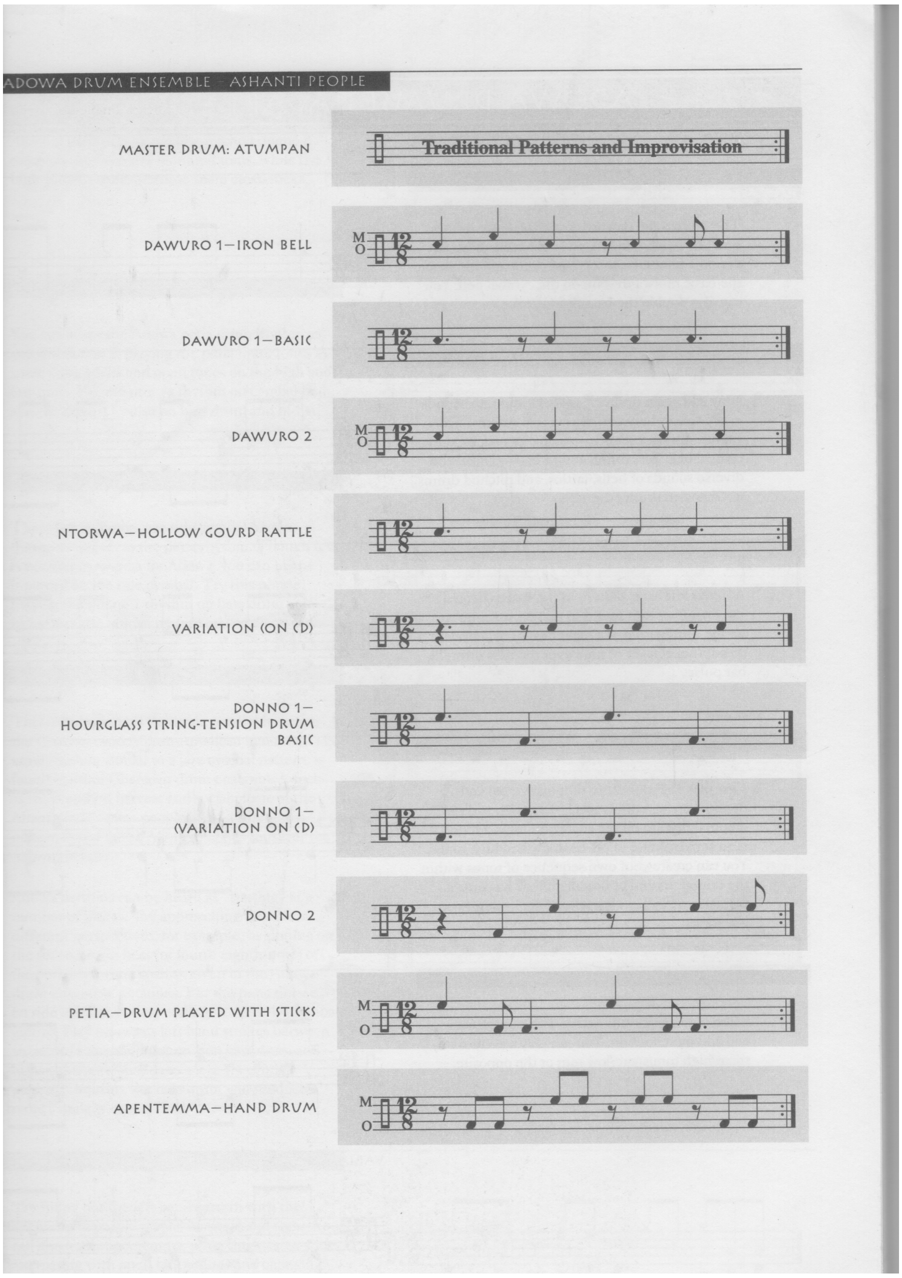
ADOWA


ADOWA DRUM ENSEMBLE ASHANTI PEOPLE
MASTER DRUM: ATUMPAN
Traditional Patterns and Improvisation
DAWURO 1—IRON BELL
DAWURO 1—BASIC
DAWURO 2
NTORWA—HOLLOW GOURD RATTLE
VARIATION (ON CD)
DONNO 1—
HOURGLASS STRING-TENSION DRUM
BASIC
DONNO 1—
(VARIATION ON CD)
DONNO 2
PETIA—DRUM PLAYED WITH STICKS
APENTEMMA—HAND DRUM

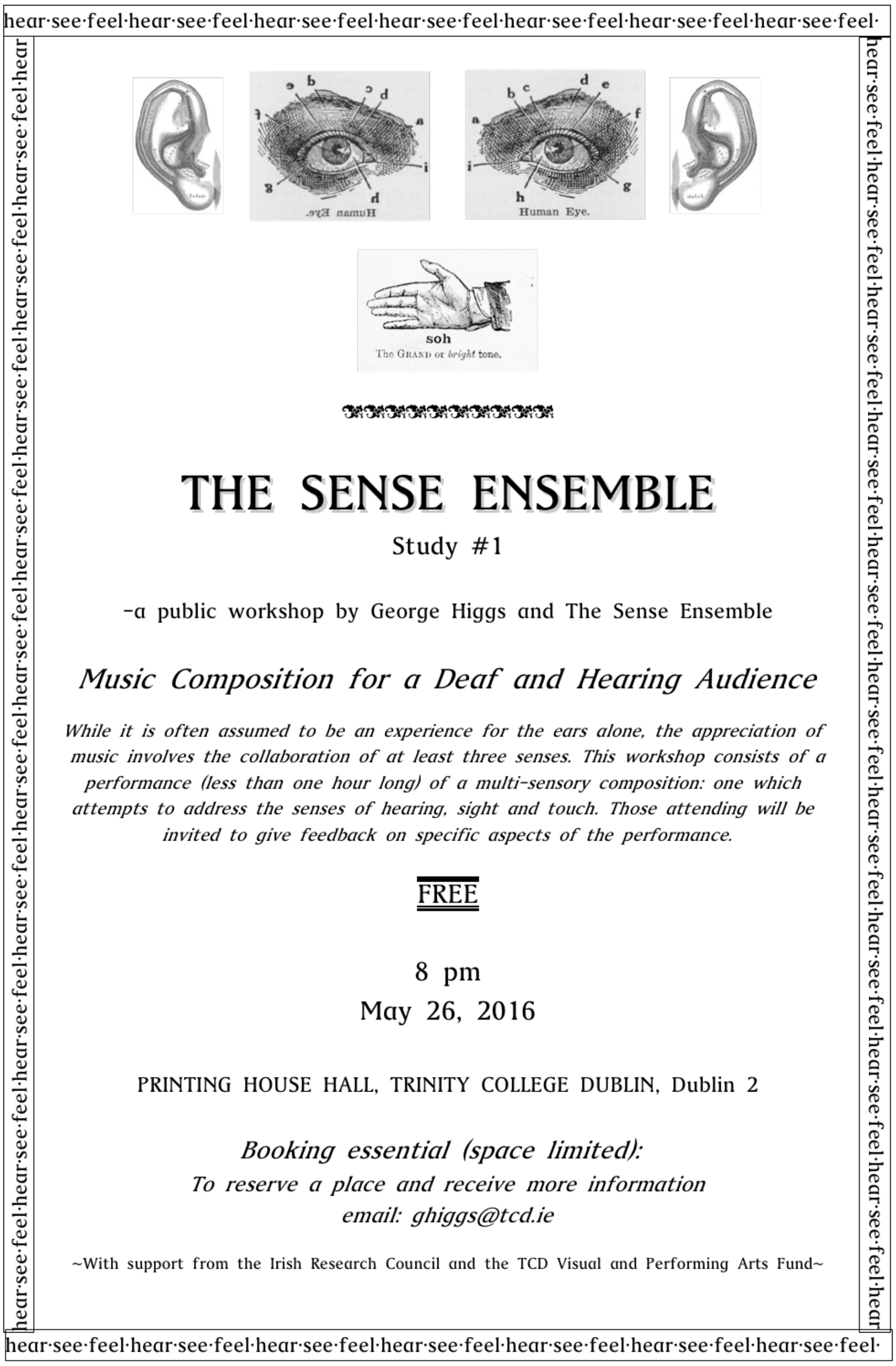
GAHU


GAHU DRUM ENSEMBLE—EWE PEOPLE
MASTER DRUM: ATSIMEVU/BOBA
Traditional Patterns and Improvisation
GANKOGUI—METAL DOUBLE BELL
SECOND GANKOGUI
AXATSE—GOURD RATTLE
HAND
LEG
VARIATION
HAND
LEG
KAGANU—SMALL DRUM
O
KAGANU INTERLUDE PATTERN
M
O
x = muted
KIDI—MEDIUM DRUM
M
O
SOGO—LOW-PITCHED DRUM
M
O

ADOWA


ADOWA DRUM ENSEMBLE ASHANTI PEOPLE
MASTER DRUM: ATUMPAN
Traditional Patterns and Improvisation
DAWURO 1—IRON BELL
DAWURO 1—BASIC
DAWURO 2
NTORWA—HOLLOW GOURD RATTLE
VARIATION (ON CD)
DONNO 1—
HOURGLASS STRING-TENSION DRUM
BASIC
DONNO 1—
(VARIATION ON CD)
DONNO 2
PETIA—DRUM PLAYED WITH STICKS
APENTEMMA—HAND DRUM

