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**Re-tuning the mind's ear: An anonymous history of acoustic
prosthetic technologies for the ear**

A thesis presented in partial fulfilment of the requirements for the degree of
Doctor of Philosophy in Communication at Massey University, Palmerston North,
New Zealand.

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Dedication

This thesis is dedicated to my beloved father, Brian Herlihy (1926 – 2011), and my dear friend and teacher, Dr Scott Thomas Eastham (1949 – 2013).

Two extraordinary men who made this endeavour possible.

With love and light.

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Abstract

Over the last century the use of wearable personal acoustic technologies for the ear in a variety of different guises has become commonplace in daily life. These devices, such as hearing aids and headphones, have the propensity to reshape auditory experience and in turn, the perception of acoustic space by enabling personalised and immersive encounters with sound that alter the user's understanding of, and relationship to, their surrounding environment.

The aim of this study is to explore how acoustic prosthetic devices modify how sound is experienced, and how ensuing changes in auditory acuity affect the user's perception of acoustic space. To achieve these aims this study compiled an anonymous history of acoustic space through the lens of various acoustic prosthetic technologies for the ear. It presents an historical analysis of the development and application of these personal devices in key areas of innovation and application, in particular hearing aids, the stethoscope, and headphones. In this thesis, a hybrid methodological approach is offered to expand Siegfried Giedion's contribution to anonymous history by integrating analysis of a post-phenomenology of embodiment. This methodology illustrates the ways in which the technological evolution of these devices across history significantly influenced the user's experience of mediated sound and, in turn, acoustic space.

This research provides further insight into, first, the ways in which hearing aids, devices used to ameliorate a deficit in hearing, historically contributed to a reshaping of the user's perception of acoustic space. Second, this thesis examines how the development and application of the stethoscope marked the beginning of a movement towards the increasing privatisation of mediated listening experiences. Finally, the influence towards private mediated experiences of sound that began to build momentum in the late nineteenth century is explored to foreground the increasingly widespread use of prosthetic technologies for the ear, in particular headphones, also examined in this thesis.

In so doing, this study draws attention to new complexities in the experience of auditory encounters facilitated by acoustic prosthetics. The thesis further reveals the paradoxical nature of these devices as their form and function has continued to evolve over time. Additionally, through the integration of digital technology, this study also explores how acoustic prosthetic wearers are able to facilitate, and control, new hybridised and customised experiences of sound and acoustic space. It is argued that the new and increasing ability to experience what is not possible through the unmediated ear raises new challenges to the ways in which acoustic space has previously been considered. Heterogeneous experiences of acoustic space made possible through rapidly advancing developments in prosthetic technologies for the ear require greater consideration, in particular the potential effect(s) that these experiences of acoustic space have upon the re-tuning of the mind's ear.

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CHAPTER ONE

Scope of the research

1.1 Introduction

In the mid-twentieth century Swiss aristocrat Madam Elisabeth de Meuron became renowned for her use of an ear trumpet as her sense of hearing began to deteriorate. When asked why she carried the trumpet, she is said to have responded, “so that I hear only what I want to hear!” (Dubler, 2007, p. 1). This striking statement sharply underscores the dual affordances of de Meuron’s signature prosthetic device and of devices like it. Yes, the ear trumpet would have both metaphorically and literally extended her ear and compromised sense of hearing by retrieving, to some degree, the ability to hear the sounds around her. Yet, as de Meuron reminds us, it enabled her to direct her auditory attention towards or away from a particular source of sound, thus effectively enabling her to shape her auditory environment.

Acoustic prosthetic technologies for the ear are personal auditory devices worn in, around, or on the ear that mediate the user’s experience of sound and acoustic space. These devices include, but are not limited to, hearing aids, headsets, headphones, and specialised auditory tools such as the stethoscope. As sound mediates the relationship between the individual and the world around them, listening acts as the “primary interface between the individual and the environment”, operating as a “path of information exchange” (Truax, 2001, p. 16).

Drawing on this insight, this thesis advances a simple argument about acoustic prosthetic technologies. Assessing the evolution of these devices from antiquity across the Western world, it contends that these ubiquitous prosthetic technologies significantly altered the user's perception of acoustic space by mediating sound in various ways, ultimately providing the individual with a different way of being in the world. As I will show, acoustic prosthetics have modified the user's perception of their environment(s), and, in the process, altered the nature of the relationship between the user and the world around them, thereby in effect "re-tuning" the mind's ear.

