Bridging the gap between Sound and Spoken Language

An investigation into the resonance between Acoustics and Early Language Acquisition

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Abstract

The study of linguistics has been dominated by a graphocentric approach to language, overlooking the fact that spoken language has at its heart a phonocentric beat. This dissertation considers the intricate relationship between sound and spoken language. The discussion centres on whether the connection between these two phenomena can support the construction of a bridge theory. Establishing such a theory is the first step towards the use of a Windows Approach to early language acquisition research. Put simply, a Windows Approach proceeds from the assumption that '[…] a phenomenon X is considered a window on a distinct phenomenon Y if by "looking at" X it is possible to "see" something of Y' (Botha 2006: 132). The study concludes with comments which touch upon the possible views a 'sound window' can offer linguists interested in understanding the child's first experience of the spoken word.

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1.1 The Problem and its Setting

It is widely acknowledged that we possess a rather robust mechanism for acquiring spoken language and that all languages are accessible to children at birth. 'From what we can tell there is virtually no way to prevent it from happening […]' (Pinker 2009: 29). Language acquisition in developmentally healthy children will naturally occur on the condition that one requirement is met: the child is in the company of one or more persons who communicate using one of the given languages used by human beings; a fact 'as remarkable as it is reassuring' (Boysson-Bardies 1999: 94). What is even more remarkable is how little is empirically known about the *way* in which spoken language comes to children.

Early language acquisition is a subject that tends to anchor itself to our own, ever-shifting, conceptions of language and child development. One rather influential concept in Western philosophy described the infant as a *tabula rasa* and is often traced, albeit erroneously, back to Aristotle in his treatise *De Anima* ([350 B.C] 1993) (Long 2004). It was a concept further popularised by Locke's writings ([1690] 1969) and although not necessarily understood exactly as originally intended, it nonetheless became a concept that permeated society's approach to infant linguistic development for a time (Boysson-Bardies 1999). The assumption being that a person's experience with the world and its environment began only *after* they were born. Yet, in terms of the infant's ability to accurately process their sonic/linguistic environment, modern research has emerged to contradict that line of thinking. Infants, it would seem, are not born empty slates but rather *tabula plenis*.

Newborn infants appear to be already equipped with a surprisingly large body of knowledge relating to the phonemic and prosodic characteristics of their ambient

language. The documented research into newborns' precise phonetic discernment has led researchers to conclude that infants' experience with the acoustics of spoken language begins *before* they are born (Kisilevsky *et al* 2003; Mehler *et al* 1988; DeCasper and Spence 1986). The difficulty this conclusion presents today's linguistic researchers is the lack of an established research approach designed to investigate the early, prenatal, stages of linguistic development, leaving this period open to a multitude of theories, none of which can be deemed definitive.

For all their perceived differences, all languages have in common certain fundamental principles. Chomsky's term *universal grammar* (1957) encapsulates this theory. However, just as a spoken language has syntax and lexis, it also has phonology. Acquiring a spoken language entails associating sounds and meaning according to the phonological and syntactic rules of that language and it is a process that remains largely elusive to the interested researcher (Bishop 1997). One widely adopted model describes it is a process that begins with an acoustic waveform which undergoes various stages of cognitive processing ending in the transformation of the original acoustic signal to meaning (ibid). Thus, the sound systems of all the world's spoken languages are surprisingly similar in their basic design given that they are all communicated via sound waves. In this sense, sound can be seen as the primary universal characteristic of spoken languages. Although the claim has been made that all spoken languages share certain, very general structural properties, no spoken language can exist without sound - it is the ecumenical medium. It is this aspect of language: its sound system and our first encounters with it that this dissertation aims to explore further.

In order to approach the problem of researching an area with seemingly limited research options, this dissertation describes a study to investigate whether a 'Windows Approach to Language Evolution' model (Botha 2006) could be adapted for the purpose of examining language acquisition and whether this could be deemed a viable approach to researching the question of early language acquisition. Put simply, a Windows Approach proceeds from the assumption that

'[…] a phenomenon X is considered a window on a distinct phenomenon Y if by "looking at" X it is possible to "see" something of Y' (Botha 2006: 132). Taking a window to be a conceptual construct for making inferences (ibid), the intent of this study is to generate an analytical framework using the Windows Approach model in response to the well-documented phenomenon of prenatal phonemic acquisition. Here, the proposed window is sound and the phenomenon in question is spoken language.

1.2 The Statement of the Problem

The purpose of this research is to investigate the viability of using a Windows Approach model to study early language acquisition using sound as the window through which to 'look at' language. In order to successfully execute a Windows Approach a *bridge theory* is required to link the window and the phenomenon under examination. A bridge theory is described by Botha as a theory which connects the properties of entities of one ontological domain with properties of entities of another (2001). The investigation that follows pursues a line of inquiry whereby the feasibility of a bridge theory is explored via interviews with various participants with related, relevant areas of expertise in the fields of acoustics and linguistics. Throughout his treatment of the approach, Botha explicitly states that the merit of the conclusions drawn from this approach '[…] rests on the merit of the bridge theory presupposed by them' (2006: 137). In the context of this research, the bridge theory needs to specify how properties of sound are systematically correlated with features of spoken language as '[…] all windows require bridge theories for warranting the inferences they allow' (ibid). The dissertation aims to investigate whether a feasible bridge theory could be constructed to underpin any future inferential steps that may be made by using sound as a window onto language acquisition.

1.3 The Importance of the Study

The overarching purpose of this study is to explore the possible influence of sound perception on language acquisition in prenatal infants. It aims to address the paucity of methods available to researchers wishing to investigate the theory of early language acquisition. It does so by approaching the problem from a prenatal perspective using acoustics as its primary focus and examining the extent to which sound perception could be used as a 'window' onto spoken language. A successful Windows Approach would thereby afford researchers an insight into how prenatal infants first experience spoken language in the womb. Such an insight would naturally foster a deeper level of linguistic understanding in those involved in ELT, for whom the study of first language acquisition has come to be acknowledged as a pragmatic source from which to draw. Any further elucidation on the nature of first language acquisition would be a welcome utility in the effort to facilitate second language acquisition and would perhaps be of value to future pedagogical advances, specifically to pedagogy related to the aural aspect of spoken language acquisition.

While many studies have been carried out outlining the linguistic abilities of newborn and young infants, to the researcher's knowledge no study currently exists which uses a Windows Approach research method using sound as an inferential window through which to explore this early point of language acquisition. The viability of this approach depends critically on the ability to detect important shared acoustic features of sound and speech.

1.4 The Hypothesis

The identification of a link between the shared acoustic features of sound and spoken languages will prove sufficiently stable to warrant the construction of a bridge theory. The bridge theory would in turn license the use of sound as a conceptual research window in a Windows Approach to the study of early language acquisition in future research studies.

1.5 The Criteria for Admissibility of Data

In the interest of scientific rigour, primary data was admissible to the study if the participants met the following criteria:

The participant held a third level degree qualification or higher in any of the following areas: linguistics; physics; music technology; sound engineering; and if they had formally expressed a research interest in any of the aforementioned areas with particular attention given to their work and research publications in connection to acoustics, psychoacoustics, and early language acquisition.

1.6 The Data

The primary data was collected using a qualitative method of investigation in the form of semi-structured interviews. The same question structure was used in each interview and was used as a general guide for discussion on the acoustic nature of spoken language. These interviews were later transcribed verbatim, described, and analysed using a thematic framework advocated by Braun and Clarke in their 2006 publication on qualitative data analysis.

1.7 The Assumptions

It is assumed that suitable candidates who meet the devised criteria for admissibility of data will be encountered in the main Limerick vicinity. It is assumed that the majority of those contacted will be willing to participate in the research in an open and informative way and within the time frame of the study. It is assumed that the data provided by the participants by way of one-to-one interviews, and the secondary data collected from the literature review, will be sufficient to address the central research question which will form the basis of the dissertation thesis.

1.8 The Delimitations

The study was moderated by criteria arising from the MA in English Language Teaching dissertation time and space parameters. The study does not intend to provide a plenary Windows Approach to early language acquisition, complete with a theoretical argument on the nature of spoken language, as this would undoubtedly go beyond the range and scope of the dissertation. Instead it aims to investigate whether this type of approach could viably support continued research in the area of early language acquisition, an area where currently there is little in the way of an organised theoretical approach, to allow for the relations among various interdisciplinary research results to be understood holistically. The first step in proposing a Windows Approach is to establish a bridge theory to warrant the inferences made using this method. Thus, this study focuses on this first step in the process: bridging the gap between sound and speech.

1.9 An Outline of the Study

Chapter One: The problem and its settings

This chapter introduces the topic of the dissertation by providing an overview of the problem and its setting with reference to seminal publications in this area and by stating the central research question it addresses.

Chapter Two: Literature Review

This chapter provides a general critical summary of the literature investigated pertaining to the topic of the study. The salient areas that emerged from the literature are: concepts of language; acoustics and psychoacoustics; early language acquisition and methods of linguistic research currently employed by researchers in this field; and the Windows Approach method.

Chapter Three: Methodology

The rationale for choosing a qualitative approach as the method of inquiry and the research design is discussed in this chapter. The theoretical underpinnings of the research are acknowledged and positioned within the design framework. Details of the interview structure, sampling method, participants, and ethical considerations are elucidated. This is followed by a discussion of the methods of data collection and data analysis.

Chapter Four: Findings and Analysis

The results delivered through the execution of methodology are presented. These were gathered using a thematic analysis and presented using a narrative descriptive design. The main themes to emerge from the data and used to support the presentation of findings are: The Human Voice, The Sound of Language, The Physics of Sound, and Perception of Sound.

Chapter Five: Discussion, Conclusions and Recommendations

The findings are discussed in relation to existing research from various disciplines and in light of the central research question. The hypothesis is revisited and the implications of the findings are discussed in a broader ontological context. Recommendations for future research are offered.

2.1 Introduction

'The transgression of disciplinary boundaries is a prerequisite for scientific advance.'

(Bourdieu 1992: 149)

Accordingly, this chapter presents a critical discussion of the selected relevant literature relating to: concepts of language; acoustics and psychoacoustics; early language acquisition and the various methods of linguistic research currently employed by researchers in this field. The following discussion identifies significant landmarks in linguistic thought and research that have shaped the way in which early language acquisition has subsequently been observed and documented. It aims to show the substantial role that linguistic theory has played in the development of methodologies in the context of early language acquisition. Data and data collection methods from the field are reviewed and the ensuing assumptions about the linguistic and perceptual abilities of newborn and prenatal infants are discussed. From there, the connections in the literature that can be made by crossing from linguistics into adjacent disciplines are explained, with particular attention given to acoustic and ecological terrains. These connections are tendered as theoretical domains, relatively uncharted as a means of further exploring the language acquisition question. One of the pertinent connections that emerged from studying the literature is the ostensible relationship between sound and spoken language. The medium of spoken language and its treatment in the literature is therefore closely observed as the researcher seeks to bring this to the forefront in order to posit the thesis of using sound as a central research lens through which to explore prenatal language development. Precedence for this type research was found in the Windows Approach to language evolution model (Botha 2006) which is discussed comprehensively in the review.

The overarching question that arises from the examination of the literature is whether an ecological approach using sound as a window to observe spoken language can facilitate our understanding of how, to borrow Pinker's description, 'a system of extraordinary complexity' (1995:135) is acquired.