APPENDIX 4.3
POSTER FOR SENSE ENSEMBLE, STUDY #1



The Sense Ensemble
Study #1

- for signs, percussion, string quartet and smoke rings

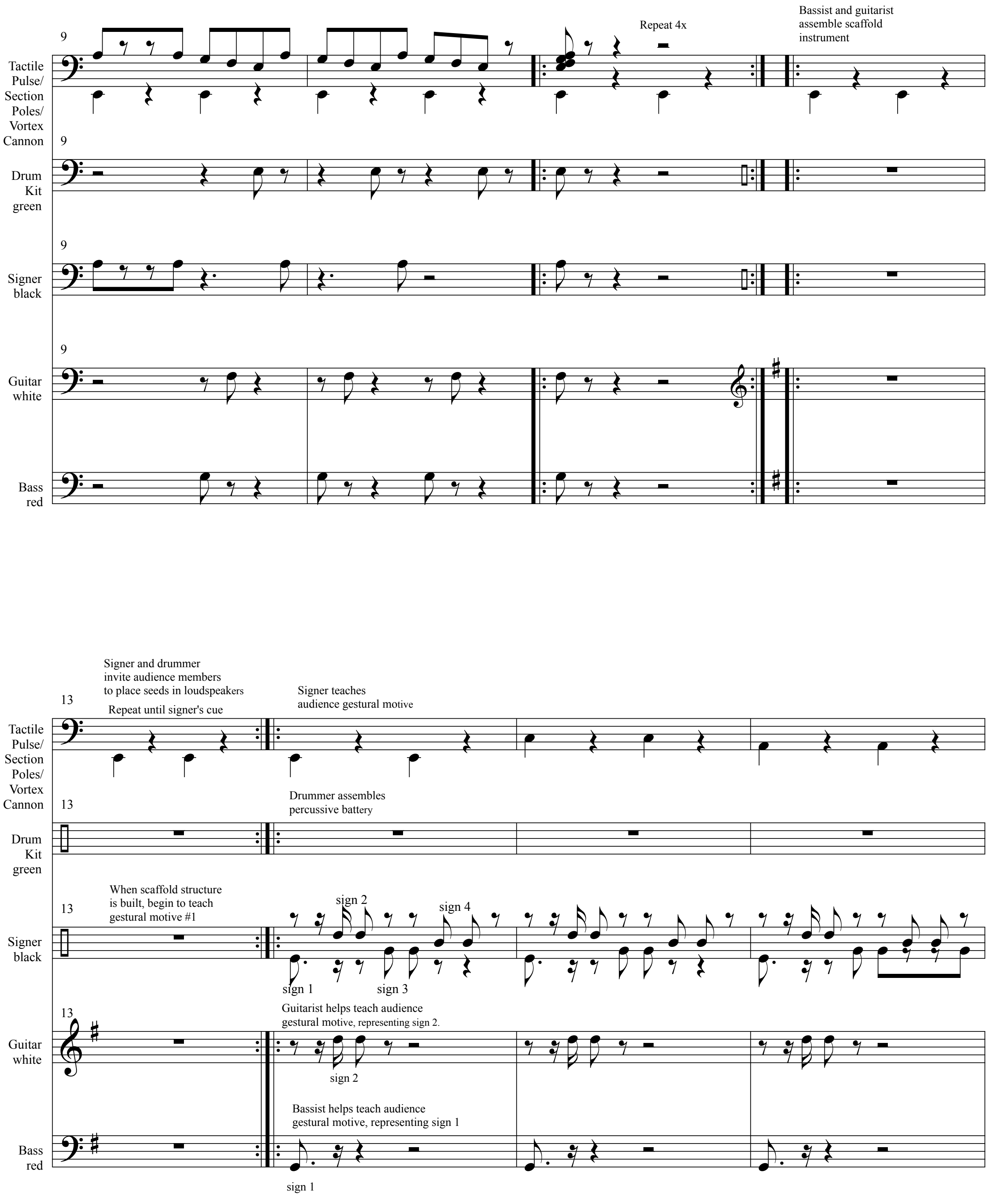
composed by George Higgs
gestural lyric developed by:
Jessica Kennedy & Caoimhe Coburn-Gray

duration: 15 minutes

The Sense Ensemble, Study #1

Composer: George Higgs

Gestural Lyric:
Jessica Kennedy &
Caoimhe Coburn-Gray



9
Repeat 4x
Bassist and guitarist
assemble scaffold
instrument
Tactile
Pulse/
Section
Poles/
Vortex
Cannon
Drum
Kit
green
Signer
black
Guitar
white
Bass
red
13
Signer and drummer
invite audience members
to place seeds in loudspeakers
Repeat until signer's cue
Signer teaches
audience gestural motive
Drummer assembles
percussive battery
When scaffold structure
is built, begin to teach
gestural motive #1
sign 1
sign 2
sign 3
sign 4
Guitarist helps teach audience
gestural motive, representing sign 2.
Bassist helps teach audience
gestural motive, representing sign 1


17
Section is repeated
until audience has
learned motive
Tactile
Pulse/
Section
Poles/
Vortex
Cannon
Drummer repeats gestural motive
accentuating hocket parts, directing
gaze at specific audience sections
Drum
Kit
green
Signer teaches
audience gestural motive
Signer
black
Guitarist helps teach audience
gestural motive, representing sign 2.
Guitar
white
sign 1
Bassist helps teach audience
gestural motive, representing sign 1
Bass
red
sign 1


21
Tactile
Pulse/
Section
Poles/
Vortex
Cannon
Drummer varies gestural motive.
Drum
Kit
green
Signer
black
Guitar
white
Bass
red


25
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Drummer repeats gestural motive accentuating hocket parts directing gaze at specific audience sections
Signer black
Signer monitors audience/player rapport re gestural motive
Guitar white
Bass red
29
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Signer cues move to b.30 when rapport is established
Guitar white
Bass red


33
Tactile Pulse/ Section Poles/ Vortex Cannon
Drummer interacts with varying gestural rhythm
Drum Kit green
Signer explores different signs, varying gestural rhythm
Signer black
Guitar white
wah
wah
wah
Bass red

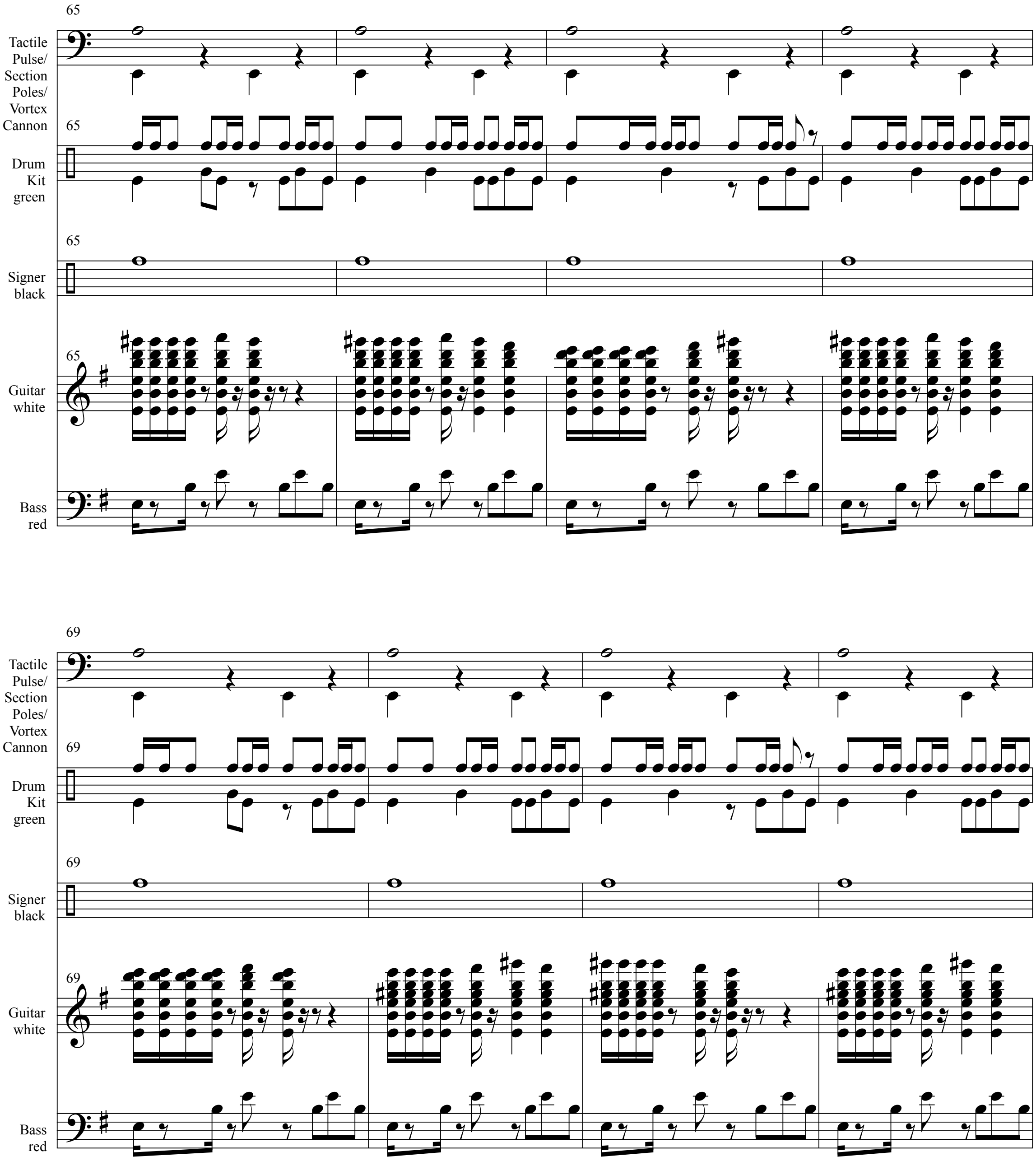

37
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
wah
Bass red


41
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red
45
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red


49
Tactile
Pulse/
Section
Poles/
Vortex
Cannon
Drum
Kit
green
Signer
black
Guitar
white
Bass
red


53
Tactile
Pulse/
Section
Poles/
Vortex
Cannon
Drum
Kit
green
Signer
black
Guitar
white
8va
Bass
red


57
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
(8va)
Guitar white
Bass red
61
Vortex cannon struck
Vortex cannon struck

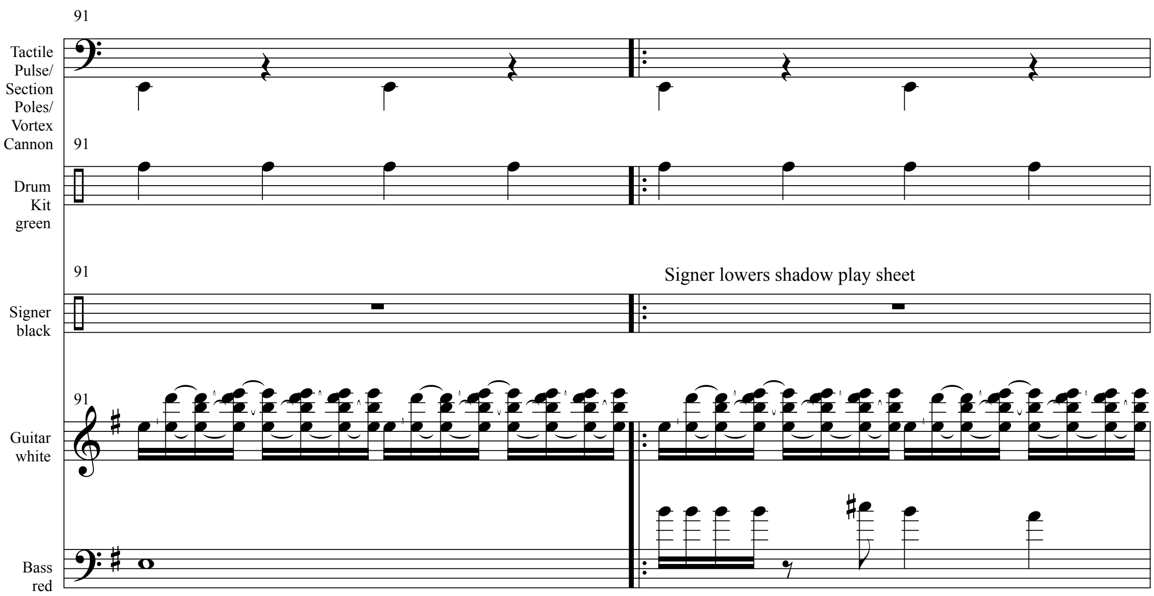

65
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red
69
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red


73
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red
77
Signer moves to the back of the hall with vortex cannon
Signer fires smoke rings at audience members and musicians
8va


81
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red


85
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red


89
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red


91
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Signer lowers shadow play sheet
Guitar white
Bass red