The use of instruments to transform the experience of sound and augment the sense of hearing can be traced back to ancient times, even though in a fragmented way because of the lack of historical material and the influence of the experiential perspective of these devices. Perhaps the earliest example of prosthetics for the ear are hearing aids, which have been in use since at least ancient times, when they were fashioned from naturally occurring materials such as wood and animal horns in order to amplify sound and provide a direct pathway for that sound to reach the ear (Bennion, 1994; Berger, 1970; Weber, 2010). However, from the early nineteenth century other acoustic prosthetics were invented and used, including the stethoscope and headphones. This study focuses on these three different types of acoustic prosthetic technologies for the ear (hearing aids, the stethoscope and headphones) because they illustrate the pervasiveness of the influence of acoustic prosthetic devices across society. All

three have had widespread influence over the modification of auditory experience, as well as providing a synopsis of human experience in responding to auditory deficiency. First, the hearing aid was developed to ameliorate situations of impaired hearing, thus giving rise to what is enduringly portrayed as a seemingly stigmatised disability, as over time this impairment was perceived as a physical and social deficit. Second, the stethoscope similarly evolved from the early nineteenth century to diagnose, improve or ease ill health through progressively improving diagnostic abilities for medicine to both identify and treat disease. Third, somewhat in contrast, headphones, although having a functional role as headsets, have primarily been designed to expedite privatised experiences of increasing immersion in entertainment and acoustic pleasure from the late nineteenth century. These devices have undergone considerable changes over a relatively short space of time (Andrisani, 2010). For example, over the last two decades alone, a plethora of acoustic prosthetics have emerged that offer new experiences of sound not possible through the naked, unmediated ear, especially in the case of hearing aids and headphones.

1.2 Existing literature

Despite the range of different auditory experiences made possible by acoustic prosthetics and their critical role historically, consideration of these devices' physiological influences has far exceeded consideration of their effects on their users' experience of acoustic space. Bregman (1990) observes that prior to

the mid-1960s very little attention was paid to perceptual or ecological questions regarding audition as there was a particular dearth of research that queries “how our auditory systems could build a picture of the world around us through their sensitivity to sound [and] asks how our environment tends to create and shape the sound around us” (p. 1). This neglect can be explained, at least in part, by the reality that, until recently, there was a strong bias towards studies concerned with the visual compared to the aural, indicative of a long-held dominance of the eye over the ear in academic discourse (Attali, 1985; McLuhan, 1962; Ong, 2002; Searle, 1983; Sterne, 2003). Bull and Back (2003) observe that “in the hierarchy of the senses, the epistemological status of hearing has come a poor second to that of vision” (p. 2), resulting in accounts of the other senses, including hearing, being “filtered through a visualist framework” (p. 2).

Since the 1970s, however, there has been a steady growth in research pertaining to the meaning and social role(s) of sound from a number of different yet interrelated disciplines in the humanities and social sciences which have contributed to the emergence of the field of sound studies (Bull & Back, 2003; Sterne, 2012). Sterne observes that over the last five decades researchers have “turned to sound and technology as a way of making sense of massive changes that had happened to culture over the previous decades” (p. 3). However, in spite of this growing body of literature pertaining to various facets of sound and listening, the main focus has been on voice (Barthes, 2012; Derrida, 2011; Finelli, 2012), sound symbolism (Hinton, Nichols and Ohala, 1994), urban soundscapes (Raimbault &

Dubois, 2005; Thibault, 2003), soundscapes in varying geographical locations (Andrisani, 2010; Feld, 2010) and how different cultures treat sound (Hall, 2003; Kielman, 2018; McEnaney, 2015). To date, there has been a dearth of research that considers, first, how acoustic prosthetic technologies modify the experience of sound for individual users, and second, how this in turn affects the user's perception of acoustic space. In other words, there is scant analysis of the way in which the mind's ear is re-tuned through changes in the perception of sound.

What makes this oversight noteworthy is that there are three significant bodies of literature that are both methodologically equipped and theoretically motivated to explore the differences in mediated experiences of sound and acoustic space. The first is research conducted within the field of media ecology, a broad area of scholarly inquiry concerned with media, their effects, and the study of media as environments. Since the mid-twentieth century a number of media ecologists have considered the various ways that media technologies extend the body and augment one or more of the senses, thus modifying the user's experience of, and interaction with, the world in some manner. Indeed, the current gap in research pertaining to acoustic prosthetics within the realm of media ecology is even more surprising when one considers that the concept of 'acoustic space' was formally established by the field's figureheads, Edmund Carpenter and Marshall McLuhan (1960), who coined the term in the 1950s as a means of contrasting and comparing the differences between the visual and acoustic worlds. For Carpenter and McLuhan, visual space, which was dominant in Western culture's mapping

and understanding of the world prior to the early nineteenth century, is continuous and homogenous, whereas acoustic space is a world that is constantly in a state of flux, defined by simultaneity, movement and heterogeneity (Carpenter & McLuhan, 1960). This explanation offered by Carpenter and McLuhan stresses the enormity of the shift from visual to acoustic space that took place with the advent of Gutenberg's printing press in the fifteenth century. However, while there is a body of scholarship that delves into their explanation of visual and acoustic spaces in relation to the written word and temporality (for example, Cavell, 2002; Findlay-White & Logan, 2016; Gow, 2001; Levinson, 1999; Ouzounian, 2007; Schafer, 1994), to date, their notion of acoustic space has not been directly applied to the exploration of the wider phenomenological effects of acoustic prosthetic technologies for the ear.