However, such an approach is necessarily speculative. In light of the frame and scope of this dissertation one aspect of the predominant question was identified as fundamental to the central research question, namely the connection between sound and spoken language. Therefore, it was this aspect which was chosen as the primary focus of the study. This acoustic connection observed in the literature was recognised as providing an important foundation for establishing a bridge theory (Botha 2001) which would empirically connect the properties of sound with those of spoken language. In a Windows Approach 'bridges are a must' (Botha 2001:69); without a supporting bridge theory in place, any inferences made using a conceptual window onto language acquisition would be considered arbitrary and unsubstantiated and the approach could therefore not claim to be scientific (ibid). Thus, the analysis of the literature presented here facilitated the emergence and identification of the central research question: 'Can a bridge theory be constructed to underpin any future inferential steps that may be made by using sound as a window onto language acquisition?'

2.2 Concepts of language: Signs and Sounds

In his attempt to give a 'serviceable definition of language', Sapir offers the following: 'Language is a purely human and non-instinctive method of communicating ideas, emotions and desires by means of a system of voluntarily produced symbols' (1921: 7). Keeping this system of symbols in mind, let us turn to how this might be explained theoretically. In their chapter on semiotic theory, Howells and Negreiros (2012) convey the essence of semiotics by discussing a passage in Melville's *Moby Dick* which resonates with the Swiss linguist Saussure's observations on language. Stopping to look at the gold doubloon nailed

to the ship's mast as an incentive to his crew to kill the great whale, and for the first time noticing and beginning to interpret the inscriptions and figures stamped on the coin, Ahab remarks that ' […] some certain significance lurks in all things, else all things are little worth, and the round world but an empty cipher' (Melville 1892: 404). A fine example of the interconnected relationship between the sign, the signifier and the signified; both coin and language rely on a system of signs or signals which enable people to communicate with each other. Yet, in spite of the fact that Saussure's structuralism originally stemmed from his analysis of the segmentation of sound from the vocal tract ([1916] 2013), the tendency within child language acquisition, and indeed many areas of formal linguistic research, has been to overemphasise the notion of language as 'text/object' (Forrester 2000).

2.3 Linguistic research: The Frame Shapes Our View

This overtly 'scriptist bias' (Chandler 1994: para.1) derives from a view of language as a formal object, not as a dynamic sound signal. It is clear that this historically narrow view of language as an object, primarily a textual one, has had a far-reaching impact on the way in which language has been studied and taught throughout the centuries. It is a bias that underpins the noticeably 'lexical' definitions which inform the study of language acquisition (Forrester 2000) and permeated how most people think of language: as a written rather than spoken semiotic system. Historically many linguists have assumed this textual stance on language and perhaps lost sight of the fact that, in Bloomfield's words, 'writing is not language, but merely a way of talking about language by means of visible marks' (1933: 21). How is it that the line between orality and literacy came to be so blurred among linguists interested in researching language's beginnings? McLuhan (2011) argued that our senses are deeply influenced by dominant technologies, and modern technologies have brought about a perceptual shift: we have moved from an aural way of experiencing the world to a visual one. Taking this view, it is more than conceivable that linguistic research has also been affected by this inherent visual perception of spoken language. According to Ong, this graphocentric view of language has developed and prevailed because we have '[…] so deeply interiorized writing, made it so much part of ourselves […] we find it

difficult to consider writing to be a technology' (1982: 82). Yet, as Chandler (2007) reminds us, Saussure's was originally a theory borne of a phonocentric view, privileging spoken rather than written language, and in his work he drew a clear distinction between the written sign and the *image acoustique* ('sound-image') ([1916] 2013). At an abstract level then, speech is a message encoded by sounds and, as language users, we are all acoustic 'semioticians' (Howells and Negreiros 2012: 121) whether we know it or not.

2.4 The Sound of language

In a bid to address Chomsky's rather sensible assertion that 'there is little point in speculating about the process of acquisition without a much better understanding of what is acquired' (1959: 55), the literature was studied to identify the 'design features' which characterise language. In her review, Aitchison identifies ten elements that 'capture the essential features of language' (1998: 27). She names the following: use of the vocal-auditory channel, arbitrariness, semanticity, cultural transmission, spontaneous usage, turn taking, duality, displacement, structure-dependence and creativity (ibid). It is noteworthy that the *use of the vocal-auditory channel* is listed first. Of course, language itself can be transferred without sound: sign language, writing, Braille etc. are all functioning systems of communication, and so it follows that the auditory characteristic of speech is what distinguishes it from all other types of language. The vocal-auditory channel is one of the unassailable tenets of spoken communication, a fact wielding so much influence that often the term 'language' is used synonymously with 'speech'. It supports the claim that sound is perhaps the most obvious characteristic of spoken language and yet 'we continue to find it difficult to remember that children learn language as accountable sound performance, and only later learning that these noises are described as words, sentences and all other constructs which derive from the invention of writing' (Forrester 2000: 4.3).

In order to speculate about its acquisition, it was found that Forrester's (2000: 4.1) definition of language does well to express what is at the heart of this dissertation: 'language is first and foremost sound, or at least the business of making meaning through the use of sound'. All spoken languages can be said to make use of a finite number of distinguishable sounds, ranging from as low as eleven (Hawaiian) to over sixty (some languages in the Caucasus) (Aronoff 2007), which are concatenated together in time to produce speech. These basic linguistic units are called phonemes, which each have their own unique articulatory configurations (Fant 1960). Phonemes themselves have no meaning, but in their sequences they combine to form syllables and then words which are assigned meanings and 'certain significances' by society. Every language has its own distinctive system of sound patterns used to convey messages. Forrester (2000) points out that by losing sight of the fact that spoken language is sound first and speech second we are positioning ourselves at a rather weakened starting point for conceptualising. The text you are currently reading is based on a system which indicates little more than specific sound contrasts. Rosen and Fourcin caution against dealing with speech as mere phonemic contrasts and instead assert that speech perception should be studied from the point of view of their *acoustic features*. They make the point that we have become so familiar with our writing system that we tend to forget that many important features are not catered for in script and are thus omitted from simple phonemic analysis: accent, harmonics, voice pitch, length, loudness, formant transitions etc. (1986). Language is after all a 'system of voluntary produced symbols' and in speech 'these symbols are, in the first instance, auditory […]' (Sapir 1921: 7).

'Of all the sounds experienced by human listeners, those of speech are certainly the most important' (Rosen and Fourcin 1986: 373). Take the word 'mat', for example: it consists of a three-phoneme sequence: /m/ /æ/ /t/. The /m/ is produced by closing the lips, lowering the velum and vibrating the vocal folds while exhaling. This is followed by a partial opening of the mouth with lips pulled back, and a movement which positions the tongue low and resting towards the front of the mouth creating the /æ/. From there, the tongue must move to the alveolar ridge

behind the top teeth and the final sound is released by blocking the vocal tract so that the airflow ceases and for a finish, a release burst culminating in the plosive /t/ sound. Aitchison (1998) calculates that if you take the average English word to have four phonemes and we speak at a rate of five words per second, the continuous speech stream consists of approximately twenty sounds a second. It is the act of segmenting this speech stream which Ohala (2008) posits as the first step in phonological acquisition. Kuhl (1987) argues that although newborns do not yet possess the anatomy to produce speech sounds, they do have the ability to unravel the flow of speech. In fact, their astute perceptual abilities have been demonstrated through a variety of techniques devised by researchers whose subjects are naturally taciturn about the whole process.

2.5 Early language acquisition research: Methods and Findings

There are many ways to study language but only one is devoted to understanding how children acquire language early in life: early language acquisition research. King (2006) highlights the fact that the fundamental conceptions about language held by early language acquisition researchers are intimately connected to their subsequent research approaches and, in turn, their results act as evidence in support of their original position on language. It is these primary, epistemological positions that influence the way the researcher sees the problem (Hubbard and Levy, in Press). Therefore, acquisition linguists' conceptions of language drive not only how the research problem is formulated but perhaps more importantly, they drive the method of investigation. It seems a rather self-reflexive approach to a problem and one which could only continue to generate homogenous data were its cyclical nature to be left unchecked. In the latter half of the twentieth century, the field of language acquisition was dominated by the revival of the 'nature-nurture' debate spearheaded by Chomsky and Skinner, a long running debate which has been in various stages of fluctuation since it was first documented in Plato's dialogues (Aitchison 1998). This period witnessed a challenge to the long serving theory of language as an expression of 'verbal behaviour' (Skinner 1957: 3) in the shape of a theory which posited an 'innate language faculty' as its core tenet

(Chomsky 1959). Naturally, each camp found evidence that supported the main claim for the strikingly different approach to language at the heart of each theory.

At the turn of the century, Kuhl (2000) wrote that the emerging view of language acquisition argues for new theories that can no longer be accounted for by either Skinnerian reinforcement or Chomskyan innateness hypotheses. The new theories being sought are in response to the data of experimental studies suggesting a language acquisition process that transcends that which can be explained by classic theories (Kuhl *et al* 2003).

The linguistic aptitudes of infants have been highlighted by experiments designed using various innovative techniques to study their receptive language skills. The high amplitude sucking technique (HAS) (Siqueland and DeLucia 1969), the head-turn preference procedure (HTPP) (Nelson *et al* 1995) and more recently, the heart rate monitor have offered linguists further insights into language perception in both prenatal and newborn infants. Experiments using these techniques have revealed some interesting results: the linguistic researchers Trehub (1973) and Eimas *et al* (1971) observed that four-week old infants can discriminate among individual speech sounds: vowels and consonants. They can even discriminate between two sounds so similar that they differ only in the place of articulation. These findings, amongst others, have led to the now widely accepted view that infants can discriminate among virtually all the phonetic units used by the world's languages (Kuhl *et al* 2008). The seeming decline in this perceptual ability as the infant grows has formed the basis of support for the critical or sensitive period hypothesis (Penfield and Roberts 1959; Lenneberg 1967). At only four days old, infants were found to be able to discriminate their maternal language (ambient language) from other languages regardless of the speaker (Mehler *et al* 1988).

In their seminal experiment, DeCasper and Spence (1986) showed that newborns can distinguish passages heard prenatally from those heard after birth. They

published observations that newborns seem to be able to discern familiar speech patterns heard previously *in utero* regardless of the speaker, proving that prenatal experience has bearing on their acoustic perception *ex utero*. Using their findings they claimed that the fetus can, and does, experience their mother's voice in the third trimester (ibid), a point reiterated in more recent literature (Kisilevsky *et al* 2003). Although we cannot yet speak definitively of the underlying process of phonetic recognition, we can with great certainty comment on the prenatal and neonatal infant's ability to distinguish speech sounds with a high degree of accuracy. This research supports Ohala's statement that 'learning to perceive the sounds of a language is accomplished much more rapidly than the overall work involved in learning a language in its entirety' (2008: 19). These findings have shown beyond doubt that the child's experience with sound and acoustic transmission begins at a much earlier point in development than previously thought. 'Our first experience with language arguably comes in the womb' (Ohala 2008: 19).