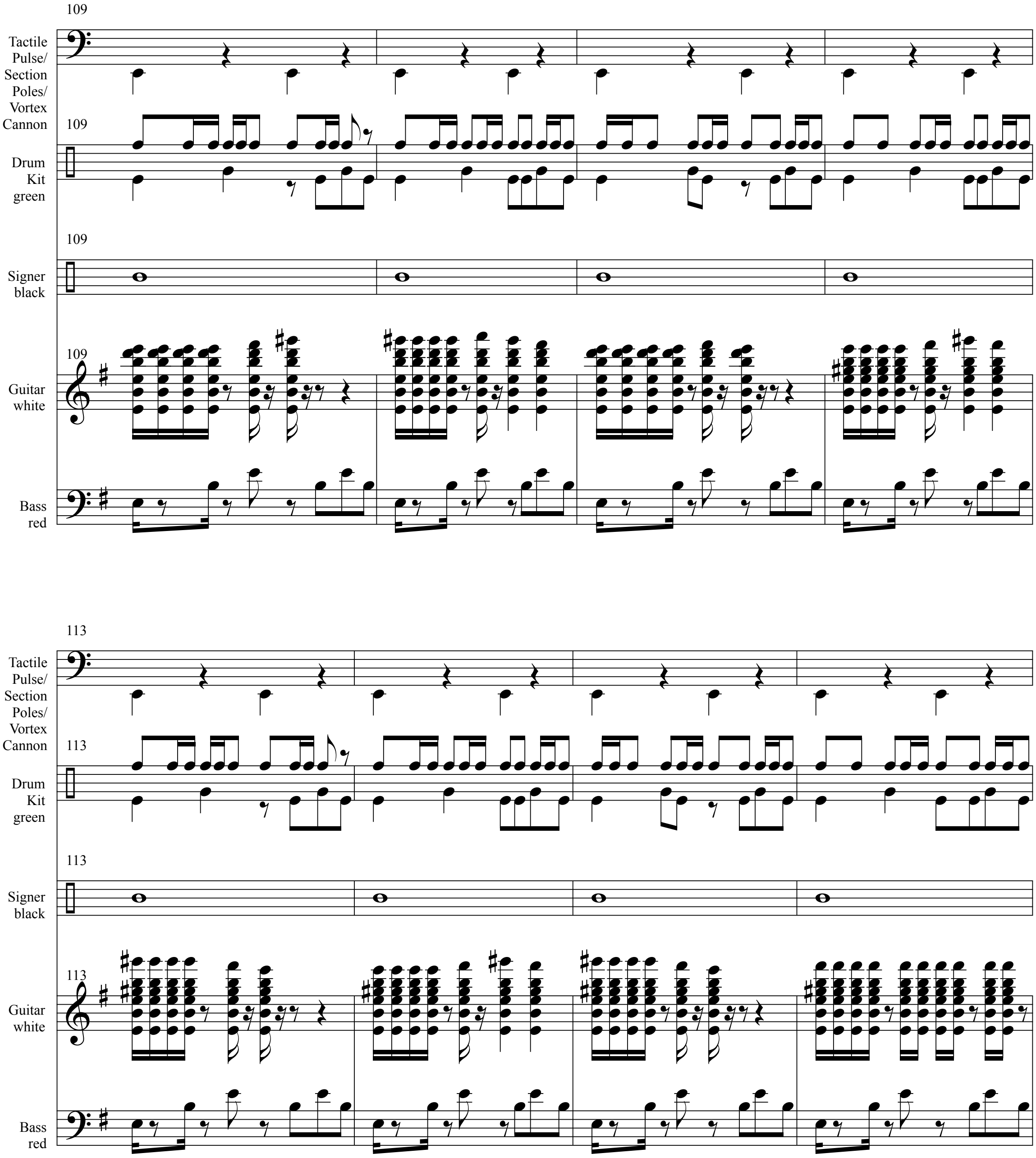

93
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red
95


97
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red


99
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red


101
Tactile Pulse/ Section Poles/ Vortex Cannon
101
Drum Kit green
flam
101
Signer black
Signer performs shadow-play semaphore
101
Guitar white
Bass red


105
Tactile Pulse/ Section Poles/ Vortex Cannon
105
Drum Kit green
105
Signer black
105
Guitar white
Bass red


109
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red
113


117
House lights down
Tactile Pulse/ Section Poles/ Vortex Cannon
Drum Kit green
Signer black
Guitar white
Bass red

Appendix 4.5
Questionnaire for Sense Ensemble, Study #1

The Sense Ensemble, Study #1
Questionnaire
This was intended to be a multi-sensory musical performance, that is, one that addresses multiple senses: hearing, sight and touch. Your answers will help determine whether it was successful in this way, or how it could be more successful.

Please circle one answer per question.
Please feel free to add your own comments on the back of the page.

Are you deaf or hard of hearing?
Yes
No

Did you understand that the colour of the pea you were given corresponded to the colour of the flag next to the section you sat in?
Yes
No

Did you feel the vibrations moving through the room?
Yes
No

Did you understand that you were being taught a pattern by the signer?
Yes
No

Did you feel the ***gestures*** the signer was performing were musical in nature?
Yes
No

Did you feel yourself to be a member of your section (where you were sitting) when you were performing your signs?
Yes
No

Did you feel involved the performance?
Yes
No

Did you feel musically engaged by the performance?
Yes
No

Did you feel a heightened awareness of senses beyond hearing for your experience of the music?
Yes
No

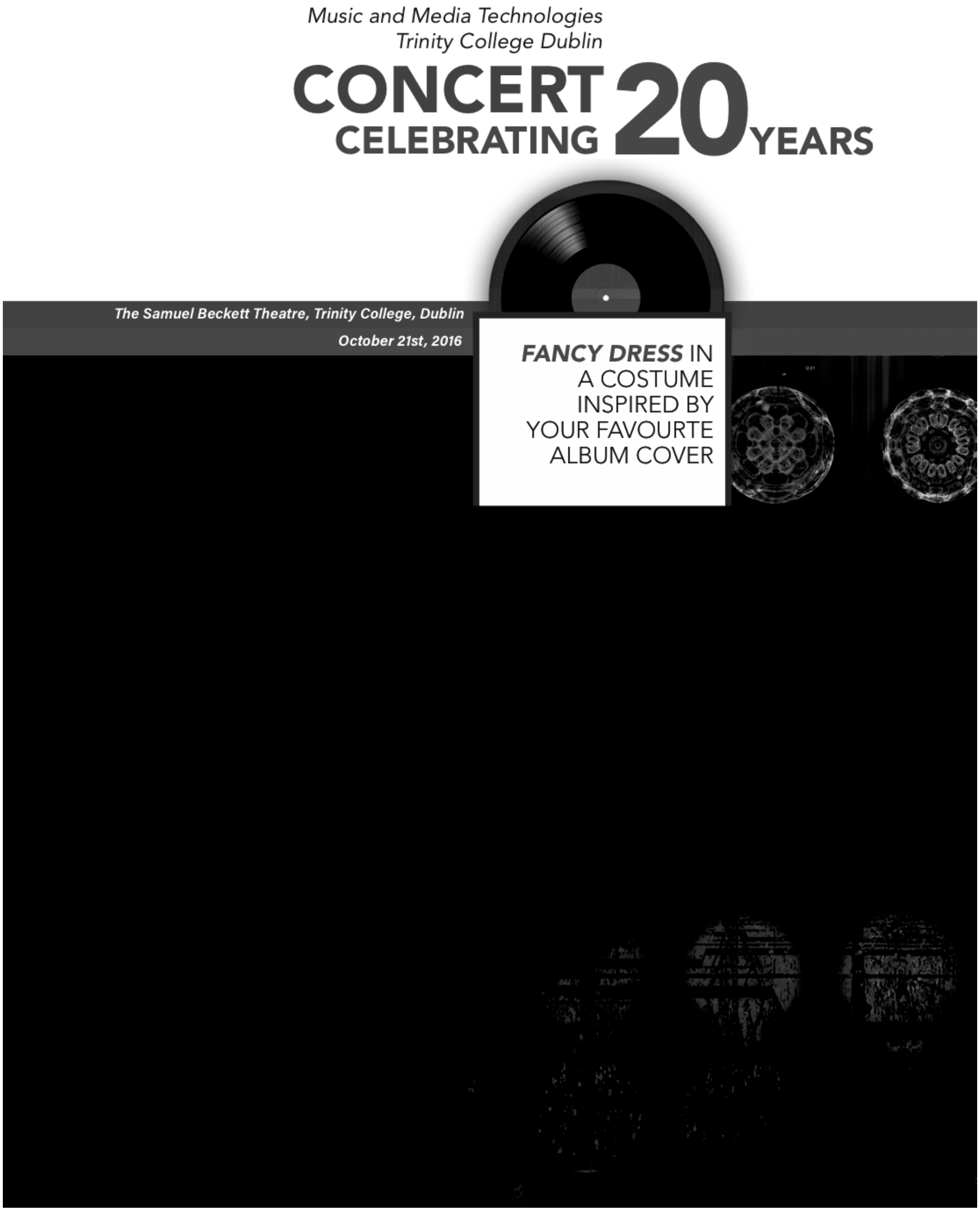
Did you feel the following senses were engaged musically in this performance:

Hearing?
Yes
No

Sight?
Yes
No

Touch?
Yes
No

APPENDIX 4.6
CONCERT PROGRAMME FOR SENSE ENSEMBLE, STUDY #2 (RELEVANT PAGES)



Celebrating 20 Years

October 21st, 2016

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

CRASH ENSEMBLE

FANCY DRESS

Website: http://www.tcd.ie/eleceng/mmt/
Facebook: https://www.facebook.com/mmttcd/

Samuel Beckett Theatre, Trinity College, Dublin

Concert Programme:

	ARTIST	TITLE
1	**Miriam Ingram**	Forever
2	**Enda Bates**	Apophany
3	Music and Performer - **Natasa Paulberg**, Visuals - **Eileen Carpio**	Eli Eli
4	**Neil O'Connor**	Somnus
5	Visuals - **Maura McDonnell**, Music - **Bébhinn McDonnell**	Duel Tones
6	Composed by the late **Conor Walsh**, Arranged by **Mark Hennessey**	Banphrionsa
7	**George Higgs**	The Sense Ensemble, Study #2

THE AFTER SHOW PARTY IN THE DINING HALL, TCD

Music and Media Technologies

Postgraduate Course, Trinity College Dublin

MMT Origins:

Over its 20-year lifespan, Music and Media Technologies has evolved into an academic programme with a concentrated focus on the application of digital technologies to the creation of new musical and artistic experiences.