The second of these bodies of work, the burgeoning field of sound studies, has thus far also paid little attention to the relationship between acoustic prosthetics for the ear and acoustic space. Sound studies is an interdisciplinary field of inquiry concerned with all types of matters related to sound and the forces that shape what we listen to and how we listen (Sterne, 2012). Over the last four decades research conducted under the broad banner of the discipline has recognised that technological advances made in audio technology since the late nineteenth century have changed the ways in which sound is reproduced and experienced. For example, a key foundational text of sound studies is acoustic ecologist R. Murray Schafer's *Soundscape: Our sonic environment and the tuning of*

the world (1994), which introduces the idea of the soundscape as “a total appreciation of the sonic environment” (p. 2). Yet while Schafer’s work has been widely cited and developed in a number of studies pertaining to acoustic environments, very little attention has been paid to how influential acoustic prosthetics might be in altering the experience of sound and, in turn, have an effect on the relationship between the wearer and their surrounding environment. Jonathan Sterne (2003), also a prominent voice in the field of sound studies, considers various sound reproduction technologies of the late eighteenth and early nineteenth centuries such as the gramophone and the telephone. Sterne’s primary point of concern is the social and cultural worlds from which these devices emerged and “how those technologies crystallised and combined larger social currents” (p. 2). In contrast, this thesis focuses on the historical phenomenology of acoustic space as experienced by individual users of acoustic prosthetic technologies for the ear.

It is also important to acknowledge the third body of research that deals with acoustic prosthetics, namely undertaken within the fields of medicine and audiology. These disciplines are theoretically and methodologically equipped to examine the potential for various acoustic prosthetics for the ear to alter how sound is reproduced and heard from a physiological stance. Yet because the scientific bio-medical model underpinning these disciplines traditionally assumes a mind-body separation (Descartes, 1983), the focus of these two approaches is exclusively on the physical impact(s) of these devices and thus on

the body rather than the mind. Studies from these perspectives, in other words, primarily focus on the physical to examine how acoustic prosthetic technologies, first, increase sound energy, and second, how headphones contribute to hearing loss. For example, there is a specific concern with how the prolonged use of these devices, or exposure to loud sounds, can damage the inner ear mechanism (Catalano & Levin, 1985; Dalton, Cruickshanks, Klein, Klein, Wiley & Nondahl, 2003; Daniel, 2007; Henderson, Testa & Hartnick, 2011; Lee, Senders, Gantz & Otto, 1985; Rabinowitz, 2000; Schaette & McAlpine, 2011; Smoorenburg, 1992; Sommer, 2017). Overlooking the potential of these devices to affect the user's perception of acoustic space, these studies treat sound as a form of energy.

Those who did move beyond the bio-medical model to consider broader cultural shifts included Carpenter and McLuhan (1960), who in the 1950s and 60s prophesied that media forms would continue to unite cultures and societies in new forms of acoustic space. In turn, they hypothesised that this would bring about new ways of thinking about, and interacting with, the environment. Yet despite their contention, more emphasis has subsequently been given to shifts from orality to literacy, and the impact of the printed word and electric and digital media on human experience. Consequently, the ways that changes in the perception of acoustic space mediated through acoustic prosthetics have contributed to shifts in how soundscapes are experienced and understood has not been questioned. To date, the effects that such changes

have on the relationship between the individual and their immediate environment have largely been overlooked. In light of this resulting gap in the way personal auditory devices have changed, and continue to change, our perception of acoustic space, this is a timely subject of examination. The role played by these technologies in restructuring the experience of sound and acoustic space requires scholarly consideration and analysis. If such research is not undertaken, it is unlikely that there is a potential to develop an understanding of, or appreciate the influence that, different acoustic prosthetics have upon the perception of acoustic space and how this affects the wearer's relationship with their surrounding environment and experience of being in the world.

McLuhan (2003) stresses the urgency of analysing new media environments in order to anticipate and assess the extent of their effects and discover the changes that occur through the use of various technologies. Significant changes in the form and functionality of acoustic prosthetics have built momentum over the last century driven by the technological advances of the current digital age, with each new generation of prosthetic devices “re-tuning” the mind's ear. It is the desire to understand these changes that drives this research.

1.3 Research questions

The aim of this study is to explore the different ways in which acoustic prosthetic devices have historically altered how the user experienced sound. In turn, this study also examines how this shift changed the ways in which those same users perceived acoustic space. In contrast to the earlier work in the field, this thesis addresses the different ways in which acoustic prosthetics historically changed how acoustic space was perceived by individuals, and the impact this had upon the relationship between the user and their surrounding environment.

Accordingly, the questions that inform this study are:

- (1) “What effect(s) have acoustic prosthetic technologies for the ear had upon the user’s perception of acoustic space?”

Question One addresses the way in which acoustic space is experienced from the phenomenological perspective of the ‘body situated in the world’.

- (2) “How have these devices influenced a shift in the mediated perception of acoustic space over time?”

Question Two considers how advances in auditory technology have increasingly altered the ways in which acoustic space is experienced, while drawing attention to the ways in which we listen and perceive sound have deeply historical characteristics.

- (3) “How have changes in the experience of acoustic space altered the relationship between the individual and their environment(s)?”