2.6 A New View

The results have called for a new view on language acquisition, one that accounts for both the initial state of linguistic knowledge in infants, and infants' seemingly extraordinary ability to learn simply by listening to ambient language. The infant's well-documented 'rapid accomplishment of sound perception' (Ohala 2008: 19) leads one to hypothesize that there is some type of 'prenatal framework' (De Boysson- Bardies 1999: 24) that aids them in encoding the sounds of language. In theory, it is a framework which might help infants identify not only the phonetic distinctions which are used in their environmental language but also those sounds present in speech as opposed to those which are acoustic but not language *per se*. Therefore, it would seem likely that one of the child's first tasks in their new, *ex utero* world is to learn what sounds to pay attention to and what sounds to tune out (Forrester 2000). It is widely acknowledged that language is present in the form of 'mother's voice' throughout the pregnancy, and so this sound stimulation would probably be well-placed to receive special attention throughout the tandem development of the auditory and neural systems as a result. Indeed, neurology tells us there are three main consecutive stages of cortical development: cellular

proliferation and differentiation, neuronal migration and cortical organization. All this takes place in various overlapping sequences up to the twenty-second week of gestation (Guerreiro *et al* 2009). We know that in neural development, the entire creation of cortical neurons takes place in the sixth and seventh week *in utero* and as no new neurons are ever created after this point, it is fair to say that neurological patterning must begin early (Boysson-Bardies 1999).

Kuhl *et al* (2008: 983) proposed the concept of Native Language Neural Commitment (NLNC) positing that 'neural networks become committed to patterns of native language speech.' Taking this into account, and considering the empirical evidence of familiarisation with the mother's language, it is highly plausible that the sound stimulations received *in utero* contribute to the priming of sensory pathways and calibrate the perception to certain characteristics of speech sounds (Boysson-Bardies 1999). Forrester (2000: 4.4) further remarks that as infants *in utero* our primary sensation environment is tactile and auditory before it is visual: 'we feel and "sound" our way into the world before we perceive that world visually.' To begin to understand the mechanism beneath this developmental process it may be necessary to broaden the range of physical parameters and perceptual experiences currently under consideration. This brings us to an interesting impasse: if we are to examine spoken language through an analysis of sound perception, we must first ask what Gaver (1993a: 5; 1993b) calls 'two simple but fundamental questions': 'What do we hear?' and 'How do we hear it?'

2.7 Acoustic Phonetics

In her introduction to acoustic phonetics, Zsiga (2006: 32) describes speech sounds as 'moving air' and her succinct explanation of the physical process of sound transmission is useful to reflect on here. She uses the example of a tuning fork as an example of a simplex sound:

> As the ends of a tuning fork vibrate, they set the air particles next to them vibrating as well, following the same back and forth motion. These moving air

> particles alternately push and pull on the particles next to them, and so on, so that the pattern of vibration moves outward from the tuning fork like ripples in a pond these moving patterns of vibration are called sound waves.
>
> (Zsiga 2006: 33)

The same thing happens in speech as air passes out of the trachea and over the vocal folds: the folds begin to vibrate and the vibrations cause sound waves which move out past the lips and into the world. 'The sensation of *voice* is typically associated with this vibration' (Rosen and Fourcin 1986: 376). When these sound waves reach a membrane, like that found inside our inner ear, it begins vibrating according to the same pattern. In his treatise on the different forms of language, Bringhurst (2004: 1) uses an elegant metaphor to describe the relationship between words and meanings: 'drop a word in the ocean of meaning and concentric ripples form'. He then evokes the image of many words being dropped simultaneously, as happens in natural speech. In order to make sense of them together one must look not at the ripples each cause but focus instead on the interaction of those ripples. This, according to Bringhurst, is how we listen (ibid). An interesting question that arises in the context of early language acquisition is: how do we listen before we have been inducted into the semantic code of a language? The way the sounds of a language behave is not unlike this metaphor of interacting ripples. Individual phonemes show co-articulatory effects depending on the sounds that surround them, resulting in all of the sounds merging to form a continuous flow of speech (Bishop 1997). Considering that a child *in utero* is experiencing not words and sentences but a pure acoustic stream of information we must begin to rethink how to approach the issue of prenatal acquisition with the more targeted questions: 'what do *they* hear?' and 'how do *they* hear it?'

2.8 The Unique Quality of Voice

Rosen and Fourcin (1986: 374) speak of the 'intimate relationship' that exists between the acoustic properties of speech sounds and their source and Zsiga (2006) likens the voice to a fingerprint. Each person's speech organs are individual and this is reflected in their unique vibration pattern or formant structure, a view

which is echoed throughout the literature by those who study the acoustic features of the voice. Indeed, our own word 'person' is from the Latin *per sona*: 'that through which comes sound' (Watts 1999: i). Interesting data emerged at the beginning of this century which showed that infants learn phonetically from listening to a live human being but not from a disembodied source, even if the acoustic information remains the same in both situations (Kuhl *et al* 2003). The experiment highlighted something of note: if phonetic learning is triggered solely by linguistic input, then exposure to language via other audio sources (CD, DVD etc.) should have resulted in learning. This proved not to be the case and prompted the critical question 'what does a live person provide that a DVD cannot?' (2003: 9100). In an attempt to answer this, early language acquisition researchers may find a useful framework in a Gibson inspired ecological approach to perception.

2.9 Ecological Acoustics

In order to discuss an ecological framework let us first return to Gaver's original questions about what and how we hear. In a spoken language context, Handel (1993:160) delves a little further by asking if speech perception is truly based on the recovery of phonetic units, as previously defined, and if the acoustic signal as portrayed in spectrograms is the correct representation for a fuller understanding of perception. This usefully introduces two important themes in terms of an ecological approach to perception: dichotomies versus continua. Traditional studies of acoustics deal only in part with what Gaver (1993a: 6) identifies as a 'continuum of energy' between the source event, in this case the speaker, and the experience. Typical research in psychoacoustics tends to focus on the sound itself thus missing the acoustic array of data that is informative about the event (Jenkins 1985). Taking an ecological approach to speech would mean a closer examination of the data available about the source. We are organisms which acquire knowledge about the environment that surrounds us through auditory signals (Forrester 2000). This is clear from the studies related to 'echolocation', a term widely used to describe how those with visual impairments use sound to navigate the surrounding environment (McGrath *et al* 1999). It is very likely that sighted individuals are also sensitive to this auditory patterning (Gaver 1993a) but in their case vision is the

dominant sensory mode and therefore it is relied on more as the optimal sensory channel (McGrath *et al* 1999). In terms of how we first experience spoken language, this ecological framework may provide researchers with a wider scope of research terrain, which would complement the view offered by traditional psychoacoustics.

2.10 A Cross-Disciplinary Approach to Language Acquisition

It is widely speculated that some type of spoken language developed between 100,000 and 50,000 years ago, yet for all its time in development there exists little direct evidence relating to the speech of our distant ancestors (Yule 2006). In modern linguistic research, a number of strategies have been developed to counter this problem of evidential paucity. In their research, Mithen (2005) and Brown (2001) both use the parallels between music and speech to make inferences about the genesis of language. Wilkins and Wakefield (1995) use archaeological artefacts as a source of data to argue their claims for linguistic capacity based on the shape of fossil hominid skulls. In their seminal paper discussing language evolution, Pinker and Bloom (1990) use less historical evidence and draw instead on scientific data available across a variety of different fields to argue against the Chomskyan paradigm of language. While their publication did not purport to furnish the field with a new theory of language evolution, it did present an innovative, cross-disciplinary methodological framework for the study of language evolution.

> We think there is a wealth of respectable new scientific information relevant to the evolution of language that has never been properly synthesized. The computational theory of mind, generative grammar, articulatory and acoustic phonetics, developmental psycholinguistics, and the study of dynamics of diachronic change could profitably be combined with recent molecular, archeological, and comparative neuroanatomical discoveries and with strategic modeling of evolution using insights from evolutionary theory and anthropology.
>
> (Pinker and Bloom 1990: paragraph 6)

In the same paper, they also asserted that '[…] language acquisition in the child should systematically differ from language evolution in the species and attempts to analogize them are misleading'. However, there seems to be nothing stopping a similar methodological approach being used in researching the problem of early language acquisition.

One research approach of interest to the dissertation, developed to mitigate the absence of evidence related to language evolution, has been written about extensively by Botha (2009; 2006; 2004; 2003; 2001) and is known as the Windows Approach. It is perhaps the most formalised model of its type to appear with regard to researching language evolution, as evidenced by its fastidious description as a model with a definitive structural framework provided for every point in the process (for further details of the model see Botha 2004). In an article explaining the conceptual foundations of this approach, Botha describes it as proceeding '[…] from the assumption that language evolution can be studied by examining other phenomena about which there is direct evidence' (2006: 129). Accordingly, a 'window' is 'a phenomenon that has properties believed to offer a "view" on properties of some aspect or aspects of language evolution' (Botha 2006: 132). These views manifest when inferences or conclusions about the opaque phenomenon in question can be made on the basis of data relating to the distinct phenomenon about which there is much evidence available. He includes sign language and pidgin languages as two such viable windows successfully used to make inferences about language evolution. In order to avoid arbitrary and speculative inferential 'jumps' when using this approach, a careful and empirical approach is necessary when constructing a window (Botha 2004). To ensure that any conclusions drawn are non-arbitrary and to licence the researcher to move, inferentially, from one domain to the other, what is known in this context as a *bridge theory* is necessary. Only when a window is shown to have shared properties which bridge the gap between the two phenomena in a non-arbitrary way can it claim to be grounded and thus instantiate any inferences made by the Windows Approach (Botha 2001).

2.11 Conclusion

The literature reviewed above indicates a potential research window in sound. The well-established link between sound and spoken language provides a strong foundation to warrant an investigation into the construction of a bridge theory to further explore the shared properties and correlations of sound and spoken language. If successful, the development of a bridge theory would allow for the adaptation of Windows Approach model to be seen as a viable approach to examine early language acquisition. By using the well-understood phenomenon of sound as a window, it would permit researchers to draw on knowledge from adjacent fields connected to acoustics, previously thought to have no bearing on linguistics. While the study may prove the approach untenable, it nonetheless should act as a heuristically powerful tool, the use of which should generate questions which are highly specific to the problem of early language acquisition which, in turn, may lead to a deeper understanding of the area.

3.1 Introduction

'No method is absolutely weak or strong, but rather more or less useful or appropriate in relation to certain purposes' (Sandelowski 2000: 335). The purpose of this qualitative study is to explore current perceptions of the acoustic features of spoken language and the possible influence of sound perception on the early stages of linguistic development. In selecting a research approach, the relative merits and limitations of both quantitative and qualitative methods were considered. As Creswell (2003: 22) states: '[…] if a concept or phenomenon needs to be understood because little research has been done on it, then it merits a qualitative approach.' He further states that qualitative research is preferable when the researcher is interested in an area that is relatively under-represented in the literature and the important variables to examine are therefore not immediately obvious (ibid). Morse (1991) also highlights that qualitative research may be needed when the topic is new or when the topic has never been addressed with a certain sample of people.

3.2 Qualitative Description

In this case, all of the aforementioned factors converged to influence the decision to choose a qualitative research approach. Furthermore, a qualitative descriptive method was chosen as the most appropriate form as, according to Sandelowski (2000: 337), a fundamental qualitative description is a valuable methodological approach '[…] especially amenable to obtaining straight and largely unadorned answers to questions of special relevance […]' and so the researcher, interested in the facts naturally stays '[…] close to their data and to the surface of words and events.' As opposed to phenomenological, theoretic, or narrative descriptions which re-present events in other terms, the description in qualitative descriptive studies entails the presentation of the facts of the case in everyday language (ibid). Here, a qualitative descriptive study was selected as it provided a means of

fostering the development of shared meaning among participants in an interdisciplinary approach to a research question designed to investigate the relatively under explored relationship between sound and spoken language and its role in early language acquisition. The collected data was then set against a backdrop of related literature in order to contextualise the participants' reflections on the topic and to elaborate on some of the more abstruse aspects of the subject. A qualitative descriptive approach was chosen because it fit the primary objective of the study, which was to explore the acoustic nature of spoken language according to the views of those connected to facets of the phenomenon through their own professional disciplines and research areas. This data was then used to test the hypothesis that the measure of shared acoustic features of sound and spoken language would licence the construction of a bridge theory and thus warrant a Windows Approach to early language acquisition. This chapter is a description of the process involving the researcher and participants designed to examine their views and knowledge of the subject of sound and language according to their own distinct discipline.