The origins of MMT are to be found in the coalescence of a number of divergent musical interests from a few diverse individuals. In the mid-1990s Dermot Furlong had a 5 member research group in the Electronic and Elec. Eng. Dept. concentrated on stereo and surround sound technologies. The thought emerged that this was an area that surely must be of interest to musicians, and so in 1995 he approached Grad. Studies in TCD to explore the possibilities of initiating a new course relating to music and audio technologies. Coincidently, about this time Bill Whelan as Director of Irish Film Orchestras had approached the Music Dept. in TCD in order to explore the possibility of TCD producing musically competent graduates who also had a facility with the music technologies that were then being exploited in the film world.
As a consequence, some days after talking with Grad. Studies about initiating a new course relating to music and technology, Dermot Furlong was approached by TCD's then Vice Provost David Spearman saying: "I hear you are interested in Music Technologies…". From that initial conversation, meetings were organised between Dermot Furlong (Elec. Eng.), Simon Tresize (Music), and Bill Whelan. It was agreed that there was sufficient interest between the TCD personnel to start something new relating to music technologies.
However, the Music Department did not then have any staff who had the necessary technological expertise in order to engage with this new area, and so it was agreed that a new Lecturer position in Music would be advertised in order to attract a suitable individual. A large number of individuals were interviewed, with Dermot, Simon and Bill all taking part in the interview process. At the close of proceedings it was agreed that the position should be offered to Donnacha Dennehy. So began a very fruitful interaction between Dermot and Donnacha. From the outset, they were in agreement that the course objective should be to encourage the creation of new music through the exploitation of the emerging digital technologies, rather than just be the enhancement of music production efficiencies through the use of technology.
Significantly, at about this time, Dermot also happened to witness a short film piece on RTE television which featured archival rural Irish landscape footage being presented in accompaniment with a musical piece featuring the choral group Anúna. He was struck by how aesthetically effective the joint media presentation was, and the thought arose that working in the digital domain with audio and music could easily be extended to encompass other media modalities. Thus began the Visual Music concerns that have been a notable feature of MMT activities since its origin. From its outset, the artistic focus of MMT has been on the creative exploration of music and audio-visual composition, with further associated interests in the exploitation of interactive technologies. Some examples of MMT student works can be found at:
http://www.tcd.ie/eleceng/mmt/showcase.php

Dermot Furlong,
Course Director,
Music & Media Technologies

Music and Media Technologies

Photograph: George Higgs

BIOGRAPHY

George Higgs is pursuing a Ph.D. at Trinity College Dublin: 'An Approach to Music Composition for the Deaf'. His work includes opera, symphony, compositions for small ensemble, music for experimental theatre, work for installation and a number of HIGGSTRUMENTS designed for the performance of certain compositions: DOOR (a musical door two musicians wheel around a city stopping periodically to perform a composition); The Jimmy Rig Slip Jig (an instrument performers build in the act of playing a composition); The Joculator (an electro-acoustic vehicle the composer powers by his own pedaling); Kahoogaphone (a machine designed not to work); The Evolvaphone (a booth which creates a musical composition from participants' initials using the process of Natural Selection).
George's page: http://www.georgehiggs.com

PROGRAMME NOTE

Music involves much more than hearing. All of our senses – arguably 9 in number - are in fact collaborating in our musical experience as a kind of 'sense ensemble'.
This composition is the second in an experimental research series exploring approaches to music composition for deaf audiences; or more generally music that appeals to the multiple senses responsible for our appreciation of music. The performance features smoke ring cannons, two signing percussionists and string quartet.

Many thanks to Neimhin Robinson (smoking signer), Dr Dermot Furlong (nonsmoking supervisor) and the Irish Research Council.

Artist: George Higgs

Title: The Sense Ensemble, Study #2
Year: 2016

Instrumentation: String quartet, vortex cannons, silent signing singer, percussion, electric bass, and tape

Duration: 8 mins

MMT Graduate: 2004

PRODUCTION

Dermot Furlong	MC
Donnacha Dennehy	MC
Jenny Kirkwood	Producer
Jimmy Eadie	Production Manager
Adrian Hart	Stage Manager
Mark Hennessy	PR
Enda Bates	Spatial Recording
Mick Canney	Lighting
Derek McCreanor	Sound Engineer
Eoghan Tyrell	Sound Assistant
Maura McDonnell	Design
Mark Linnane	Film

The Sense Ensemble
Study #2

- for signs, percussion, string quartet
and smoke rings

by George Higgs

duration: 8 minutes

The Sense Ensemble
Study #2

-for:
2 Signer/Percussionists (SP1 and SP2)
violin1
violin2
viola
cello

by George Higgs

Background

This composition is the second study in the Sense Ensemble, an experimental research series which explores approaches to music composition for deaf audiences; or more generally music that appeals to a collaboration of those senses which are primarily responsible for the appreciation of music: hearing, sight and feeling.

Study #1 experimented with a wide range of devices for addressing multiple senses: subwoofers, vibrating speakers which allowed a continuous pulse to be heard and felt throughout the performance space, sign language rhythms, vortex rings. The fundamental interest was in gesture in its broadest sense: how a sense of bodily movement is fundamental to our understanding of music.

The present study continues this exploration, focussing on the use of ostensibly visual signals to establish a musical sense, and then playing with the combination of senses that come into play in the experience of these signals.

Vortex Cannon

This is effectively a drum which, when struck, produces a toroid shaped vortex (a donut shaped ring) of air. When smoke is put into the drum, a smoke ring is produced.

Two signer percussionists (SP1 and SP2) will be using these drums to produce invisible rings of air and smoke rings.

The members of the string quartet need to coordinate with the percussionists, in terms of timing for the striking of the vortex cannons. Furthermore, the journey of the smoke ring itself, as it travels across the auditorium, will need to be followed carefully by the string players at certain points in the piece. This is explained further in the "Plan of Piece' notes below, and in the score itself.

Lights

Lighting design and cues will be scored, as they are crucial for the nuances of the vortex rings.

Necessary Lights:
(x2) 15/30 Profile (to focus on the vortex cannon percussionists with blue gels

(x8) Fresnels: positioned on either side of the auditorium above the seating, using both forward and rear lighting rails. These fresnels will capture the smoke rings in motion as they progress from front to back. Ideally, the fresnels cuing would be dynamic, with intensity changing as the smoke ring moved from the front to the back.
Blue gels.

The smoke ring will be sent from the stage, move quickly at first, then slow down to waver and fall off its linear course and finally disperse.

Body signs

The 2 percussionists will use a series of rhythmic gesticulations, which will accompany and complement their performance on the vortex cannons.
The string quartet will emulate these signs with sonic analogues on their instruments.

The string quartet is further asked to reinforce their own playing through bodily movement that works with the rhythms they're performing. Of course, all musicians must move out of necessity, but some are inclined to move more with the rhythm of their playing. Because this piece aims to amplify the visual elements of performance, it is encouraged that bodily movement be more deliberate on the part of the players. To be more specific, in certain places, such as Section B where the players are all sharing an even fundamental rhythm, this bodily movement is meant to be on each beat of the bar (see notes on Section B below in the 'Plan of Piece'). In all other places where the rhythm is not as common, each player should make an effort to emphasize their metrical accents in a way that is natural. I didn't feel it fair to prescribe a certain movement for individual players outside of Section B because it may make the playing unduly challenging (I may not choose a movement natural to that performer).

String Quartet

“Chopping”

While it's understood that the members of the quartet may not be well acquainted with the percussive blue grass technique known as the 'chop', none of the chops in this score are much more than muted strings played with emphasis. No prior experience with the technique is really required. What follows are some simple notes which might make things easier (I also have very good, and relatively short, video tutorial by the well known fiddler Casey Dreissen which I can provide the players with).

Bow area: All chopping is executed using the part of the bow between the end of the binding and the frog ('au talon'). Rosin should be liberally applied to this area of the hair.

Muting strings: fingerboard hand should mute strings during the chop.

Bow hold: straighten thumb so that hair is at an angle to the stings

Basic chop:
Down bow chop:Bring bow down on muted strings at an angle to produce a scratch sound.
Up bow chop: Lift bow up from muted strings at an angle to produce a scratch sound

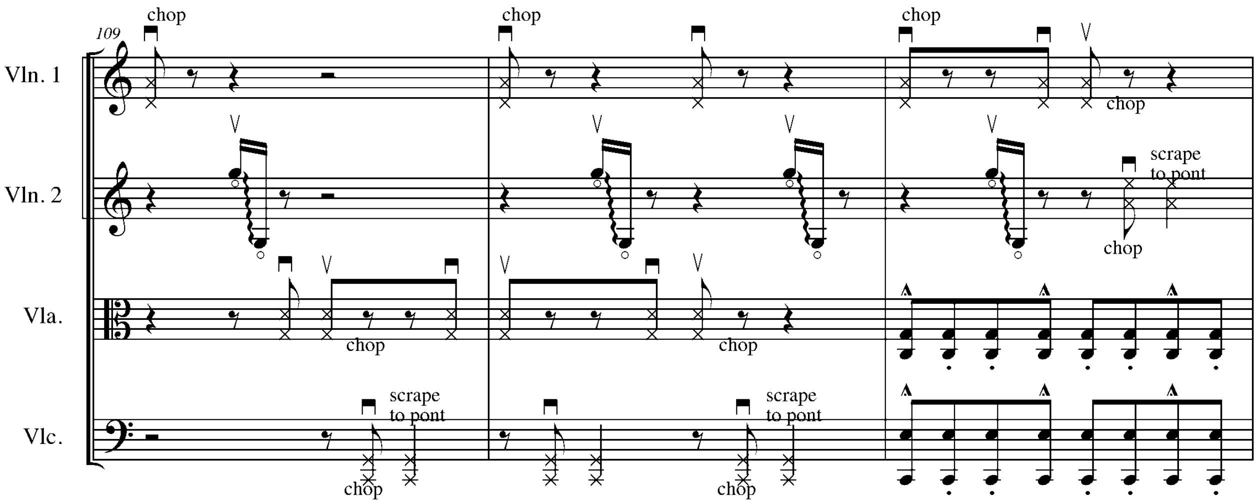
The scratch sound can greatly vary in intensity, between a subtle non-pitched sound and quite a strident sound. A sound falling somewhere between would be best for this piece.

Two strings are generally chopped at the same time. Different strings produce a different timbre of chop. I have generally indicated which strings to chop on.
All notes with an 'x' notehead specify a chop. The pitches notated generally indicate which open strings should be chopped.

Extra chopping notes:

1)Scrape to pont (for cellist and violin 2)

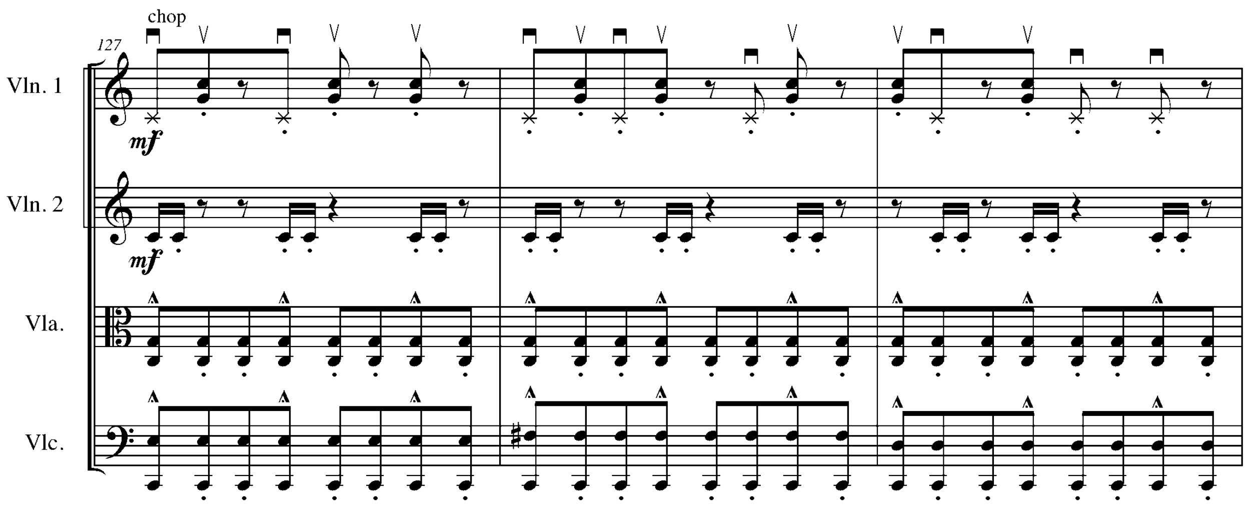
This follows on immediately after a chop for the cellist and violin 2, signifying a dragging movement of the bow (au talon) towards the bridge on muted strings. As indicated in the score, this movement lasts for a whole crotchet; the down bow chop necessarily is much shorter – effectively an impulse – in terms of duration.