The final question examines the potential for technologically-enabled experiences of private and interiorised acoustic space to contribute to a displacement of the mind’s ear within the exterior soundscape. Whereas hearing aids were used to ameliorate a deficit in hearing through opening up the exterior soundscape, the stethoscope and headphones facilitated the user’s perception of a privatised and interiorised acoustic space. Thus, the use of prosthetic auditory devices had potential to fracture the relationship between the user and their surrounding environment.

This thesis explores acoustic prosthetic technologies from an historical standpoint as “the ways in which we listen to, or concentrate on anything, have a deeply historical character” (Crary, 2001, p. 1). By taking an historical approach, this research considers how various acoustic prosthetic devices led individuals to define their perception of, and attention to, acoustic space, and how this in turn has contributed to both a re-engagement and also a disengagement from attention to broader exterior acoustic environments. Therefore, the questions posed by this thesis will be answered through a phenomenological historical examination of various acoustic prosthetic

technologies for the ear, predominantly from the early nineteenth century to the present.

1.4 Research aims

This thesis aims to address the gap in available research pertaining to acoustic prosthetic technologies for the ear and acoustic space in the fields of media ecology and sound studies. The study seeks to reveal the nuances of differing mediated experiences of acoustic space across different periods. To do so, it traces the historical development and use of these devices from antiquity to the present, focusing on three key groups of acoustic prosthetics identified as being key sites of innovation and influence: hearing aids, the stethoscope and headphones.

By presenting an historical phenomenology of these personal auditory devices, this research aims to map and examine key moments in the evolution of acoustic prosthetics for the ear, and discuss how these devices contributed to shifts in the way that acoustic space was perceived by the user, and the ways in which this altered their experience of, and relationship to, the world around them. In doing so, this study identifies and discusses the subtle, and in some cases pronounced, differences in the experience of acoustic space offered through various auditory devices. Furthermore, it also considers how these different experiences of auditory environments compare to McLuhan and Carpenter's (1960) concept of acoustic space, which until now appears to have largely gone

unchallenged. Ultimately, this research offers a fresh perspective into how acoustic space is understood and can be approached in future scholarly discourse. Finally, the hybridised interdisciplinary methodological strategy applied in this thesis also makes a contribution to the field of media ecology by presenting a practical approach to research into how media artefacts affect human perception and the way that the sensory world is experienced.

1.5 Methodologies and method used

This research employs a novel, hybridised methodological strategy. This approach applies a methodology informed by media ecology which combines first, media archaeology (specifically Sigfried Giedion's (1948) approach to anonymous history), and second, a post-phenomenology of sound drawn from Don Ihde's (2007) theory of embodiment relations grounded in the work of Merleau-Ponty (2013). By applying this approach, this study is methodologically equipped, first, to trace the historical evolution of acoustic prosthetic technologies for the ear in key areas of innovation, and second, provide insight into how these devices mediated sound and altered the perception of acoustic space from a historical phenomenological viewpoint. Combining these two methodologies enables this study to illustrate the effects these devices had on the perception of sound and acoustic space for the user. Media ecology, which is first and foremost concerned with the study of the effects of media and the environments created by human-made technologies, informs the approach taken in this thesis as it is concerned

with the effects of acoustic prosthetics for the ear upon users' experience of auditory environments. Furthermore, the concept of acoustic space was established within this field, and this thesis draws on the original definition of acoustic space presented by media ecologists Carpenter and McLuhan (1960).

As a variant of media archaeology, anonymous history operates as a means of tracing modes of day-to-day life as affected by technology. Giedion (2013) explains that anonymous history “inquire[s] in the first line into the tools that have moulded our present-day living. We would know how this mode of life came about, and something of the process of its growth” (p. 2). In *Mechanization takes command: A contribution to anonymous history* (1948; 2013) Giedion presents a history of the Industrial Revolution through the lens of the technologies that contributed to process of mechanisation. In so doing, he offers an alternative approach to the writing of histories of technology and their effects upon humankind. He asserts that inanimate objects have their own stories to tell in terms of how they helped to shape modern life, while revealing the complex relationships between humans and their technologies.

After discovering a deficit in historical documentation pertaining to the devices he wished to examine, Giedion (1948; 2013) turns his attention towards an examination of the physicality of the devices themselves. He approaches technological artefacts that were used in daily life as things to be studied to reveal some of the extent of their influence to build his historical narrative. For example, he identified and used patents, pamphlets, advertisements and information

sourced directly from manufacturers to examine technological effects. He argued that a simple coffee spoon, a seemingly insignificant instrument that was an outgrowth of the world, had the propensity to alter daily life. Giedion's method for the writing of a history of technology provides a means of exploring the development and use of everyday items that are frequently taken for granted. Furthermore, this approach is suitable for the aims of this study due to a deficit of records and accounts pertaining to the development, use and lived experience of a number of acoustic prosthetics prior to the mid twentieth century.