3.3 The Research Approach

'Indeed qualitative work is produced not from any "pure" use of a method, but from the use of methods that are variously textured, toned and hued' (Sandelowski 2000: 337). As this study was particularly interested in gaining insights into the acoustic properties of spoken language, and, in turn, the impact this may have on auditory perception and language acquisition, it therefore meant that it took on overtones of other disciplines and their frameworks. 'As the inquiry proceeds, it becomes increasingly focused; salient elements begin to emerge, insights grow, external theory appropriate to interpretations is determined, and the study's internal theory begins to be grounded in the data obtained' (Davis 1995: 445). Following a review of the literature and the data collection, parts of the dissertation were drawn to different fields of study dealing with: acoustic features of language; human perception of sound; prenatal perception of sound; acoustic environments; psychoacoustics; and ecological acoustics.

3.3.1 The Interviews

Scientific research, in Wengraf's view, has to do with 'getting a better understanding of reality' (2001: 3-4) and interviews are purposeful conversations directed towards developing a shared understanding of another's perspective of the world (Aita and Richer 2005). For the purpose of this study the researcher adopted a similarly realist position and individual interviews were deemed the best method to serve the topic and purpose of enquiry. The goal was an authentic insight into participants' understandings and reflections on the nature of sound as the medium of spoken language stemming from their own distinct knowledge base.

3.3.2 Semi-Structured Interviews

Interviews range from totally unstructured, where the content is completely controlled by the participant, to structured, which is similar to a questionnaire. Semi-structured interviews fall somewhere in the middle and can provide '[…] detail, depth, and an insider's perspective […]' (Leech 2002: 665). Furthermore, semi-structured interviews were deemed a good fit as they can also provide reliable, comparable qualitative data while affording participants the freedom to express their views in their own terms (Cohen and Crabtree 2006). As this dissertation had at its core an interest in the research benefits of multi-disciplinary cross-pollination it seemed a natural way of affording each participant the opportunity to give answers which were informed by their own individual discipline. The right to anonymity was raised by participants early in the research design. In order to respect this request, one-to-one, semi-structured interviews were chosen as the central method of data collection. By choosing to interview participants individually, rather than together, anonymity was preserved amongst the group.

3.3.3 Interview Questions

All participants, having read and signed a Consent Form (see Appendix C), were interviewed and audio-recorded for between thirty and ninety minutes. Open-ended, semi-structured questions and prompts were used with a degree of flexibility. The researcher allowed for topical trajectories that strayed from the question guide to be pursued and discussed as she was aware that these

trajectories can sometimes offer new and insightful ways of seeing and understanding the research topic (Cohen and Crabtree 2006; Leech 2002). However, the use of a question guide allowed the researcher to re-focus when necessary.

3.3.4 Interview structure

The interview was divided into four main areas:

1. Phonological/Acoustic features of language
2. Human Perception of Sound
3. The Acoustic Environment of the Womb
4. Prenatal Perception of Sound

Following a review of the literature, a template of questions was developed (see Appendix B). The questions were designed in order to gain access to specific information and target data. The researcher was influenced by the idea that question order is important in interviews (Leech 2002) and so the interview was designed to move from relatively straightforward questions at the beginning to more speculative and therefore challenging as the interview proceeded. The question sequence also added to the consistency of the interviews and enabled the data to be more easily compared across interviews. Each area contained approximately three questions relating to the general area of interest. Questions were adapted, omitted or elaborated according to the demand of each individual interview context. Aware that the type of questions being asked may not have been ones the participant had spent much time thinking about previously, and yet curious to hear their perspective, it was decided to employ a tactic that allowed for the participant to speak from a safer position which removed them from the often restrictive 'field representative' stance. This was done by asking them to state, after each question, whether it was related to something that fell inside or outside their expertise in their respective fields. The intention was to ensure the participant would continue to talk instead of closing up to avoid making statements that could be interpreted as representative of the entire field. The researcher adopted an open, friendly stance with the interviewee and so there were many instances of 'talking back' (Griffin 1990) in order to promote a two-way dialogue to explore key themes.

3.3.5 The Participants

Table One Profile of Participants					
Name	**Age**	**Gender**	**Profession**	**Qualifications**	**Research Interests**
A	45-60	Female	Speech & Language Therapist, Lecturer and Researcher	B.A. (Hons) Social Anthropology & Linguistics, MSc. Speech & Language Therapy.	Developmental speech and language disorders.
B	45-60	Male	Lecturer and Researcher	Degree in Electronic Engineering and Telecommunications, M.Sc. by research.	Acoustics and Ecological Psychology.
C	45-60	Male	Sound Artist and Researcher	Diploma in Audio Recording Technology (OIART), Degree in Theoretical Physics, MA in Music Technology.	Sound and Acoustic Ecology.
D	30-45	Male	Lecturer and Researcher	BSc in Applied Physics, PhD by research.	Science Education (Physics).

It was decided to use a purposeful sampling strategy (Patton 1990). There were two main reasons for this choice. The first being that as data analysis in qualitative research tends to be time consuming and given the time and space parameters of the dissertation, the researcher believed that by using a smaller, more select group the proper attention could be paid to the data analysis, which would provide the bedrock of the research. The second reason was somewhat more significant: participants were deliberately chosen based on the supposition that their academic and professional backgrounds would position them to have the specific information to answer the research question as their work was closely connected to either acoustics, linguistics or both. This conclusion was arrived at by a close examination of participants' professions, research backgrounds and publications, and through introductions and recommendations provided by the participants themselves. The recommendations by the participants were seen as valuable as they were able to identify others with similar, relevant areas of expertise based on their knowledge of the academic community. It was paramount that participants were familiar with

acoustics and psychoacoustics and so this was seen as a determining factor when selecting participants. As Sandelowski (2000: 338) points out, the ultimate goal in any qualitative study '[…] is to obtain cases deemed information-rich for the purpose of study.' As the dissertation was interested in exploring the relationship between sound and spoken language, participants were recruited whose background and qualifications were linked to the topic and would therefore position them to provide trustworthy data about the subject. This also allowed for the inclusion of participants from distinct fields of research in order to get a broader picture of the topic while exploring the benefits of an inter-disciplinary approach to the research question. As Creswell (2003: 21) states: 'certain types of research problems call for specific approaches.'

3.4 Ethical Issues in the Research Process

Creswell recognises that ethical issues exist at all stages of the research process, from topic selection through to the dissemination of the research findings (2009) and so the researcher remained mindful of this throughout the process. Initial contact was made with each participant via e-mail, meetings, or phone calls. At this time, a brief description of the topic and tentative research design was outlined and all participants indicated that they would be willing to be interviewed. It was agreed that they would be formally contacted again closer to the time that the research would take place. The issue of anonymity was raised at this initial stage by some of the prospective participants and it became clear that this would need to be assured and managed dutifully throughout the process. The use of individual interviews, as opposed to a focus group, ensured full confidentiality among the participants. Ethical approval was sought before any research involving the participants was conducted. Approval was granted by the University of Limerick research ethics committee in July 2013 on the condition that participants' right to anonymity be further observed by removing, or avoiding, any reference to their respective departments and universities in the research findings. The researcher responded to the requirements of the ethics committee, and the participants who indicated anonymity as desirable, by using pseudonyms and removing any data that could potentially reveal the identity of the participants. Thus, any obviously identifiable

statements and additional information relating to either public or private identity e.g., department, university, nationality etc. were removed from the data presented here. The raw data was uploaded and kept in a password protected hard drive and hard copies of transcripts used in coding were kept in a locked file and subsequently destroyed. The researcher was the only person to have access to the material at any point throughout the process.

3.5 The Research Study

At the research stage, participants were first sent an electronic copy of the Information Sheet elucidating of the exact nature of the study and a copy of the Interview Questions which would be used by the researcher (see Appendices A and B). The Information Sheet contained information relevant to the research topic and the participant in terms of expectations, the style of interview and the data collection process. It was made clear that the information would be used to present a thesis. They were advised that, with their permission, the interview would be audio recorded and accessed only by the researcher and informed that all information taken from the interview would be kept securely for seven years and the dissertation would not be published outside of the University of Limerick. In Creswell's treatment of qualitative research methods, he opines that the researcher should not engage in deception about the nature of the study, even if it results in non-participation (Creswell 2009). This authentic approach resonated with the researcher and therefore full disclosure was provided by way of supplying the Interview Questions ahead of time. Participants were therefore afforded the opportunity to become familiar with the core structure of the interview and subsequently make an informed decision whether to participate or not. It was the researcher's intent to foster an open, trusting relationship in order to establish the best possible environment to enable the data to rise, unhindered, to the surface and to be examined without any distraction.

Each participant had the final decision on the time and place for their interview to take place. The researcher was careful to communicate that she was flexible to meet at a time and place that was convenient for the participant. It was made clear that should participants wish to be interviewed on their 'own territory' (Hammersley and Atkinson 2007: 116) the researcher would be happy to oblige. This was done with the intention of promoting the participants' sense of comfort conducive to encouraging conversation flow in comfortable surroundings. Two interviews were carried out in the participants departmental offices and the remaining interviews were conducted in an agreed upon quiet, private space. All four participants agreed to the interview and on the appointed day they each formally signed a Consent Form (see Appendix C) where the voluntary nature of their participation and their right to withdraw at any time was reiterated.

3.6 Data Analysis

Braun and Clarke aptly point out that in order to determine the type of analysis you want to do, the researcher must reflect first on the claims that they want to make in relation to the data set (2006). In their comprehensive treatment of Thematic Analysis, they observe that one use of this type of analysis is to provide a rich thematic description of the entire data set ensuring that the reader gets a sense of the predominantly important themes. Although they caution that this method can cause some depth and complexity to be lost, they affirm that by using this method a rich overall description can be maintained. The authors highlight the advantages of this type of analysis when writing a short dissertation or adhering to a word limit. They further emphasise the advantages of using this type of analysis when investigating an under-researched area, or when participants' views on the topic are unknown (ibid). It was for these reasons that this approach was used to analyse the data of a study whose aim was to investigate the various attitudes and perspectives to the relatively under-explored relationship between sound and spoken language.

3.7 Axiological Assumptions

> The interviews that you do or that you study are not asocial, ahistorical events. You do not leave behind your anxieties, your hopes, your blindspots, your prejudices, your class, race or gender, your location in global structure, your age and historical positions, your emotions, your past and your sense of possible futures when you set up an interview […]. Nor do you do so when you sit down to analyse the material you have produced.
>
> (Wengraf 2001: 4-5)

This was borne in mind when coming to analyse the data taken from the interviews. It has been widely acknowledged that theoretical underpinnings shape the overall research: its conceptualisation and procedure, analysis and interpretation; all aspects of the research, to varying degrees, are either directly or indirectly influenced by theory (Hubbard and Levy, in Press). Neuman concisely describes the role of theory as this:

> Theory frames how we look at and think about a topic. It gives us concepts, provides basic assumptions, directs us to the important questions, and suggests ways for us to makes sense of data. Theory enables us to connect a single study to the immense base of knowledge to which other researchers contribute. To use an analogy, theory helps a researcher see the forest instead of just a single tree.
>
> (Neuman 2003: 65)

It is important at this point for the researcher to acknowledge her own theoretical positions and values in relation to the research data. The data collected here were analysed using thematic analysis which was influenced by insights from ecological frameworks, specifically Bronfenbrenner's Bio-Ecological systems theory (1992) which holds that development reflects the influence of several environmental systems, and that a person's own biology may be considered part of one of those systems known as the microsystem. The microsystem is the layer of relationships closest to the child and encompasses the interactions a child has with their immediate surroundings. In the case of prenatal development, the environment is taken to be the mother's womb and the interactions are those sensory perceptions

experienced *in utero*. Informed by other ecological theories of perception (Gibson 1963; Gaver 1993a; 1993b), the application of these theories to the auditory perception of prenatal infants also shaped the thematic analysis of the collected data and served to '[…] set the boundaries and largely govern points of focus, the concepts or constructs included and excluded, those foregrounded and those that remain in the background' (Hubbard and Levy, in Press).