The cellist will be executing this movement away from herself (bars 2-5, bars 107-110 and bars 155-158) while the violin 2 will be making the movement towards her body (bars 111-118). This will likely be obvious to the players, but I wanted to point out that the movement is different for each.

2)Violin 1 and 2: chop of muted strings against unmuted chord

For bars 127-134, the first violin performs a muted chop back to back against an unmuted pitched double stop (a similar issue arises for the second violin a few bars on).



I've envisaged this for a fingered C chord, so that the muted chop is played on the C (on the G string) and the unmuted pitched notes are played, as scored, on the G and C (on the D and A strings). This approach is trickier than it perhaps needs to be, as the first violin will need to roll the bow quickly from the angle needed for the G string to the angle needed for the D and A string double stop, and bow up on top of it all. I liked the idea of this move, as it contributes extra percussion on the roll. Still, if it makes the movement laborious (not to mention the sound), then of course it's perfectly fine to execute the muted chop on the same strings as the unmuted double stop. In other words, the same double stop (G and C on the D and A strings) will be fingered and played throughout these bars; the quavers indicated by an 'x' would simply be muted.

The same applies to the subsequent muted strings and chords in bars 130-134 for the first violin, and in bars 139-146 for both the first and second violin; i.e., if using three strings is problematic, keeping it on two is fine.

Plan of Piece

Section A:

The signer teaches the percussionist a series of hand gestures, some of which have percussive qualities.
The signer then teaches these same gestures to the string quartet. However, rather than using their hands they interpret the gestures using their instruments as scored in bars 2 through 6. Each member of the quartet takes a different sign, thus they hocket the gestural rhythm. The string players are taught these signs one by one. Thus what is scored here is only the combined rhythm in its complete form. The singer will cue members of the quartet in and out, as the percussionist interacts with the different parts of the rhythm.

Because the emphasis here is on communication, this isn't scored through, and the quartet wait for the final cue to to rest before moving to Section B.

Section B:

This section involves the vortex cannon being struck, and the string players following the movement of the smoke ring from the stage to the back of the auditorium. The quartet should use the score as a guideline, but interact as much as possible with the movement of the ring, which will slow down as it progresses across the large chamber.

According to the score, the quartet bows a series of double stops using tremolo with decreasing speed and increasingly clear articulation. The exact rates of ritardandi are relative to how many bars are scored for each chord. As a general rule of thumb the tempo should come gradually to a sense of rest (like a steam train coming a halt at a station) by the last beat in each section.
In these sections, the notated move from measured tremolo to staccato notes simply aims to underline the slowing in tempo. Thus, this change from semi-legato to clearly articulated notes can be gradual, and needn't be governed directly by the bar lines in the score. Moreover, it is probably better if the members of the

quartet happen to make the change at slightly different times.
That said, it is important that the ritardando itself is coordinated strictly between the players, even if the articulation shift is not. The cellist is musically in the best position to cue this, as she is simply punctuating the beat with crotchets.
The note in b. 2, “nod on beats”, prescribes a method for keeping tempo together. At the cellist's lead, the quartet needs syncronize their ritardandi throughout the section by this nodding.

Finally, this section introduces the use of more percussive bowing, even on notes which are pitched. Thus, in these sections where a ritardando is indicated, in the final bar, or bars in certain cases, of the ritardando there is a note for 'au talon'. This move toward the frog of the bow is meant to increase the percussive quality of the notes by virtue of the greater hair tension near the frog ('near the frog' meaning anything from the furthers end of the winding to the frog; about 3 inches of bow hair. Adequate rosin should be applied in this sometimes neglected area). Furthermore, it is desirable that this move toward the frog, as well as the simultaneous ritardando, will be accompanied by an increase in pressure of the bow on the two strings of the double stop. In this way, the sound produced should be more like a 'pluck' than a bowed sound; the result of putting bow pressure on the strings, creating a significant tension, and then releasing the bow for a sharp attack.
Incidentally, this technique – putting pressure on the strings and playing close to the frog – is essential to the chop; which is discussed above.

Section C:
This section uses a considerable amount of chopping, which is discussed above.
As explained before, rhythmic bodily movement in this section should be emphasized, but should suit the players' part. At times, therefore, the body movement may seem suitably disjointed; as in bars 57-59.

Score

The Sense Ensemble

Study #2

Composer:
George Higgs

Gestural Lyricists:
Jessica Kennedy,
Caoimhe Coburn-Gray
and George Higgs


15
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
21
SP1 counts audience in.
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.

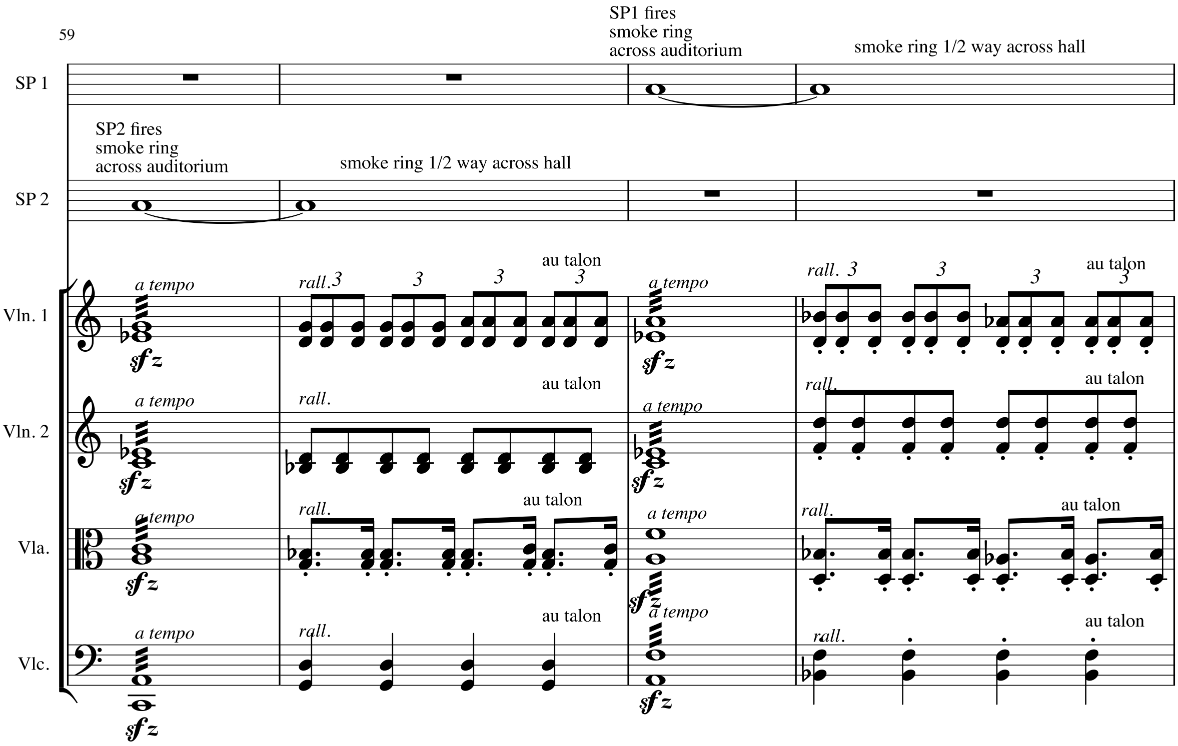

25
SP1 teaches audience the gestural motive
sign 1
sign 2
sign 3
sign 4
SP 1
SP2 teaches quartet the gestural motive
SP 2
Vln. 1
chop
mf
Vln. 2
mf
Vla.
chop
mf
Vlc.
mf
chop
scrape
to pont
28
SP1 counts
audience in.
SP1 enacts the gestural motive with the audience.
SP2 enacts the gestural motive with the audience.

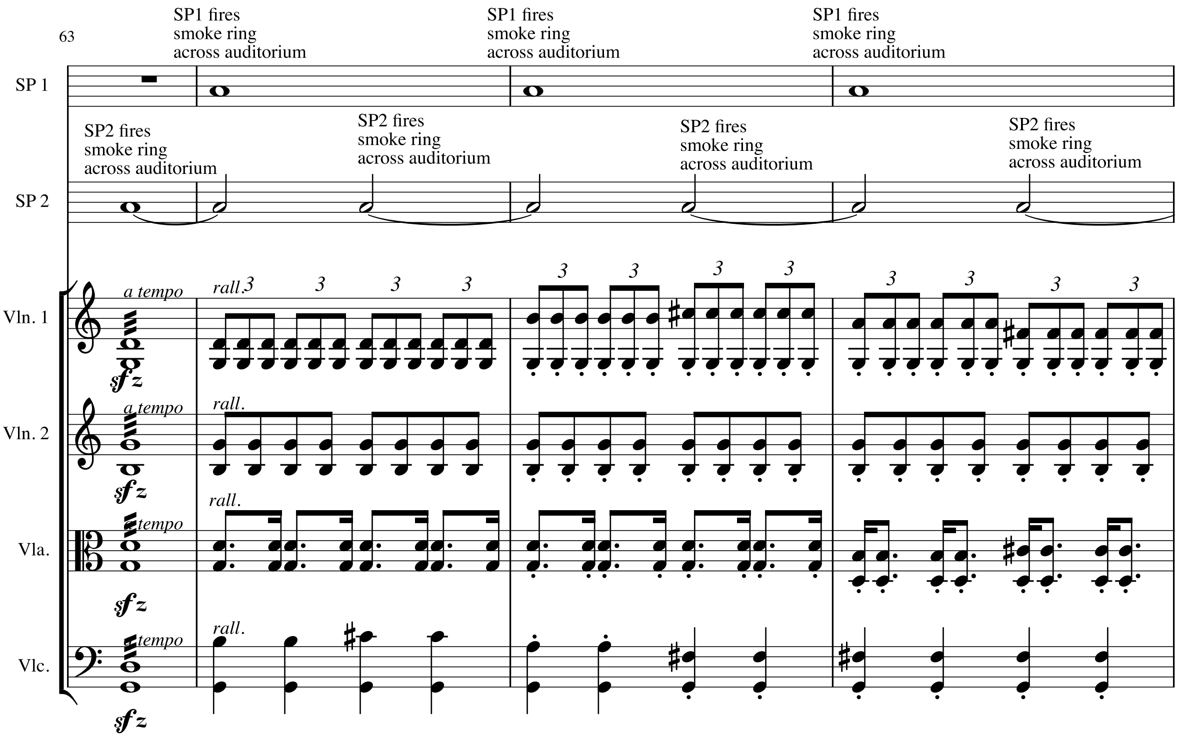

34
B
SP 1
SP 2
SP2 fires
smoke ring
across auditorium
Vln. 1
Vln. 2
Vla.
Vlc.
chop
scrape
to pont
nod on beat 1
mf
sfz
39
Fresnels should shift intensity
from front to rear rail for all smoke
ring movement.
SP1 fires
smoke ring
across auditorium
smoke ring 1/2 way across hall
smoke ring 3/4 across hall
smoke ring comes to a halt and disperses
rall.
nod on beats
au talon
a tempo
3