However, while Giedion's anonymous history provides an approach to the examination of technological artefacts, it does not enable us to explore the integral role of acoustic prosthetics in changing a user's perceptions of acoustic space. To make up for this deficit, this study combines anonymous history with an approach grounded in the phenomenology of sound and informed by Maurice Merleau-Ponty (2013) and Don Ihde's (2007) theory of embodiment relations. Merleau-Ponty coined the concept of the embodiment relation of the body situated in the world, illustrating how the use of objects such as a feathered hat and walking stick have the propensity to extend the user's body into the world. However, it was Ihde who developed the notion further, explaining embodiment relations as a type of existential relationship when technological devices such as eyeglasses and musical instruments potentially operate as an extension of the body to become factored into the bodily experience of the world. Ihde's emphasis is on building post-phenomenological theory and using devices to illustrate related concepts is based

on various aspects of sound, as he argues for the centrality of sound in human perception. Yet although Ihde included his experience of hearing aids, his viewpoint on the embodiment of acoustic prosthetic devices through his own experience of hearing aids is presentist and ahistorical, drawing predominantly from his own personal experience. Consequently, he does not consider questions related to the broader phenomenological effect(s) on the user's perception of acoustic space, and the historical development and application of these instruments. Therefore, some of the questions that drive this thesis attempt to augment brief discussions of acoustic prosthetic devices for the ear that have come before.

The integration of this hybridised methodological strategy facilitates this research to add to the current body of knowledge by illustrating the influence of acoustic prosthetic technologies for the ear, not only in the mediation of sound, but also in the subsequent effect on the perception of the world around us. This methodological approach provides a means through which to explore, first, the various ways that acoustic prosthetics altered the experience of acoustic space; second, how the mediated perception of acoustic space shifted over time; and finally, how changes in the ways that acoustic space was perceived altered the relationship between the user of the prosthetic and their surrounding environment(s). Furthermore, the interdisciplinary method employed in this thesis also makes a potential contribution by offering a practical approach for

future historical studies considering the influence of media where historical documentation is limited.

1.6 Chapter summaries

Chapter Two presents a review of existing literature on auditory space and acoustic prosthetic technologies for the ear. Tracing the origins of the concept of acoustic space, it provides an overview of how acoustic space has been understood and applied in extant scholarship. The chapter then proceeds to examine existing literature concerning acoustic prosthetics for the ear, in particular hearing aids, the stethoscope and headphones. This review of literature discusses current gaps in research pertaining to the experience of the phenomena of acoustic space, and the relationship between acoustic prosthetic devices and acoustic environments in the fields of media ecology, sound studies and phenomenology.

Chapter Three discusses the method and methodological approach applied in this thesis. This research not only makes a contribution to the field of media ecology by presenting a study of the effects of acoustic prosthetic devices upon the perception of acoustic space, but also develops and applies an interdisciplinary framework through which to explore these effects. The chapter provides an overview of media ecology, anonymous history as a branch of media archaeology, and phenomenology, specifically Ihde's theory of embodiment relations. This is followed by a discussion of how these approaches have been incorporated into an approach that enables this thesis to meet its aims to present an anonymous history

of acoustic space through the phenomenological lens of acoustic prosthetic technologies for the ear.

Chapter Four traces key historical moments in the development and use of hearing aids from the rudimentary instruments of antiquity to programmable digital aids of the present. This chapter contends that over time the function of hearing aids has become paradoxical through the capacity of these devices to provide privatised and customised experiences of non-ambient sound as opposed to opening the ear to shared soundscapes. It will be argued that these devices, once used to extend the ear and the sense of hearing through the amplification of sound, have evolved to become auditory technologies that offer the user increasingly personalised and private experiences of sound and acoustic space. This chapter also explores the nature of the embodiment relation(s) that take place between the user and the device, and how this relationship plays a role in the shaping of the user's ensuing sense of emplacement in, or displacement from, their surrounding environment.

Chapter Five examines the development of the stethoscope in the early nineteenth century, a specialised medical tool developed specifically to aid physicians in the diagnosis of internal illness. It argues that the stethoscope not only transformed the way in which the physician perceived acoustic space, but also facilitated the ability to detect two separate, private interiorised acoustic spaces that could not be detected by the naked, unmediated ear. First, it contemplates how the monaural stethoscope altered the physician's perception of their

surrounding acoustic space, and their ability to perceive an internal acoustic space within the body of the patient. It then investigates the effects that the binaural stethoscope had upon the physician's perception of both interior and exterior acoustic spaces. Finally, it considers how the use of the stethoscope affected the physician's sense of space and how this contributed to feelings of displacement from their physical surroundings.

Chapter Six explores the historical phenomenological effects of headphones and how different types of headphones have changed how acoustic space is perceived. It traces the evolution of headphones used predominantly for entertainment and leisure purposes from their initial development in the late nineteenth century to the present. This chapter argues that across technologically enabled modernity, headphones generated newly privatised experiences of remote, isolated acoustic pleasure, leading to new discontinuities in the perception of acoustic space. It pays particular attention to how different types of headphones have altered how sound and acoustic space were perceived by the user. Attention is also paid to how digital headphones enable the experience of hybridised acoustic space through the merging of two formerly distinct and independent acoustic spaces.

Chapter Seven concludes with an overview of the key findings of the research while recognising the limitations of the approach. It discusses the relevance and value of the findings contributed by this study, the implications

which arise, and finally, makes recommendations for further research into acoustic prosthetic technologies for the ear.