3.8 Thematic Analysis

The data was analysed using Braun and Clarke's 2006 framework of analysis. According to the authors, the five definitive stages of analysis are as follows:

3.8.1 Stage One: Familiarising yourself with the data

After each interview, the researcher found a quiet place and attentively listened back to the full recording within twenty-four hours. During this time, brief notes were made of outstanding points, sentences or moments and that registered as important or salient to the study. This type of 'instant debriefing' is advocated by Wengraf in his section on 'post-interview debriefing' (2001: 209) and the resulting notes described as: '[…] memories, ideas, *anythings* […]' stimulated by the act of listening (ibid: 142). Each interview was then transcribed using the verbatim principle. 'Later on, you may produce ''cleaned up versions'' (post zero), but you should always start with a clean verbatim one' (ibid: 213). Once the transcriptions were complete, the written and audio data were compared to verify accuracy. Initially, each transcript was read twice and the third reading was done whilst listening simultaneously to the audio. Listening to the participants' intonation, word stress and other paralinguistic cues aided the researcher in gaining a greater insight into their utterances and facilitated the next stage of the data analysis: generating initial codes.

3.8.2 Stage Two: Generating initial codes

Initial codes were generated in response to the research question using a more explicitly analyst-driven 'theoretical' approach: the researcher deductively coded for

data relating to the specific research question. The initial codes were generated manually by simply grouping together features of the data that struck the researcher as interesting or pertinent to the central research question. At this point, the researcher began to get a sense of the emerging themes.

3.8.3 Stage Three: Searching for themes

'In qualitative descriptive studies, language is the vehicle of communication, not itself an interpretative structure that must be read' (Sandelowski 2000: 336). Following from this, the researcher approached the search for themes from a semantic perspective. That is to say, that the themes were identified within the primary level of explicit or surface meanings (Braun and Clarke 2006) and the researcher did not analyse in depth anything beyond what the participants actually said. At this stage, the codes were sorted into potential themes. This was done by organising the notes made directly onto the margins of the transcripts into 'theme-piles' (Bruan and Clarke 2006: 19). Visual representations were used in the form of coloured post-its and highlighting techniques to help sort the different codes into themes. Through the process of writing out headings and summations of each code, the researcher was able to consider how to place, collapse, and divide codes to form an encompassing theme, which was then assigned a colour. This method also allowed for a certain amount of experimentation in the collection of viable themes. The 'sense of emerging themes' began to take on a more solid form.

3.8.4 Stage Four: Reviewing themes

Braun and Clarke divide this stage of reviewing and refining themes into two distinct parts. The first phase is one in which the analyst examines the *coded data extracts* for each theme critically to ensure that they cohere and fit within the thematic pattern. Once this had been done, the attention turned to the *entire data set*. Here, a point was reached where it was felt that the themes fit together to tell, what the authors describe as the 'overall story' of the data they emerged from.

3.8.5 Stage Five: Defining and naming themes

'It is important that by the end of this phase you can clearly define what your themes are, and what they are not' (Braun and Clarke 2006: 22). The researcher,

being conscious that descriptive studies present the facts to the reader in everyday language (Sandelowski 2000), named the themes in a way that would give the reader an immediate sense each theme's essence while also anchoring the individual themes to the aspect of the overall data that they captured.

3.8.6 Stage Six: Producing the report

The thematically organised data now formed the foundation on which the qualitative report is written. Specific examples were taken from the data to support the themes identified and are presented in the next chapter.

3.9 Limitations

The researcher is conscious that being relatively inexperienced in the art of interviewing for research may have affected the data and resulted in missed opportunities for securing information. The sample size used in the study was small and therefore may affect the scope of application of these findings. However, the participants were specifically chosen based on the assumption that their professional backgrounds and qualifications would enable them to provide rich and trustworthy data about the subject. A larger sample may have produced more data but would not have generated the 'information-rich' (Sandelowski 2000: 338) data the researcher was seeking. Thus, the adage 'less is more' was followed.

4.1 Introduction

This chapter presents the findings of the study, the aim of which was to explore participants' perceptions of the correlations between the properties of sound and those of spoken language. The purpose of this research was to use the collected qualitative data to investigate the viability of using a Windows Approach model to study early language acquisition. In order to successfully use a Windows Approach a *bridge theo*ry is required to link the window used to make inferences about the phenomenon under examination. Here, the proposed window is sound and the phenomenon in question is spoken language. The data from four semi-structured, one-to-one interviews is examined using Braun and Clarke's 2006 framework of thematic analysis as outlined in the previous chapter. In keeping with a qualitative descriptive design, the researcher presents the findings as a 'straight descriptive summary of the informational contents of data organized in a way that best fits the data' (Sandelowski 2000: 339). The data is further analysed in light of the research question presented in Chapter One: whether a feasible bridge theory connecting sound and spoken language could be constructed. In line with this, the data was divided into four main themes: The Human Voice, The Sound of Language, The Physics of Sound and Perception of Sound. Each theme is described in detail and participants' statements are included to support the themes and illustrate the data that emerged in the findings. The participants' pseudonym and transcript line number are given below each statement. The following is a list of the themes and sub-themes generated by the analysis:

Table Two Themes & Sub-themes	
Theme	**Sub-theme**
4.2 The Human Voice	*Paralinguistic cues*
	Invariants
4.3 The Sound of Language	*Natural Acoustic Features of Speech*
	Synthesising Speech Sounds
4.4 The Physics of Sound	*Sound in the Air*
	Sound in the Womb
4.4 Perception of Sound	*The Development of the Auditory System*
	Holistic Perception: cross-talk between the senses

4.2 Theme One: The Human Voice

All participants described the process of using the voice to speak roughly using the source-filter model of speech production. This widely employed model shows speech sounds to be created by a combination of a source of sound energy modulated by a filter function determined by the shape of the vocal tract. Equally, all participants noted that the acoustic nature of the voice was naturally individual to the 'sounder' (speaker) that produces it. They all discussed aspects of the voice that carry information other than language and in turn, they discussed the types of information that are communicated.

4.2.1. Paralinguistic cues

'[…] so there's a lot embedded in that sound that's larger than language, it's a language in its own right, it's communicating something.'

(B, 102)

All participants made multiple references to features that are conveyed through the acoustic signal of the voice that are separate to language. All of them mentioned the role that the physicality of the speaker plays in the sound emission of the voice:

'Everyone's vocal chords will vibrate at slightly different frequencies, but the actual acoustic signal is then modified by the resonant cavities that you use so, that's partly fixed, you know, depending on your stature and so on.'

(A, 16)

Parts of the body responsible for refining and shaping the sound of a person's voice were identified by all participants. These were namely: the lungs, larynx length, vocal chords, diaphragm, mouth and nasal cavities.

'[…] the air in the lungs, that provides the energy which then, the vocal chords are the parts that vibrate and produce actual, actual vibrations in the air: sound longitudinal waves […] and then it's amplified- actually a lot, the whole system acts like an amplifier I believe, but the throat and mouth […] and even the sinus cavities act as an amplifier, your whole head does really[…]'

(C, 31)

'You could say that embedded in the acoustic features of the speech are all the physical dimensions of a large part of our heads, nasal cavity, tongue, throat, everything all the way down to the top of your chest'

(B, 58)

'And that's why when you listen to a speaker like Bob Dylan or Kurt Cobain for example, they have a very distinctive tone because instead of speaking from the diaphragm, they don't use the diaphragm as much, so it, the tone starts to come through their nose [···]'

(D, 16)

One participant spoke about the phenomenon whereby the physicality of a speaker's body matches the auditory image of their voice, agreeing with the researcher's reiterated understanding of the voice to be not unlike a 3-D projection of the physical source that is enabling such a sound to be produced. They subsequently commented:

'The voice is three dimensional in that sense.'

(B, 66)

The data illustrates that the participants strongly believe the whole body to work together as a 'system', manipulating the acoustic energy provided by the breath, to produce a unique acoustic pattern individual to each speaker. All participants indicated that, aside from communicating language, the voice carries other paralinguistic information about the speaker. The fact that mood, age and health are discernible through the voice was also mentioned to a greater or lesser degree by all participants. This point was furthered by three of the participants. They noted the phenomenon of listening to different speakers, all of whose speech carries an array of different spectral fluctuations, and the yet the hearer is still able to extract the linguistic code embedded in the complex sound. This is discussed in greater detail in the following section.

4.2.2. Invariants

The underlying consistency that allows us to understand a range of voices, regardless of the affective factors that might be present, was identified by one participant as a fundamental *'pattern'* (D, 72, 82, 124, 259) while two of the participants used the term *'invariant'* to describe this feature of speech.

*'[…] let's say you take one person speaking, they might be…normal, clear articulate voice or * they might be very silent or whispering, **they might be sleepy, they're not woken up yet, or drunk, or affected by any number of conditions but the language, the words are still coming through right?'*

*(*whispering voice, ** low voice)*

(B, 126)

*'Now if I say the word "orange" or with a different accent or different sound or loudly or quietly or with a high pitch, am, it's just the consistency that matters, I mean I recognise within that whether it's high pitched, low pitched, a very thick accent or a weak accent that the same consistency of "*orange", "*orange", "*orange", you know, it will all sound the same.'*

*(*different pitches and intonations)*

(D, 148)

'There is nothing we can say, well this is /p/ you know, <u>this</u> is the ideal /p/ you know? I mean it will differ every time, even within the same speaker it differs, you know, at different times they'll say it differently.'

(A, 241)

In their discussion of invariance, both participants A and B flagged it as a significant area of speech perception, '*the core of the actual scientific issue*' (B, 494) and one that has thus far remained opaque to linguists and indeed other researchers interested in a deeper understanding of perception. It was not an area of inquiry that was initially prompted by the researcher but nonetheless it emerged as a salient theme in the data.

'This is one of the major questions in speech perception: the problem of non-invariance.'

(A, 235)

'What is it our brains are decoding? Both mathematically and philosophically what you're looking for: the invariance.'

(B, 140)

4.2.3 Analysis

In relation to the correlations of sound and spoken language, this theme seems to indicate that the natural sounds carried by the speaking voice work together with the sound repository of a language to create a multi-dimensional sound source. These easily perceived features emerge and are influenced by a person's physical and emotional make up, highlighting the interconnectedness of pure acoustic information and the sound bank of the language in use. Viewing the speaker as a sound source manipulating acoustic energy is an important point when demonstrating the connection between spoken language and sound. This link therefore acts as the keystone of the bridge theory under construction in this study.