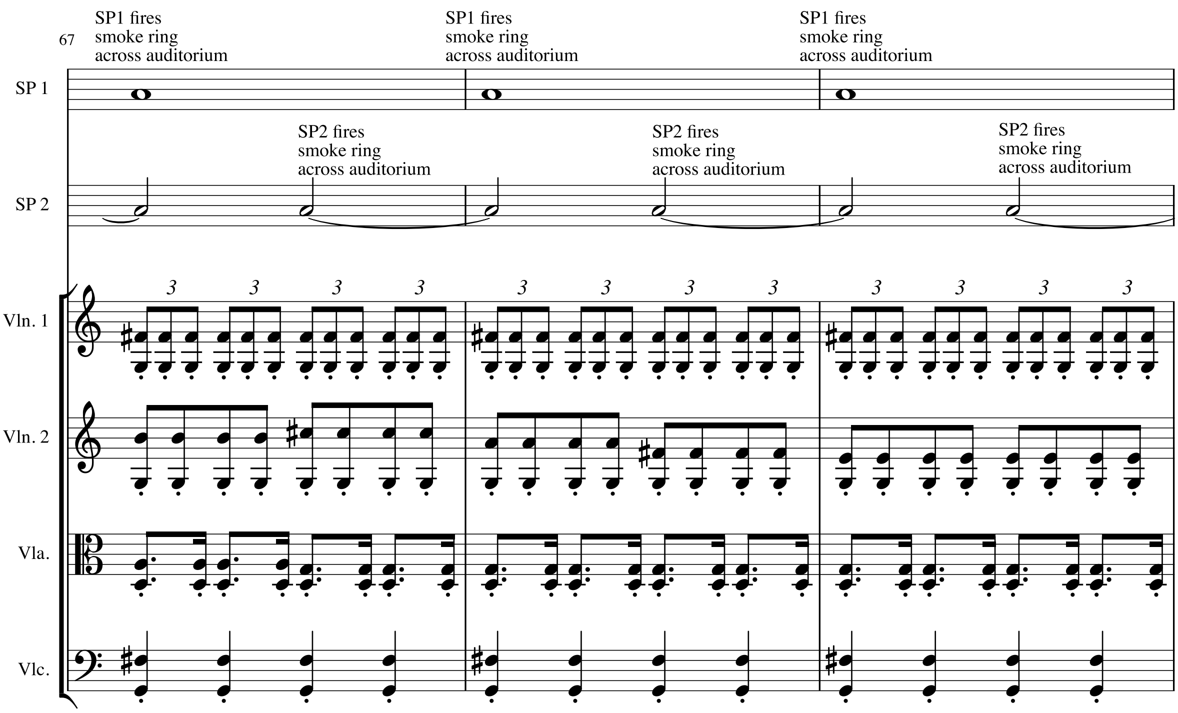

44
smoke ring 1/2 way across hall
smoke ring 3/4 across hall
smoke ring comes to a halt and disperses
SP 1
SP2 fires
smoke ring
across auditorium
SP 2
rall.
au talon
a tempo
Vln. 1
sfz
Vln. 2
Vla.
Vlc.
49
smoke ring 1/2 way across hall
smoke ring 3/4 across hall


51
SP1 fires
smoke ring
across auditorium
smoke ring 1/2 way across hall
SP 1
smoke ring comes to a halt and disperses
SP 2
au talon
a tempo
rall.
Vln. 1
sfz
Vln. 2
Vla.
Vlc.
55
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.


56
smoke ring 3/4 across hall
smoke ring comes to a halt and disperses
SP 1
SP 2
au talon
Vln. 1
au talon
Vln. 2
au talon
Vla.
au talon
Vlc.


59
SP1 fires
smoke ring
across auditorium
smoke ring 1/2 way across hall
SP 1
SP2 fires
smoke ring
across auditorium
smoke ring 1/2 way across hall
SP 2
a tempo
rall.
au talon
Vln. 1
Vln. 2
Vla.
Vlc.


63
SP1 fires
smoke ring
across auditorium
SP1 fires
smoke ring
across auditorium
SP1 fires
smoke ring
across auditorium
SP 1
SP2 fires
smoke ring
across auditorium
SP2 fires
smoke ring
across auditorium
SP2 fires
smoke ring
across auditorium
SP2 fires
smoke ring
across auditorium
SP 2
a tempo
rall.
Vln. 1
a tempo
rall.
Vln. 2
tempo
rall.
Vla.
tempo
rall.
Vlc.


67
SP1 fires
smoke ring
across auditorium
SP1 fires
smoke ring
across auditorium
SP1 fires
smoke ring
across auditorium
SP 1
SP2 fires
smoke ring
across auditorium
SP2 fires
smoke ring
across auditorium
SP2 fires
smoke ring
across auditorium
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.

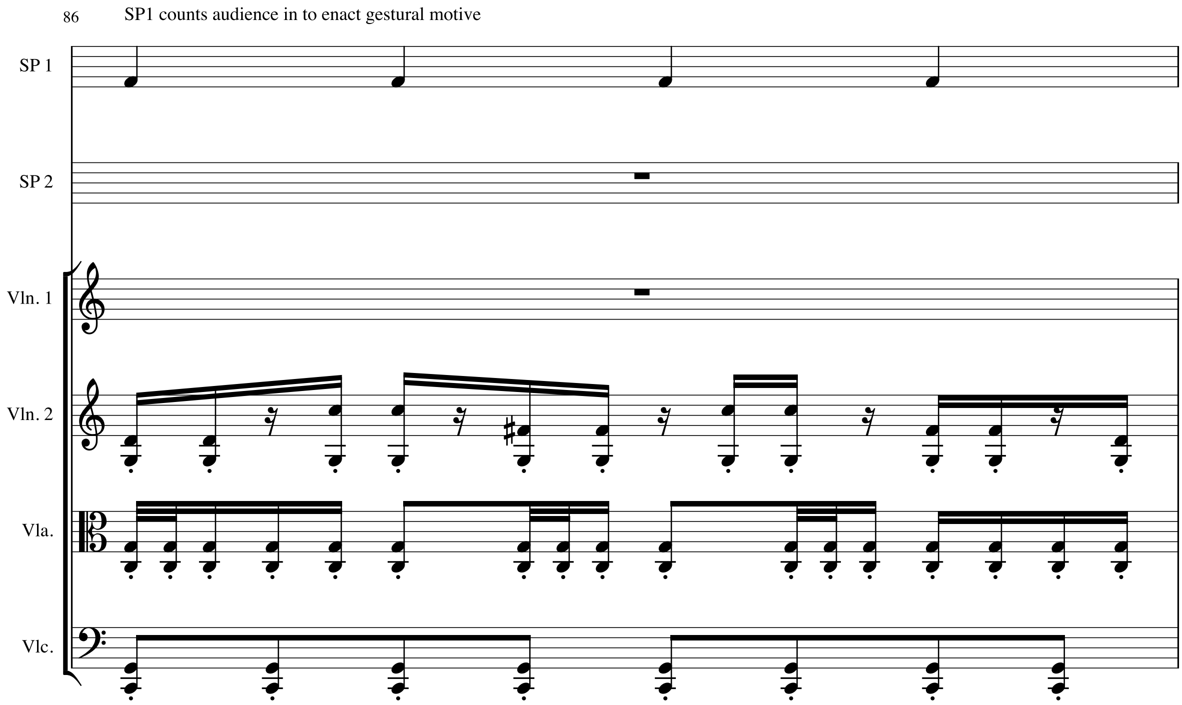

70
SP1 fires
smoke ring
across auditorium
SP 1
SP2 fires
smoke ring
across auditorium
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
71
SP1 fires
smoke ring
across auditorium
SP1 fires
smoke ring
across auditorium
2nd time only (before CODA)
Fire smoke rings at audience,
SP2 and string quartet.
SP1 fires
smoke ring
across auditorium
SP2 fires
smoke ring
across auditorium
Fire smoke rings at
audience, SP1 and
string quartet.
2nd time only (before CODA)
SP2 fires
smoke ring
across auditorium
SP2 fires
smoke ring
across auditorium


74
SP1 fires
smoke ring
across auditorium
SP 1
SP 2
SP2 fires
smoke ring
across auditorium
Vln. 1
Vln. 2
Vla.
Vlc.
3
75
SP1 fires
smoke ring
across auditorium
SP2 fires
smoke ring
across auditorium
C
SP2 fires
smoke ring
across auditorium
To Coda
a tempo
mf


78
SP1 counts audience in to enact gestural motive
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.

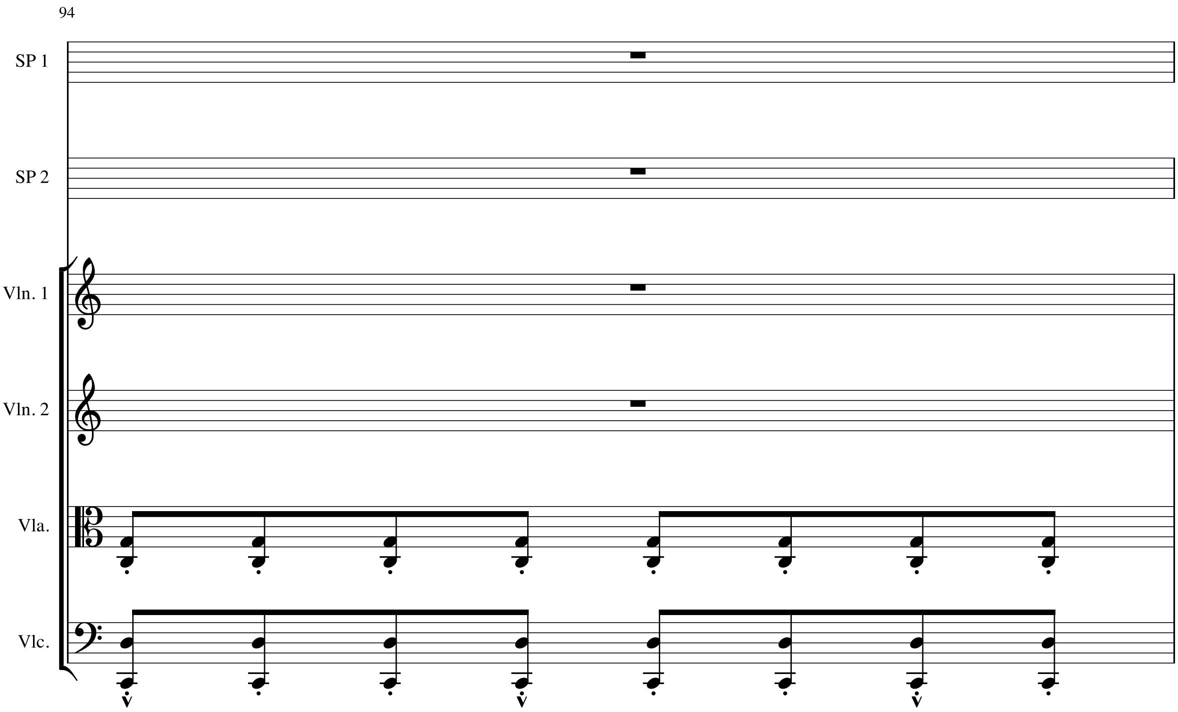

79
SP1 enacts the gestural motive with audience
sign 2
sign 4
SP 1
sign 1
sign 3
SP2 enacts the gestural motive with audience
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.