CHAPTER TWO

Literature Review

2.1 Introduction

This chapter provides an overview of existing scholarly contributions to the study of acoustic space and acoustic prosthetic technologies for the ear, reviewing the ways in which sound and the concept of acoustic space have been examined in relation to various acoustic prosthetic devices. Finally, extant literature on the phenomenology of sound will be introduced.

Despite the ubiquitous nature of acoustic prosthetics for the ear, in particular hearing aids and headphones, to date little attention has been paid to the various ways that these devices changed the experience of sound and acoustic space for the user. While there is an existing body of literature that pertains to, first, acoustic space, and second, acoustic prosthetic technologies for the ear, the problem is that there is a paucity of research that examines the potential relationship between both bodies of work. Consequently, there is a scarcity of studies that examine how the use of various acoustic prosthetic technologies for the ear have altered the user's perception of acoustic space and their surrounding environment from an historical perspective. For example, Canadian artist, writer and acoustic designer Charles Stankievich (2007) observes that "a survey of literature on the topic reveals that little is written on the history and development of headphones compared to the length of their use" (p. 55). The reasons for this

oversight remain unclear, leaving it open to speculation. One possible reason, as suggested by Stankievich, is that these acoustic prosthetics are frequently neglected or disregarded by scholars on the grounds of being a “fashionable” technology, and therefore not worthy of serious consideration (personal communication, 4 June, 2012).

Similarly, there is a shortfall in scholarship regarding how hearing aids have affected the perception of sound and acoustic space across history from a phenomenological perspective. Again, the reasons for this neglect are not evident. However, a further potential contributing factor to this lack of research may be the historical dominance of the eye over the ear in academic discourse. Cultural and media theorists Marshall McLuhan and Edmund Carpenter (1953) argue that much of human thinking is constructed in terms of visual rather than auditory models, regardless of whether an auditory model may be more appropriate.

This chapter provides an overview of extant research that deals with the exploration of acoustic space and prosthetic technologies for the ear within the fields of media ecology, sound studies, and phenomenology. It examines existing bodies of literature pertaining to these three areas, and identifies the deficiencies in this research, thus solidifying the context and rationale for this study’s intervention while establishing its significance and validity. First, this chapter examines research on acoustic space, and discusses the founding of the concept by media ecologists Edmund Carpenter and Marshall McLuhan. It then considers research within the broad field of sound studies that outlines and applies the

notion of acoustic space in various contexts, and how this has contributed to how acoustic space is understood. Second, this chapter delves into the existing body of literature pertaining to various acoustic prosthetic technologies for the ear across different branches of sound studies, specifically extant research regarding auditory space and personal auditory devices. It pays particular attention to studies that contribute to how this thesis approaches and deals with the experience of acoustic space, specifically varying approaches to the consideration of acoustic devices taken by research within this body of work. Finally, this chapter investigates research on the phenomenology of sound, in particular scholarship that considers how sound is mediated, and how this alters the perception of acoustic phenomena.

2.2 Media ecology and the concept of acoustic space

The media technologies that we encounter in our day-to-day lives, whether it is a seemingly simple instrument such as a pen or a mobile phone, wield their own set of effects upon the user. In doing so, media “work us over completely” as they are “so pervasive in their personal, political, economic, aesthetic, psychological, moral, ethical, and social consequences that they leave no part of us untouched, unaffected, unaltered” (McLuhan & Fiore, 1996, p. 26), as the range of their effects can be diverse and far-reaching. Media ecology as a field of research, therefore, seeks to reveal and scrutinise these effects so that we may understand the implications of the use of our technologies. The term ‘media’ refers to any instrument or technology that alters an environment in some manner. The

environments that media ecologists are concerned with as not typically 'natural' environments per se, but rather the environments that are created and or/altered through the use of human-made technologies. Media ecologists, therefore, examine how media shape an environment, and how they change how we communicate, think, and perceive the world around us.

One of the pillars of the field of media ecology, media theorist and cultural critic Neil Postman, is widely recognised as having coined the term 'media ecology' in the 1960s. Postman describes media ecology as the study of environments impacted or created by various media forms. Offering a biological metaphor to underscore his definition, Postman (1992) explains,

A medium is a technology in which a culture grows; that is to say, it gives form to a culture's politics, social organisation, and habitual ways of thinking...We put the word 'media' in front of the word 'ecology' to suggest that we are not simply interested in media, but in the ways in which the interaction between media and human beings give a culture its character and, one might say, help a culture maintain its symbolic balance (p. 10).

It is possible to construe from Postman's explanation that media ecology is not simply the study of environments and how they are changed by media, but how media shift and influence the symbolic balance between humankind and their technologies, and how this affects their experience and understanding of, and relationship to, the world around them. As humans create and shape the tools

that they use, they are deeply affected and influenced by these technologies. In order to describe and illustrate a primary facet of media effects, in the 1950s media ecologists Edmund Carpenter and Marshall McLuhan coined the term 'acoustic space'. By developing this term they set out to articulate the differences between visual and aural spaces; spaces that were significantly affected through the development and use of various media technologies.