4.3 Theme Two: The Sound of Language

This theme reflects participants' responses to questions designed to draw on their understandings of the acoustic nature of spoken language. In response to the following questions: 'Based on your work, do you think certain features of spoken language could be classed primarily as acoustic features?' and 'In your opinion what makes spoken language distinct from everyday sounds found in the environment?' a detailed description of speech emerged as seen through a purely acoustic analysis. All participants acknowledged that as sound is the medium of spoken language there are naturally occurring acoustic features present at all times.

'Spoken language <u>is</u> a set of acoustic features. I mean if you compare it to, let's say sign language or written language.'

(B, 112)

'I mean spoken language is sound'

(D, 70)

When describing the experience of listening to a foreign language poetry recital as a listener with no underlying knowledge of the poet's language, one participant said the following:

'[…] I enjoyed the process and perhaps because I, I don't mind listening to language as pure sound.'

(C, 115)

This seems to indicate that when a language is stripped of its semantics, one experiences only the part that remains, the medium, as 'pure sound'. On the other hand, one could interpret this as being more indicative of the rhythmic nature of the poetry rather than the language itself.

4.3.1 Natural Acoustic Features of Speech

The following were mentioned by almost all of the participants as features of language that could be categorised as 'acoustic features': sound waves, vibrations, frequency, pitch, tone, amplitude, harmonics and formants, with one participant neatly consolidating all of these features with the simple remark that in language:

'[…] the actual things we hear are all acoustic things.'

(A, 35)

Three of the four participants hypothesised that the *combined acoustic complexity* is one of the prominent features of the voice that sets it apart and distinguishes it from other comparatively simpler environmental sounds.

'So I wouldn't say, in terms of acoustics, that there is anything unique about the human voice except it's where all these things come together in this one particular way.'

(C, 293)

Formants in particular were mentioned by these participants as being present in the sound of spoken language but are relatively absent from other naturally occurring sounds. The exceptions mentioned were certain musical instruments that successfully trick the ear. The 'sleight of ear' is accomplished because these

instruments tend to mimic a set of formants considered particularly 'human-sounding' such as the violin, the Theremin and the so-called *Vox Humana* stop of the classical organ. One of the three participants further intimated that what creates in the hearer the impression of a human voice is not the language *per se* but what they called the *'spectral flux' (B, 156)*. The participant ascribes the spectral flux to our inability to instantaneously change the shape of our articulators and speech organs and so the voice must instead follow the fluid path of one movement to the next in the speech process.

'So everything moves but it has a distance to travel all the time and this is really what is creating a flux, it's a trajectory, it's a gesture and we're picking up those trajectories when we think something is sounding like a human voice.'

(B, 216)

When asked if the spectral flux could be considered an outstanding affective factor in a prenatal baby's ability to distinguish human from environmental sounds, this participant responded:

'Probably, yes.'

(B, 478)

In contrast, one participant felt that nothing in particular separated the human voice from other environmental sounds and speculated instead that the mechanism used for processing sounds might be distinct for language as opposed to language sounding distinctive.

'I mean acoustic parameters are all the same so, you know, a sound wave is a sound wave! [···] what may be different is the way we process them.'

(A, 40)

4.3.2 Synthesising Speech Sounds

Three of the participants mentioned speech synthesis systems as a way of illustrating that voice recognition and synthesis is an area that has been trammelled by a lack of progress in the field of speech perception. They were of the opinion that although we seem to be able to describe, annotate and map speech sounds to a very high degree, when it comes to recreating them something is lost. The lack of success in this area would seem to suggest that researchers are overlooking certain aspects of human speech sounds or perhaps it indicates that some features are so connected to the source that they simply cannot be recreated without losing the natural sound.

'They don't do it terribly well.'

(A, 56)

'It actually hasn't improved in twenty years, much [···] it's become cheaper and more accessible but the quality has hardly improved [···] it has a pretty high failure rate.'

(C, 183)

'A computational auditory scene analysis, interesting as a modelling approach, but artificial hearing is not really on, you find odd papers claiming so but when you scrutinise them it's not working.'

(B, 504)

4.3.3 Analysis

In terms of shared properties of sound and spoken language, the data presents a view that language, leaving aside its semantic nature, is perceived first and foremost as sound. It follows from this that the receiver is naturally navigating through an array of acoustic features before any cognition stage can take place. The fact that everything we hear of language is communicated from a sound source via sound waves demonstrates that all the annotated properties found in sound waves can therefore be said to be present in spoken language; both speech and sound are fundamentally created and received in the same way. There may be properties of speech that are not present in sound but there are certainly no features of sound absent from speech. Although sound and language tend to be treated as different ontological domains, the data offers a clear interrelation with properties of both entities. This interrelation is fundamental to the bridge theory construct.

4.4 Theme Three: The Physics of Sound

All participants relied on a traditional sound wave description for the production, propagation and detection of spoken language. It was noted by all the participants that spoken language is carried by the voice and regardless of the melodic contrasts that differ from language to language, it is all generated by acoustic energy and could therefore be incorporated in this type of description.

'[···] all sound is essentially the compression and refraction of air molecules, so it's being compressed and expanded, compressed and expanded to create the harmonics and the frequencies and the amplitude that you see or hear. So, it's all the same thing, it's all the compression of air molecules in one form or another be it the wind howling or someone shouting. [···] there's no difference in the nature of it [···]'

(D, 111)

*Interviewer: 'The human voice produces, is produced and moves and hits the receiver in the same way that (*clap) a hand clap might?'*

(I, 238)

Participant: 'Yeah, in terms of the physics of it, it is identical.'

(C, 239)

4.4.1 Sound in the Air

'I mean essentially all sounds need a medium to travel through – there's no sound in space.'

(D, 109)

The researcher was interested in analysing the data to get a clear picture of how sound behaves in an air borne environment. The idea that emerged from participants' descriptions was one that showed how sound travels in waves through the acoustic channels that are provided in the atmosphere. In speech, these waves are created and shaped by the speech organs of a speaker and travel outward from their source longitudinally; that is to say, the waves do not travel up and down but rather out and away from the speaker. Physically speaking, what the speaker produces are waves of dense and less dense air which travel without changing in nature until they come into contact with a membrane.

'Say, for example, I gave a continuous "ohhhhhhhhhhhhhhh" sort of sound, it's a kind, it's a standing wave in your mouth.'

(D, 60)

'[…] it's pressure waves in the air so the air is either denser or more rarefied and that happens sequentially in waves that are longitudinal that come towards you […]'

(C, 239)

4.4.2 Sound in the Womb

The following sub-theme emerged primarily through a line of questioning designed to generate data dealing with sound in other media. It is apparent from the data that all participants determined that when sound is introduced into other media there are notable differences and changes in its qualities. Taking the example of a pregnant woman, participants described how they thought environmental sound might be distorted by the different media, such as the abdominal barrier and the amniotic fluid, which the sounds would necessarily permeate. Three participants discussed the effect on refraction and everyone mentioned the change in speed that occurs when sound enters a liquid environment. All participants described the abdominal barrier as acting as a sound 'filter' meaning there are certain speech sounds that will not carry across this type of medium, namely the higher frequencies of speech.

'The environment of the womb isn't such that it would allow those higher frequencies through.'

(A, 129)

'Basically it's a low pass filter.'

(B, 378)

One participant described how things might sound in the womb as opposed to in an air borne environment in the following way:

'You're hearing things very differently now because it's going through a different medium. It's the same sound but it's heard in a different way because, almost like it's further away because it's obviously dampened by the water but it also changes the nature of it […]'

(D, 210)

Interestingly, two participants spoke about the fact that even when high frequencies are attenuated by the filter banks the overall spectral flux, that is to say the discreet configurations, remains intact. Both used the example of still recognising a person's voice from behind a door or a wall, which also act as low pass filters.

'I think the frequencies would change but not necessarily the harmonics.'

(D, 210 cont.)

'Just because you're immersed in fluid etc. that means the higher formants are more dampened but the spectral flux between them is still the same, right?'

(B, 490)

When asked if the liquid medium of the amniotic fluid would affect the way the acoustic energy was transmitted and therefore perceived, one participant's response was the following:

'A lot of it would be translated into kinetic energy rather than simply sound energy which would be outside, so you'd feel it more.'

(D, 236)

One participant, when discussing frequencies, explained that higher frequencies do not have as much kinetic energy as lower ones. He elaborated this point by explaining that the energy carried by the lower frequency wave lengths are more likely to be 'in sync' with our body form and therefore the potential to resonate with our bodies is greater.

'I mean why do people go to a techno gig and stand next to the bass bins? You know, cause you want to feel the base blow your··· [···] you're feeling your whole body vibrate [···]'

(C, 476)

The topic of resonance was further discussed by two of the participants, with one explaining how you would identify the resonance frequency of an entity in the following way:

'[…] you expose a system, whatever the system is, to vibrations of different frequencies and you look at what frequencies get dampened in relation to others, and you could say amplified, but that's when it's resonating, so it's actually moving with the… the medium becomes the message […]'

(B, 418)

Another participant further hypothesised about the possibility of resonance being experienced by a fetus *in utero*, conjecturing that:

'[…] in the womb there could be those sorts of phenomena, so specific frequencies could actually come through a lot louder than others depending on their resonance properties […] I would have no idea if it's true or not […] I suppose it's possible.'

(C, 604)

The next area of note in connection to the theme of sound in the womb was the particular data that emerged in relation to the mother's voice. All participants referred to the mother's voice as being an influential sound stimulus for the fetus. Repeated reference to its consistency, volume and the way in which the sound of the voice is conducted throughout the whole body, all indicate that the mother's own voice is an important sound stimulus when considering the auditory environment of the womb.

'I would hazard a guess that the voice could be the single strongest auditory input that a fetus could have.'

(C, 770)

'It's a stimuli that never goes away during pregnancy.'

(B, 426)

4.4.3 Analysis

The data corroborates the fact that research into prenatal linguistic development and the sonic environment of the fetus relies on traditional explanations of psychophysics. This highlights the dependency of this area of language study on the descriptive methods employed in physics and acoustics. The data shows that in order to assess the linguistic environment of the womb the researcher must resort to using the physics of sound as, having no clear alternative, this is the only way one can proceed in the investigation. Interestingly, what this emphasises is the fact that spoken language, in many ways, behaves just like any other sound wave and therefore this method of inquiry is advantageous. The ability of the methods of physics, acoustics and psychoacoustics to aid in the investigation of linguistic environments shows that although the dovetail between sound and language broadens as one enters areas like semantics and pragmatics, there is an early point where the two are joined harmoniously. When assessing the viability of a bridge theory this juncture serves to strengthen the bridge.

4.5 Theme Four: Perception of Sound

Quite a lot of data was generated around the topic of perception and sound perception. This theme is of particular importance to the overall picture that the data served to illustrate. Two sub-themes emerged that the researcher felt compelled to discuss in light of the overall research topic: the development of the auditory system, and perceptual senses. All participants mentioned the auditory system as playing a major role in how we hear sound. The physiology of the auditory system was discussed in detail by all participants, highlighting the effect that sound vibrations have on the ear, inner ear and basilar membrane. Two participants discussed the impact of having a binaural system of hearing, and all

acknowledged the subsequent neural processing that takes place when the sound travels through the auditory cortex and enters the brain.

4.5.1 The Development of the Auditory System

When participants began discussing sound perceptions of prenatal babies in the interviews, interesting views emerged in relation the development of the child's auditory system. One participant, while discussing the possibility of the mother's voice being present throughout the pregnancy, pointed out that one should consider the stage of development of the auditory system: the point was made that although the mother's voice is undoubtedly present throughout the entire pregnancy, only a portion of that would overlap with the fetus possessing a mature auditory system.