82
SP1 counts audience in to enact gestural motive
SP1 enacts the gestural motive with audience
sign 2
sign 4
sign 1
sign 3
SP2 enacts the gestural motive with audience
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
84
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
mf
mf


86
SP1 counts audience in to enact gestural motive
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.


87
SP1 enacts the gestural motive with audience
sign 2
sign 4
SP 1
sign 1
sign 3
SP2 enacts the gestural motive with audience
SP 2
chop
Vln. 1
Vln. 2
Vla.
Vlc.


89
SP1 counts audience in to enact gestural motive
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
91
SP1 enacts the gestural motive with audience
sign 2
sign 4
sign 1
sign 3
SP1 turns to face quartet.
SP2 enacts the gestural motive with audience
SP2 turns to face quartet.
chop
chop
scrape
chop
to pont

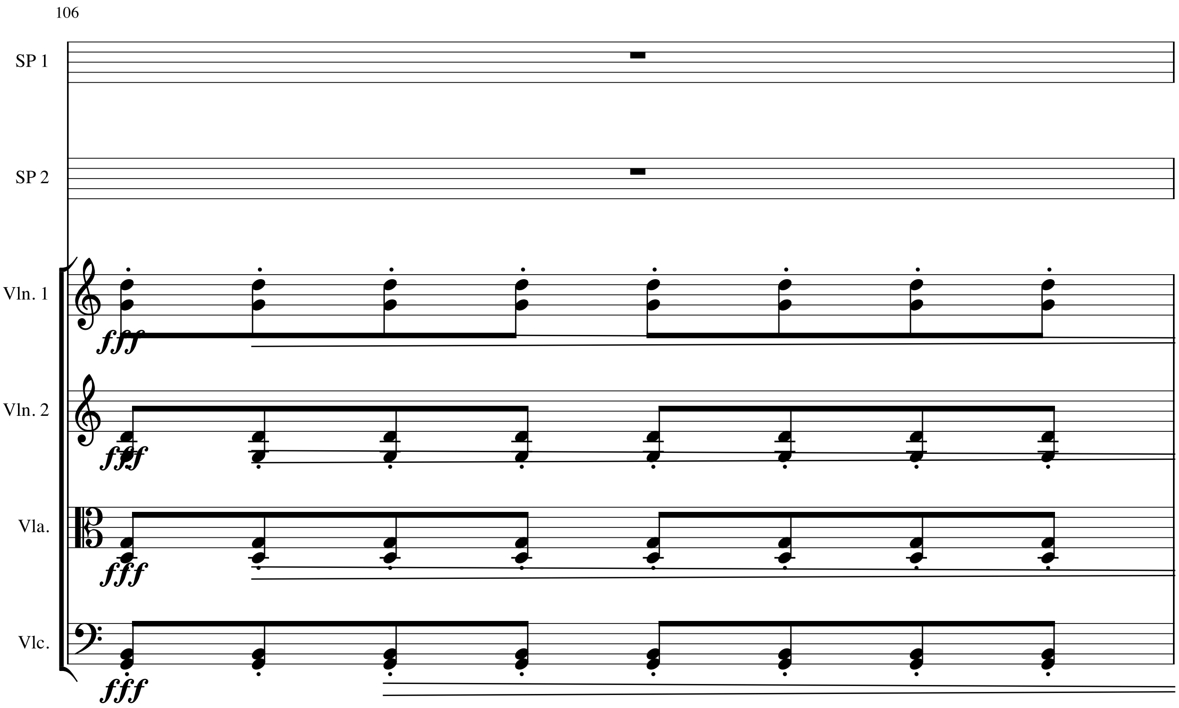

94
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.


95
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
sfz
p
mf


98
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
99
SP 1
SP 2
chop
Vln. 1
au talon
Vln. 2
Vla.
Vlc.

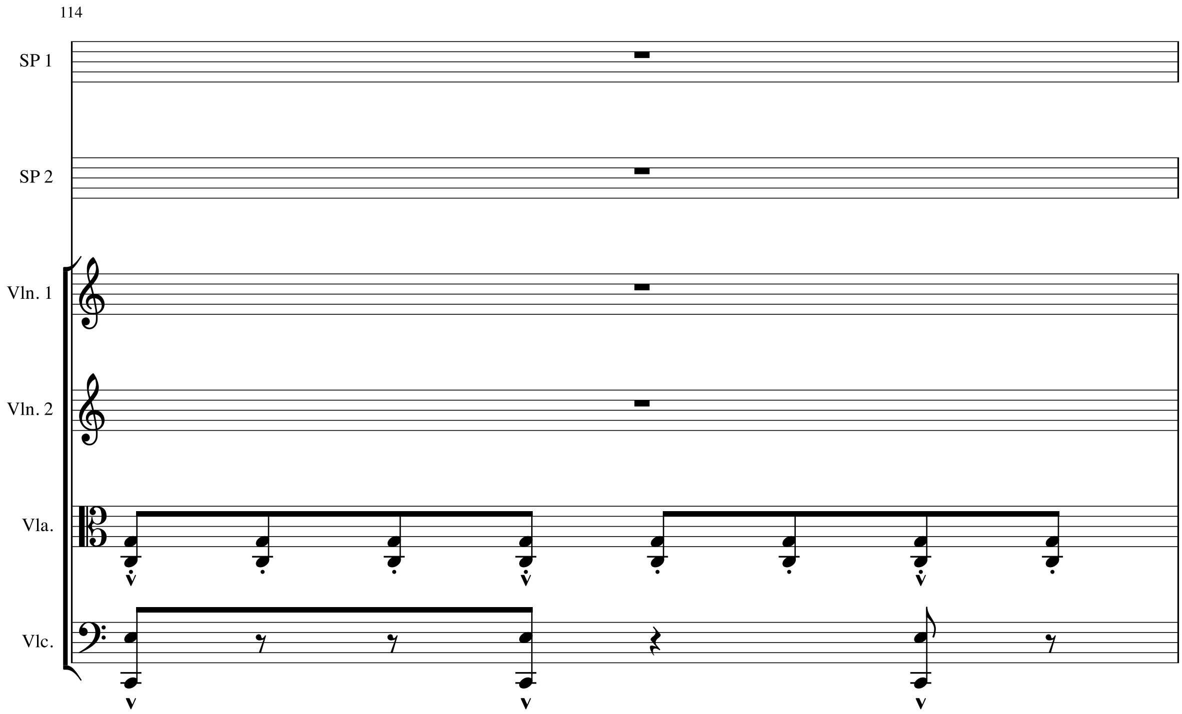

102
SP 1
SP 2
chop
Vln. 1
au talon
Vln. 2
Vla.
Vlc.


103
SP 1
SP 2
chop
chop
chop
Vln. 1
au talon
au talon
au talon
Vln. 2
Vla.
Vlc.


106
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
fff


107
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
pppp
f


110
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
knock
soundboard
knock
soundboard


114
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.

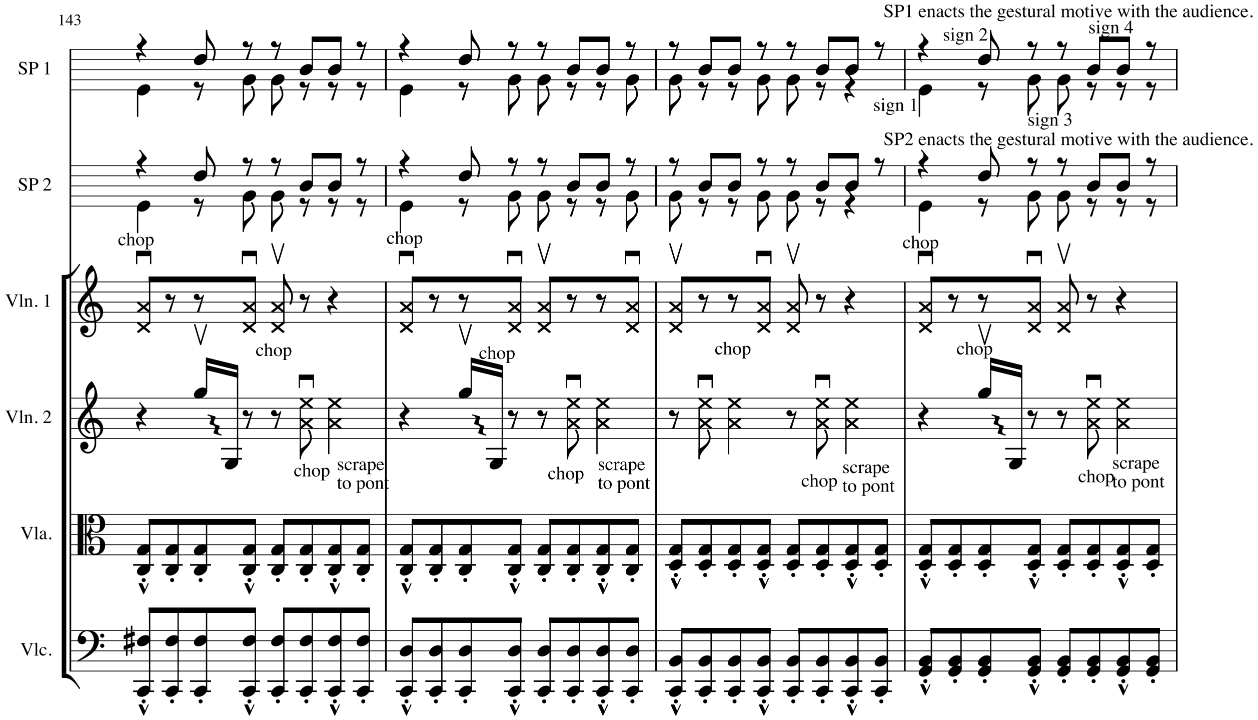

115
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
119
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.


123
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
126
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.


130
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.


131
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.


135
SP1 counts audience in.
SP1 enacts the gestural motive with the audience.
sign 1
sign 2
sign 3
sign 4
SP2 enacts the gestural motive with the audience.
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
chop
scrape to pont
139

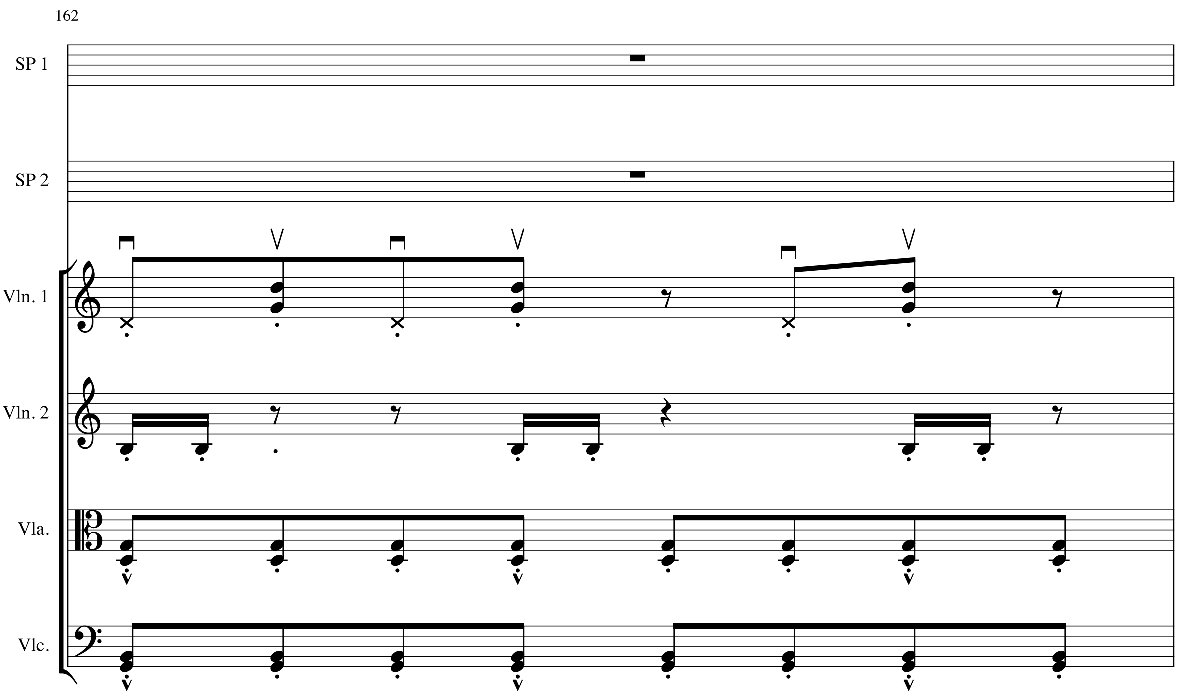

143
SP1 enacts the gestural motive with the audience.
sign 2
sign 4
SP 1
sign 1
sign 3
SP2 enacts the gestural motive with the audience.
SP 2
chop
Vln. 1
chop
Vln. 2
chop
scrape
to pont
Vla.
Vlc.