Much of the existing body of scholarly literature pertaining to acoustic space from a communication or ecological perspective has in some way been influenced and guided by Edmund Carpenter and Marshall McLuhan's explanation of the concept. Carpenter and McLuhan's study (1960) explores the shift from aural to visuality that took place with the development of the written word and the printing press in the first half of the fifteenth century. They contend that when the senses are engaged by a particular medium, the environment that results from that medium produces either a visual or acoustic space. In the same manner that visual space is characterised by an emphasis upon the eye, acoustic space is characterised by an emphasis upon the ear. Carpenter and McLuhan assert that oral cultures experienced space as being acoustic rather than visual, as their primary mode of communication was speech. They explain,

Until writing was invented, we lived in acoustic space, where the Eskimo now lives: boundless. Directionless, horizonless, the dark of the mind, the world of emotion, primordial intuition, terror. Speech is the social chart of this dark bog. Speech structures the abyss of

mental and acoustic space, shrouding the voice; it is a cosmic, invisible architecture of the human dark. Speak that I may see you. Writing turned the spotlight on the high, dim Sierras of speech; writing was the visualisation of acoustic space. It lit up the dark (1960, p. 17).

Before the development of the alphabet and the written word, McLuhan (1969) argues, humankind lived in what he later referred to as a “tribal echoland” (p. 7), where a majority of information exchange and communication occurred via sound in the form of speech or acoustic signals.

Carpenter and McLuhan’s intention in establishing the concept of acoustic space, according to Schulz (2004), was to “counter predominant scholarly assumptions about the hegemony of vision as the principal mode of perception in modernity” (p. 176). Their description of the characteristics of acoustic space laid important groundwork for how acoustic space was, and to an extent continues to be, understood. Carpenter and McLuhan (1960) explain,

Auditory space has no favoured point of focus. It is a sphere without fixed boundaries, space made by the thing itself, not space containing the thing. It is not pictorial space, boxed in, but dynamic, always in flux, creating its own dimensions moment by moment. It has no fixed boundaries; it is indifferent to background. The eye focuses, pinpoints, abstracts, locating each

object in physical space, against a background; the ear, however, favours sound from any direction. We hear equally well from right or left, front or back, above or below. If we lie down, it makes no difference, whereas in visual space the entire spectacle is altered. We can shut out the visual field by simply closing our eyes, but we are always triggered to respond to sound (p. 207).

Here, they describe acoustic space as spherical, a round three-dimensional space with undefined boundaries. This shape continues to be integral in the understanding of the form and characteristics of acoustic space, and will inform my own conceptualisation of the attributes of differing perceptions of acoustic space in Chapters Four, Five and Six. Canadian composer and acoustic ecologist R. Murray Schafer (2007), for example, in his own description of the nature of acoustic space, concurs that the sphere is the geometric figure that comes to mind when thinking of a sonic space (p. 85). This form, as McLuhan (1996) explains, is logical as sounds come to us simultaneously from every direction, therefore “the ear favours no particular point of view... It forms a seamless web around us” (p. 111). In much the same manner that a sphere surrounds an object that exists within its boundaries, the individual is enveloped by sound as they are effectively situated in the middle of this acoustic sphere. As sound travels to the listener from 360 degrees, they become the sonic equivalent of a visual vanishing point. The individual exists at the centre of their own acoustic space, with all sounds within

their 'sphere' travelling towards them, or more specifically, their ears. The ear, McLuhan elucidates, "favours no particular point of view...We say, 'Music shall fill the air'. We never say 'Music shall fill a particular segment of the air'. We hear sounds from everywhere, without ever having to focus" (p. 111). The eye can only see what lies ahead, however, the ear receives sound from every direction.

Additionally, while the body has eyelids with which to close the eyes and our visual space, physically "we simply are not equipped with ear lids" (McLuhan & Fiore, 1996, p. 111). Similarly, when describing the difference between these two forms of space, Schafer (1985) argues "auditory space is very different from visual space – we are always at the edge of visual space, looking into it with the eye. But we are always at the centre of auditory space, listening out with the ear" (p. 112). Therefore, the experience of acoustic space is constant, whether the listener is consciously aware of the nature and characteristics of their acoustic space(s) or not.

Shortly after McLuhan and Carpenter defined the concept, philosopher and cultural historian Walter Ong also alluded to the notion of acoustic space when discussing Western culture's shift from orality to literacy. Ong (2002) observes that the introduction of writing and publishing into a culture results in a dramatic shift from a group culture and mentality to one that focuses upon the individual. Words were considered to be things printed on the page as opposed to things that were spoken. Literacy, therefore, had significant cultural implications as it promoted the interiorisation of the individual as their attention was turned

towards the written word. Orality, on the other hand, promoted a sense of community and a group mentality through the act of listening as attention was turned outwards into the world. Ong explains,

Sight isolates, sound incorporates. Whereas sight situates the observer outside what he [sic] views, at a distance sound pours into the hearer...vision comes to a human being from one direction at a time...When I hear...I gather sound simultaneously from every direction at once. I am at the centre of my auditory world, which envelops me, establishing me at a kind of core of sensation and existence (p. 71).