'[…] you have to think about the maturity of the child's audiological system, you know, that it's not mature, you know, until the last, the last trimester… and so it doesn't have that long where it's able to listen to sounds.'

(A, 143)

A different view that traces the fetus' auditory development on more of a continuum was intimated by one of the participants. In their view, the idea of the auditory system developing in tandem with the sound stimuli from the mother's voice and external sound was a plausible one. According to this participant, this allows for a period of 'prenatal training' or 'tuning in' to certain aspects of speech to take place *as* our auditory cortex is formed:

'The existence of the mother's voice and the exposure is kind of, you could say, a constant stimuli, although it's not going on all the time, but it's there throughout the development of the auditory cortex etc.'

(B, 452)

One participant pointed out that even though our ears may not develop until later in the gestation period the fact that there is skin membrane prior to this means that a tactile element of perception is present prior to the ear formation.

*'I mean the skin is there all the time, and you get this sort of specialisation: *this is going to be ears, but the tactile aspects [···] they're probably pre, pre ear formation if you like.'*

*(*Gesturing to side of head)*

(B, 308)

4.5.2 Holistic Perception: Cross-talk between the Senses

The researcher found that all participants agreed that sound could be perceived in ways other than using the hearing organs, that is the ears. They all spoke to a large extent about feeling sound vibrations and the role the sense of touch plays in perceiving sound when the 'traditional' auditory system is not at our disposal. The point was illustrated by two participants with an example of a deaf person who naturally uses their other senses to perceive sound. One participant challenged a widely held belief that sensory deprived people are 'compensated' by their other senses, using the example of the often discussed 'heightened hearing' in blind people. They argued instead that we are all in possession of acute perceptual abilities but are not always conscious of it:

'I mean we perceive lots of thing and process them without realising.'

(C, 486)

'Its just they become more aware of what's there for all of us and we're unaware of it.'

(C, 498)

Two participants expanded on this point and conceptualised the body as one perceptual system:

'All our perception systems are, you know, work together.'

(B, 272)

'Everything is entwined with everything else and in the same way hearing is entwined with other senses as well, which is a further point: that how we see and how we touch influences how we hear and like there's cross modalities between senses.'

(C, 517)

They further intimated that perceiving sound is done not just with the ears but with the entire body.

'One thing I'm kind of thinking about and looking at for the past couple of years is the idea that we actually hear with our entire body.'

(B, 276)

'We hear probably with our whole body, I'd have to say.'

(C, 448)

Both participants challenged the reductionary approach to perception currently favoured by many researchers, in favour of a more integrated approach.

'So perhaps this more holistic approach to perception is a better one to look at [···]'

(B, 332)

'This breakdown between senses [···] people don't realise how arbitrary it is and how there's other ways of looking at it [···]'

(C, 513)

4.5.3 Analysis

The fact that each participant was able to conceptually bridge the gap between sound and spoken language with ease in their responses is noteworthy. The data shows that when speaking about prenatal language perception participants naturally began to speak of language in terms of acoustics. This supports the claim that entities of the two phenomena under examination can be viewed as systematically interrelated in terms of their tactile and aural perception by the receiver. This theme brings into focus the theorisation that by treating spoken

language as a sound event rather than a purely linguistic one we are thus offered the use of adjacent domains connected with sound, namely acoustic perception and in turn modularity. Taken as a structured assumption, which connects the properties of sound and language perception, this insight functions as an additional brace in the support of a bridge theory.

4.6 Conclusion

This chapter presents the findings of the study using a thematic analysis approach to the data. A number of key findings emerged from the data to validate the construction of a bridge theory. These are divided into the following themes: The Human Voice, The Sound of Language, The Physics of Sound and Perception of Sound. Each theme was then analysed in light of the central research question. The objective was to discuss the feasibility of constructing a bridge theory to underpin a Windows Approach to language acquisition using sound as a window onto language. The themes that emerged in this study are specific to this set of participants and research question and therefore cannot be assumed valid in all other contexts. However, the findings identified certain pertinent areas connecting acoustics and linguistics that can be seen as credible starting points for future research in this area. The conclusions the researcher drew from these findings will be discussed in Chapter Five where the findings will be examined against a backdrop of relevant literature.

5.1 Introduction

The findings presented in the previous chapter provide the reader with a descriptive account of the participants' observations on the acoustic nature of spoken language and prenatal language experience. These understandings were generously contributed by four participants whose professions and research areas were closely connected to the topic. The study shows that sound, as the medium of spoken language, is inextricably linked to speech in both its production and perception, therefore any inferences about language, made using sound as a Window, could be claim to be warranted and grounded both logically and scientifically. This is of special interest to the study of the prenatal stage of language acquisition as it the point in development where the gap between acoustics and linguistics is at its narrowest and therefore an ideal location for the bridge theory to stand. This chapter presents a contextualised overview of the findings of the research study in relation to the literature and a conclusion is presented in light of the study's objectives and hypothesis. It finishes with recommendations for future development, and further implications of using a Windows Approach to research early language acquisition.

5.2 Discussion of Theme One: The Human Voice

Participants indicated that the sound of the voice communicates more than just semantic signs. Their observations that the sound of each voice carries the physical blueprint of the speaker are frequently corroborated in the literature. Just as every person's vocal tract is individual, every person's formant structure is unique (Zsiga 2006). One idea that emerged from the data was that phonemes, like colours, exist on a continuum, an idea often noted in the more recent literature on the topic of speech perception. 'There is no definite borderline between acoustically similar sounds [···]' (Aitchison 1998: 202). 'Acoustically sounds and words blend into each other' (Fasold and Connor-Linton 2006: 4). This widely acknowledged 'slide

whistle' view of the acoustic continuum and individual nature of speakers would seem to point to the redundancy of studying the dynamic and varied sounds of a language using an 'idiosyncratic subset of sounds and sources' (Gaver 1993a: 3). It also highlights the improbability of finding the elusive invariant qualities in speech by using narrow psychoacoustic approaches, which seem preoccupied with the perception of phonemic contrasts (Rosen and Fourcin 1986). Gaver likened this type of approach to attempting to understand reading comprehension by only attending to people's perception of 'letter shape and spacing' (1993a: 3). The data indicates the presence of a vast 'soundscape' (Schafer 1993) in speech, which contains elements of both semantics and acoustics. By establishing this connection, a conceptual window emerges which would allow for further investigation into the role of sound in language acquisition.

5.3 Discussion of Theme Two: The Sound of Language

The 'Sound of Language' encompassed the participants' perceptions of the connection that exists between sound and spoken language. The participants' acknowledgement of the acoustic roots of speech compares well with many authors writing about sound, language and both (Ohala 2008; Forrester 2000; Ohala (J.J) 1997; Pinker 1995; Fry 1970 etc.). What emerged from the data is the idea that the speech stream is a complex sound which retains all the usual psychophysical features found in other sound phenomena which is what allows it to be plotted and measured using traditional methods (spectrogram, time-frequency graphs etc.). The lack of progressive success in voice synthesis was noted by the participants and served to highlight an interesting yet slightly vague corner in the study of psychoacoustics. The absence of 'naturalness' in synthesised speech (Lemmetty 1999) leads one to infer that the traditional analysis of speech may be overlooking a perceptually important feature of speech. It has echoes of the questions raised by Kuhl and her colleagues' 2003 experiment with newborns, which showed that recorded speech sounds do not provide the necessary opportunities for phonetic learning the way that a human speaker does. It raises a number of interesting questions, namely are researchers overlooking the importance of the spectral flux in language acquisition? Is there something in the

human voice that simply can't be captured using this segmented type of construction? The data lends itself to the observation that the acoustic properties of sound are shared by speech and this in turn would underpin a Windows Approach. This established connection may prove effective in addressing the questions raised by previous research into the fundamental role of natural speech in acquisition.

5.4 Discussion of Theme Three: The Physics of Sound

This theme highlights the participants' views that speech can be described using traditional sound wave description to show how the sound of speech behaves in the different environments it propagates. The field of language acquisition is filled with findings showing that prenatal infants attend salient patterns in the ambient language (Kisilevsky *et al* 2003; Mehler *et al* 1988; DeCasper and Spence 1986 etc.). The literature pertaining to speech perception before birth describes the intrauterine environment the infant inhabits as a 'sensorimotor world, untouched by semantics [⋯]' (Vivona 2012: 254). The data highlights the fact that at this point of development, spoken language is experienced as sound and as sound is acoustic energy it is therefore bound by the natural laws of motion; it behaves differently when it reaches the amniotic membrane. Physics can therefore be seen as a reliable tool in attempting to address the question of not only what it is the fetus hears (Querleu 1988) but also how it experiences the special sounds of language in the womb. Bridging the two phenomena in this manner would allow for an analysis of the behaviour of sound vibrations in denser mediums. The connection afforded by the bridge theory would offer researchers interested in the fetus' first sensory experience of language an interesting vantage point.

5.5 Discussion of Theme Four: Perception of Sound

Participants discussed their various different perspectives on the modular concept of sound perception. The point was made that the fetus' auditory system is not fully mature until the last trimester and it is not until this stage that the auditory system

can convey sound, a detail also noted by Boysson-Bardies (1999). A more holistic view of perception was intimated by other participants, chiming with some of the more recent literature in the area of perception. There is a body of literature that reveals a more interactive, relational approach to perception (Howes 2006) which assert that '[···] 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 [···]'(Calvert *et al* 2004: xi). Leaving behind the more traditional 'sense-by-sense' approach, where it is assumed that each sense has its 'proper sphere' (Howes 2006: 381), might open up new avenues of exploration in the field of early language acquisition by taking a less conventional approach to Forrester's (2000: 3.9) question, 'where does our sensitivity to sound begin and what form does it take?' The data show that an investigation into matters of prenatal perception allows for sound and spoken language to be taken as a singular phenomenon. This fusion of sound and speech in terms of its perception further strengthens the bridge theory presented here.

5.6 Conclusions

One of the primary aims of this study was to clear a path for further research in the area of early language acquisition using sound as a window onto spoken language. In order to make way for such a Windows Approach a bridge theory was necessary to link the conceptual window with the phenomena in question. The findings of this qualitative study complement those in the existing literature and the initial hypothesis proposed in Chapter One was proven: the study revealed the existence of a perceptible natural relationship between the properties of sound and spoken language. The participants' contributions indicated a decidedly strong nexus between sound and speech in terms of its production, propagation and perception, a view which resonates with the literature. These links provide a solid foundation on which a bridge theory can be constructed. The bridge theory in turn, merits the consideration of sound as a viable window phenomenon in a Windows Approach to language acquisition. The available evidence is not consistent with the view that language and sound are parallel entities, as one might infer from the distinct fields

devoted to their study, but rather that the medium and the message are fundamentally linked. It therefore follows that any inferences made about spoken language using sound as a lens could be claim to be valid in a scientific context.

The findings further suggest that the complex acoustic patterns of change present in speech may serve as information distinguishing the physical parameters responsible for prenatal perception of spoken language. 'These are the acoustic invariants that an ecological acoustics should be concerned with discovering' (Gaver 1993a:18). Finally and perhaps most importantly, a Windows Approach to language acquisition may offer a way of understanding the relations among existing findings which show the prenatal infant to be 'sensitive from the beginning' (Gibson 1963: 14) and suggests new avenues of ecological acoustic exploration. 'Connect, always connect' (Goethe cited in Koestler 1964: 230).