147
SP 1
SP 2
chop
Vln. 1
chop
pp
Vln. 2
chop
scrape
to pont
pp
Vla.
Vlc.


151
SP1 turns to face quartet.
SP 1
SP2 turns to face quartet.
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.


155
SP 1
SP 2
chop
Vln. 1
mf
Vln. 2
mf
Vla.
Vlc.


159
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.

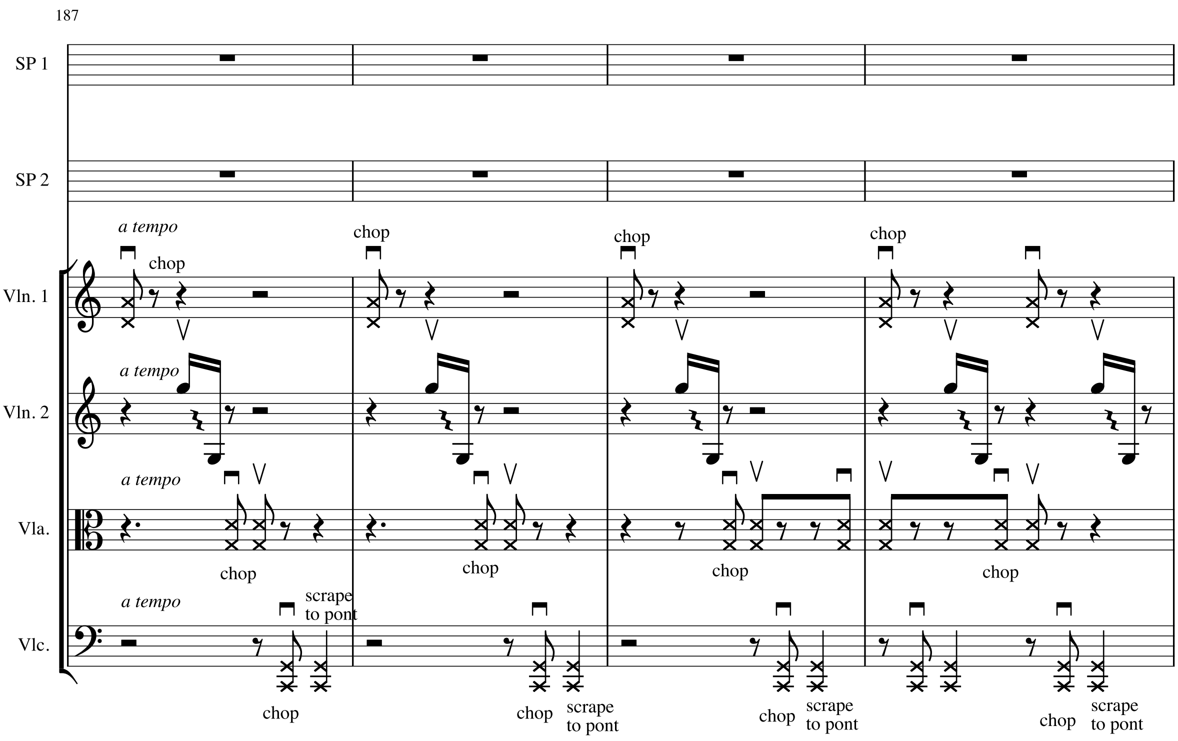

162
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.


163
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
166
SP 1
SP 2
Vln. 1
pp
Vln. 2
pp
Vla.
Vlc.


167
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
mf
mf
171
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.

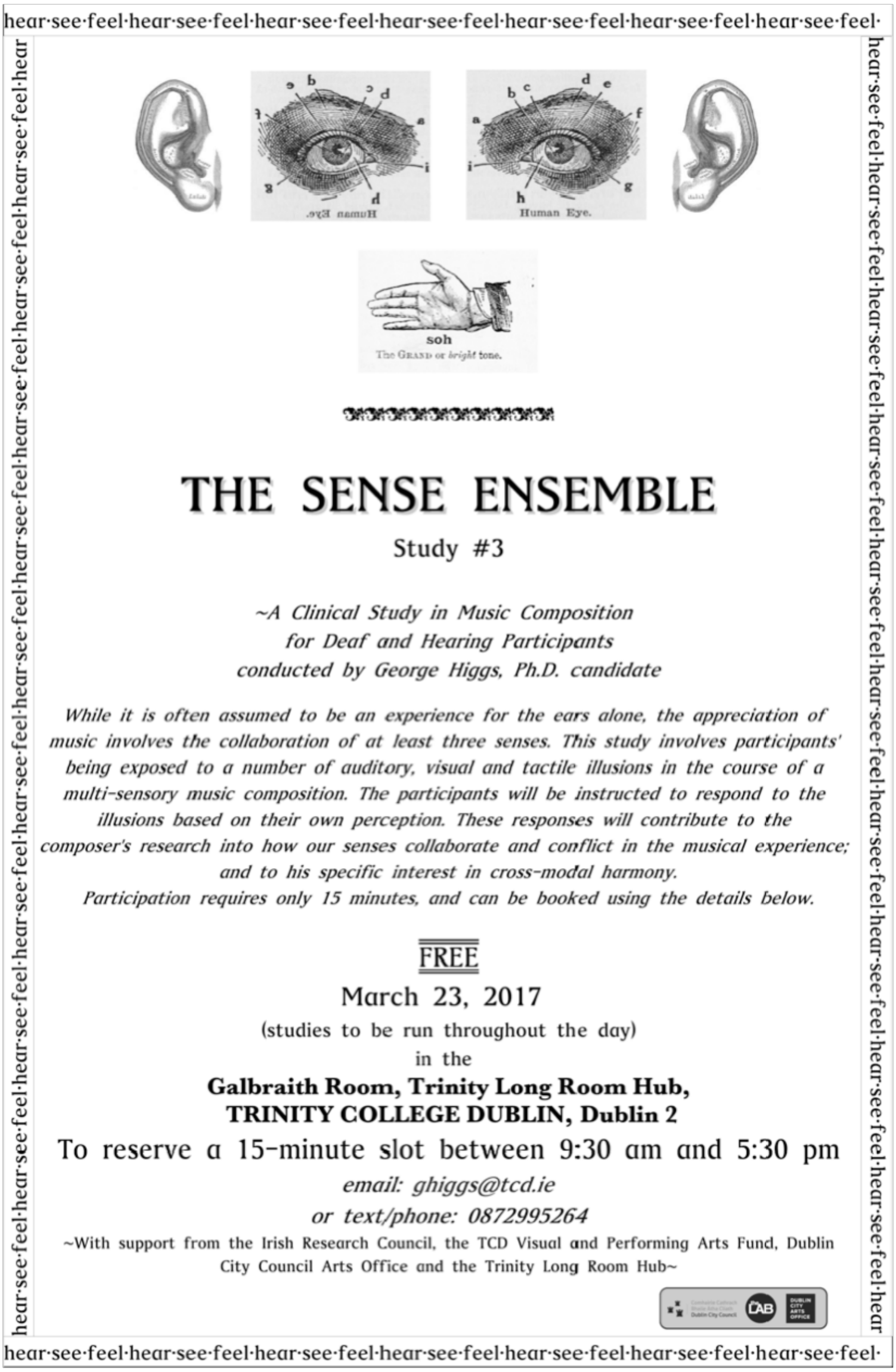

175
SP 1
SP 2
chop
Vln. 1
chop
Vln. 2
Vla.
Vlc.
179
SP1 counts
audience in.
SP1 enacts the gestural motive with the audience.
sign 2
sign 4
sign 1
sign 3
SP2 enacts the gestural motive with the audience.
chop
chop
chop
scrape
to pont


183
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
D.S. al Coda
SP1 counts
audience in.
chop
chop
chop
chop
chop
chop
chop
chop
scrape
to pont
chop
scrape
to pont
chop
scrape
to pont


187
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
a tempo
chop
a tempo
a tempo
a tempo
chop
chop
chop
chop
chop
chop
chop
scrape
to pont
chop
chop
scrape
to pont
chop
scrape
to pont
chop
scrape
to pont


191
SP 1
SP 2
Vln. 1
Vln. 2
Vla.
Vlc.
fff
fff
fff
fff

APPENDIX 4.8
POSTER FOR SENSE ENSEMBLE STUDY #3



The Sense Ensemble
Study #3

-a multisensory composition
for flashes, beeps and pulses

by George Higgs

duration: 8 minutes

The Sense Ensemble, Study #3

George Higgs

-a multisensory composition
for flashes, beeps and pulses

2017


7
Flash
Beep
Pulse
7
Synth
7
Double
Bass
11
Flash
Beep
Pulse
11
Synth
11
Double
Bass
15
Flash
Beep
Pulse
15
Synth
15
Double
Bass


19
Flash
Beep
Pulse
19
Synth
19
Double
Bass
23
Flash
Beep
Pulse
23
Synth
23
Double
Bass
27
Flash
Beep
Pulse
27
Synth
27
Double
Bass


31
Flash
Beep
Pulse
31
Synth
31
Double
Bass
stems down=arco
stems up=pizz.
34
Flash
Beep
Pulse
34
Synth
34
Double
Bass
37
Flash
Beep
Pulse
37
Synth
37
Double
Bass


40
Flash
Beep
Pulse
40
Synth
40
Double
Bass
43
Flash
Beep
Pulse
43
Synth
43
Double
Bass
46
Flash
Beep
Pulse
46
Synth
46
Double
Bass


48
Flash
Beep
Pulse
48
Synth
48
Double
Bass
50
Flash
Beep
Pulse
50
Synth
50
Double
Bass
52
Flash
Beep
Pulse
52
Synth
52
Double
Bass


55
Flash
Beep
Pulse
55
Synth
55
Double
Bass
58
Flash
Beep
Pulse
58
Synth
58
Double
Bass
60
Flash
Beep
Pulse
60
Synth
60
Double
Bass


62
Flash
Beep
Pulse
62
Synth
62
Double
Bass
64
Flash
Beep
Pulse
64
Synth
64
Double
Bass
66
Flash
Beep
Pulse
66
Synth
66
Double
Bass


68
Flash
Beep
Pulse
Synth
Double
Bass
70
72