5.7 Contribution to Knowledge

Understanding how language is perceived by prenatal infants is an important and fundamental step in furthering the field of linguistics, acquisition and language pedagogy. The development of a framework to allow a deeper and more exacting knowledge to emerge is the key to unlocking this rich and enigmatic theoretical domain, which has fascinated linguists and curious minds since the beginning of the word. This framework could potentially take the shape of a Windows Approach model.

5.8 Recommendations

One of the main accomplishments of this study is the development of a basis for further research in this area by suggesting possible avenues of exploration and rousing the curiosity of other researchers. Researchers interested in language acquisition and multi-disciplinary methodologies may wish to adopt the Windows Approach in their study of this phenomenon. In doing so more empirical work will be needed to establish this as a *bona fide* model which can serve not only the question of language evolution but one whose merits can also be appreciated by the field of language acquisition. The next logical step would be the design of a broader study using the proposed window of sound to begin making the all-important inferential steps that will offer non-arbitrary, empirical and accurate conclusions about the nature of language acquisition.

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FACULTY OF ARTS, HUMANITIES AND SOCIAL SCIENCES
RESEARCH ETHICS COMMITTEE
INFORMATION SHEET

The research
Ethics Clearance number, 2013_07_03_AHSS

My name is Úna Clancy. I am studying for an MA in English Language Teaching at the University of Limerick. As part of my MA requirements, I am writing a dissertation. The topic of my dissertation is 'Bridging the gap between Sound and Spoken Language'.

For my research, I would like to carry out interviews with people who are involved in areas of work that are connected to both sound and language.
The aim of the study is to investigate the link between the two phenomena: sound and language. The purpose of doing so is to explore the viability of using research from one field to "see" features of another - namely acoustic information to illuminate the development of language *in utero*.

What will you have to do?

I will organise a convenient time to meet with you to interview you. You will simply need to be available for no more than thirty minutes at a time and location convenient to you and respond to questions in a way that is fitting for you. There will be approximately ten questions connected to the research topic. There will be no personal questions asked. There are no wrong answers.

There will be some questions that relate directly to your professional experience/research given your line of work and likewise there may be some questions that fall outside of your field. This is to be expected due to the design of the interview and is not something to worry about; should you feel that you do not have the expertise to answer any of the questions there will be an opportunity to say so beforehand and if you would like to respond instead from a personal perspective this is perfectly OK.

What are the benefits for you?

The benefit is that this research aims to provide a view of linguistic research by drawing on other existing research in different disciplines. It is an opportunity for cross-pollination between fields and it aims to show the benefits of sharing knowledge. It is an opportunity for your expertise to be used in the attempt to illuminate an area of research into the early stages of spoken language

development. I would be happy to give you your own copy of the dissertation on its completion.

What are the risks to you?

I can anticipate no risks in your participation.

Who is taking part?

There are four other adult participants with a range of different backgrounds as the nature of the project is multi-disciplinary.

Do you have the right to anonymity and confidentiality?

Yes. All participants have the right to anonymity and confidentiality, in other words your name and personal details will not be used in the project. Any information given in the course of interview may be used in the study, but your privacy will be respected in all other matters. All information taken from the interview will be kept securely for 7 years and the dissertation will not be published outside of the University of Limerick

Do you have the right to withdraw from the research?

Yes. You have the right to decline from answering questions and withdraw from the research at any time you wish. You also have the right to contact the UL Research Ethics Governance (ULREG) committee if you have any concerns about participating in the research.

Who can you contact if you have any concerns?

You can contact:

Me: Úna Clancy
Email:12113069@studentmail.ul.ie
Phone:

My supervisor: Dr.Tadhg Ó hIfearnáin
Email:tadhg.ohifearnain@ul.ie
Phone:

Chair Faculty of Arts, Humanities and Social Science Research Ethics Committee,
c/o Faculty Office,
University of Limerick,
Email: FAHSSEthics@ul.ie

Bridging the gap between Sound and Spoken Language

Ethics clearance number, 2013_07_03_AHSS

Please read the following questions and indicate whether they fall inside/outside your field of work/research by circling the appropriate choice.

Area One: Phonological/ Acoustic features of language

Questions:

1. Can you briefly describe the physical process of using the voice to speak? *Inside/ Outside*

2. Based on your work, do you think certain features of spoken language could be classed primarily as acoustic features? If so, could you mention which aspects? *Inside/ Outside*

3. In your view, what makes spoken language distinct from everyday sounds found in the environment? *Inside/ Outside*

Prompts: (the interviewer may ask you the following questions if necessary)

- For example, can you think of any similarities in the way in which everyday sounds and spoken language travel to the receiver?
- Is there anything unique about the acoustic properties of the human voice which is not found in other natural sound phenomena?

Area Two: Human Perception of sound

Questions:

1. Based on your work, can you briefly describe how we (adult human beings) hear sound? *Inside/ Outside*
2. Based on your work, what do you understand about the way we can perceive sound apart from using our hearing organs? *Inside/ Outside*

Prompts: (the interviewer may ask you the following questions if necessary)

- For example, can we experience sound in any other way than hearing it? Through vibrations, heat, force etc. How do deaf people experience sound?

Area Three: Acoustic environment of the womb.

Question:

1. What sort of sound environment does the womb offer as a medium for sound to travel? *Inside/Outside*

Prompts: (the interviewer may ask you the following questions if necessary)

- What parts of sound reach the fetus through the abdominal barrier?
- Would the womb be considered a good sound chamber?
- Would the fact that there is amniotic fluid in the womb affect the way sound travels through to the fetus?
- What other internal sounds might the fetus be exposed to?
- Can any other parts of the mother's body conduct sound e.g. bones?

Area Four: Prenatal Perception of sound (recognition of human voice)

Questions:

1. Based on your work in the area, can you describe how prenatal babies could distinguish the sound of a human voice from other everyday sounds? *Inside/Outside*

2. If not, could you give a description according to what you think based on your experience (either personal or professional)?

Thank you!

FACULTY OF ARTS, HUMANITIES AND SOCIAL SCIENCES
RESEARCH ETHICS COMMITTEE
CONSENT FORM

Consent Section:

I, the undersigned, declare that I am willing to take part in research for the project entitled:

'Bridging the gap between Sound and Spoken Language'

Ethics Clearance number, 2013_07_03_AHSS

- I declare that I have been fully briefed on the nature of this study and my role in it and have been given the opportunity to ask questions before agreeing to participate.
- The nature of my participation has been explained to me and I have full knowledge of how the information collected will be used.
- I am also aware that my participation in this study may be recorded (video/audio) and I agree to this. However, should I feel uncomfortable at any time I can request that the recording equipment be switched off. I am entitled to copies of all recordings made and am fully informed as to what will happen to these recordings once the study is completed.
- I fully understand that there is no obligation on me to participate in this study.
- I fully understand that I am free to withdraw my participation at any time without having to explain or give a reason.
- I am also entitled to full confidentiality in terms of my participation and personal details.

_____ _____

Signature of participant Date

Extract from one-to-one semi-structured interview: Participant A

Transcript lines 1-38 of 282

1. I: Lovely, what you see there ah at the top of your page is am… "please read the following questions and indicate whether they fall inside or outside your field of work or research by circling the appropriate choice."
2. A: Uhum
3. I: So as we read each question, what I've been doing is I've been reading them aloud, and then giving am the participant a moment to think about whether its "inside" or "outside",]
4. A: Uhum
5. I: whether they're capable of answering the question or not]
6. A Uhum
7. I: and then you can circle the choice, if you wish to say something about it or if you'd prefer not to that's fine too.
8. A: Uhum
9. I: am… Ok so when we're ready I'm ready.
10. A: O.K. (laugh)
11. I: O.K. lovely (laugh) O.K. we'll start with the first question there which is…ah can you briefly describe the physical process of using the voice to speak?
12. A: Uhum, so that's "inside" yeah.
13. I: O.K. lovely, good start!
14. A: O.K. so the, ah, there are different aspects of producing speech so you start with your respiration because you need to begin an airflow in order to am make the am vocal chords vibrate
15. I: Lovely
16. A: The vibration of the vocal chords make the sound waves, so you am, the, the, the vibrations, everyone's vocal chords will vibrate at slightly different frequencies, but the, the am, the actual acoustic signal is then modified by

the resonant cavities that you use so, that's partly fixed you know depending on ,on your stature and so on

17. I: Yeah
18. A: the length of your vocal tract overall
19. I: The size of your mouth I'd imagine…
20. A: But also what you do with your articulators within certain parameters you can change the size of your vocal tract, you can lower your larynx for example that will make your voice deeper you can am modify the length and also the shape of the vocal tract and what, which resonant cavities you use so for example you can close off all the nasal cavities
21. I: [uhhum
22. A: [and just use the oral cavities and so the um size of the vocal tract then will affect which frequencies get am amplified and which frequencies are not amplified.
23. I: O.K.
24. A: And so kind of drop out of the signal that is actually sent.
25. I: O.K. so in terms of everybody having a standard way of doing it but there can be amm variation in terms of from person to person depending on the size, let's say, of ah comparing a child's way of producing sound and an adult's. you have smaller ah apparatus [I suppose
26. A: [Yes, yeah, and a man is usually bigger than the woman as well
27. I: Yeah yeah
28. A: so men generally have lower voices than women because their total vocal tract length is greater.
29. I: O.K., O.K. fantastic, thank you. Am, moving on to the next question, and feel free to ask me if you want any clarification about some of the terms that are used.
30. A: Uhum
31. I: The next question is: based on your work, do you think certain features of spoken language could be classed primarily as acoustic features?
32. A: Uhum
33. I: And if so, which aspects?
34. A: Well the ones which are conveyed by, again this would be "inside", so it would be the ones which are conveyed by the actual sound waves

themselves. So the sound waves can have characteristics of: frequency, of intensity of amplitude so you know the actual things we hear are all acoustic things.

35. I: Yeah. O.K. lovely. Am, so in terms of …you know… It's clear that spoken language is … you know the medium that it travels through is sound so, you know, in that sense there's so many acoustic ah sides to spoken language apart from the meanings which is [you know almost comes a bit later on
36. A: [Yeah, yeah, yeah
37. I: What then in your opinion would, Im just looking at question three here, what makes spoken language then distinct from everyday sounds found in the environment?
38. A: Am, (Pause) I'm, I don't know that anything makes it different. I mean acoustic, acoustic parameters are all the same so, you know so a sound wave is a sound wave!

Table One Profile of Participants					
Name	**Age**	**Gender**	**Profession**	**Qualifications**	**Research Interests**
A	45-60	Female	Speech & Language Therapist, Lecturer and Researcher	B.A. (Hons) Social Anthropology & Linguistics, MSc. Speech & Language Therapy.	Developmental speech and language disorders.
B	45-60	Male	Lecturer and Researcher	Degree in Electronic Engineering and Telecommunications, M.Sc. by research.	Acoustics and Ecological Psychology.
C	45-60	Male	Sound Artist and Researcher	Diploma in Audio Recording Technology (OIART), Degree in Theoretical Physics, MA in Music Technology.	Sound and Acoustic Ecology.
D	30-45	Male	Lecturer and Researcher	BSc in Applied Physics, PhD by research.	Science Education (Physics).

Table Two Themes & Sub-themes	
Theme	**Sub-theme**
4.2 The Human Voice	*Paralinguistic cues*
	Invariants
4.3 The Sound of Language	*Natural Acoustic Features of Speech*
	Synthesising Speech Sounds
4.4 The Physics of Sound	*Sound in the Air*
	Sound in the Womb
4.5 Perception of Sound	*The Development of the Auditory System*
	Holistic Perception: cross-talk between the senses