Although Ong does not directly refer to acoustic space by name, the description of auditory experience that he offers above directly reflects McLuhan and Carpenter's (1960) concept and definition of acoustic space. It does so by reaffirming Carpenter and McLuhan's description of sound as coming to the individual from every direction simultaneously, while also outlining the key differences between visual and acoustic experience. Yet despite establishing the term, Carpenter and McLuhan's research on acoustic space was largely theoretical. They did not apply their concept in a practical manner to acoustic technologies, nor did they test their concept against different forms of technologically enabled acoustic environments.

Carpenter and McLuhan's (1960) explanation of the characteristics and behaviour of acoustic space, and Ong's (2002) observations of acoustic experience, remain relevant. This study applies Carpenter and McLuhan's definition and visual representation of the spherical form of acoustic space. It does so because, first, it offers a framework through which to imagine how sound behaves in an open acoustic environment, and second, it provides a means by which to describe variances in the phenomenology of sound and acoustic space as mediated by different types of acoustic prosthetic technologies for the ear. Ong's explanation of acoustic experience is also important to this study as it sheds greater light upon the lived experience of sound and acoustic environments. Additionally, Ong's description of acoustic space brings forth the question of the interiorisation of the self. Although Ong contends that this was a direct result of the development of the written word, this process can also be applied to this study through the lens of acoustic prosthetic technologies for the ear, specifically through how these devices have also played an important role in the interiorisation of the perception of acoustic space.

This thesis applies these theories of acoustic space and experience to specific acoustic devices embedded in a particular history. Carpenter and McLuhan's (1960) model of acoustic space will be used to identify and discuss how different acoustic prosthetics mediate sound, and how they modify the user's lived experience of acoustic phenomena. This will illuminate how the mediated perception of sound and acoustic space engendered through acoustic prosthetic

technologies for the ear differed in some way from the concepts of acoustic space presented by McLuhan, Carpenter and Ong. By examining the use of various acoustic prosthetic technologies for the ear, namely hearing aids, the stethoscope and headphones, and exploring how their application altered the user's perception of sound and acoustic space, this study will illustrate that across history mediated perceptions of acoustic space did not always present that space as spherical in nature.

2.3 Acoustic space, sound studies and acoustic prosthetics for the ear

Acoustic space is a migratory concept that has been applied in several areas of scholarship other than media ecology. The other field that one might expect to see involved in research on acoustic space and the acoustic effects of prosthetic technologies for the ear is a broad area of scholarly inquiry that has become known as sound studies. This field of research focuses on matters concerning the experience of sound. Jonathan Sterne, a prominent voice within this area, explains that sound studies is

A name for the ferment in the human sciences that takes sound as its analytical point of departure or arrival. By analysing both sonic practices and discourses and institutions that describe them, it re-describes what sound does in the human world, and what humans do in the sonic world (2012, p. 2).

Sound studies includes research related to a number of different disciplines, for example, media studies, science, natural history, communication, cultural studies, philosophy, literature, sociology, musicology, sound design, psychology, anthropology, urban studies, architectural design, history and linguistics, to name a few. Bull and Back (2003) observe that “just as sound is no respecter of space, so sound studies transgress academic divisions” (p. 3). Therefore, scholarship conducted under the umbrella of sound studies include a wide range of interdisciplinary studies, for example, modes of listening (Berland, 1988; Choin, 2012; Kassabian, 2013; Tuuri & Eeola, 2012), music and composition (Garcia, 2015; Pinch & Bijsterveld, 2004; Dorr, 2018), sound reproduction technologies (Bull, 2000; Bull, 2007; Kittler, 2012; Sterne, 2003; Wittkower, 2008), noise (Attali, 1985; Nyerges, 2016), and sonic landscapes (Back 2012; Feld, 2010; Leppert, 1995; Schafer, 1994; Truax, 2001).

2.3.1 Acoustic ecology and acoustic space

One such early interdisciplinary branch of sound studies is the field of acoustic ecology, an area primarily concerned with the examination of sonic landscapes, and the relationship between humans and their acoustic environments, or soundscapes. Acoustic ecologist R. Murray Schafer, along with the World Soundscape Project (WSP), was integral in establishing acoustic ecology as a field of scholarship during the 1970s. Schafer (1994) explains that his soundscape research is “situated in the middle ground between science, society

and the arts” (p. 4), as he focuses on the types of sounds that are created, and exist within, different acoustic settings. Schafer pays particular attention to the ways in which these distinctive acoustic environments were changing as a result of noise pollution brought about by urbanisation and human progress.

Moreover, it appears that Schafer (1994) was the first to undertake a practical approach to the study of a form of acoustic space using Carpenter and McLuhan’s definition of the concept. He largely credits himself with drawing widespread attention to the notion of acoustic space, arguing that “despite McLuhan and Carpenter’s infatuation with the concept, acoustic space did not attract critical attention until the World Soundscape Project was established at Simon Fraser University in 1970” (p. 30). Following the fundamental observations regarding orality and literacy put forward by McLuhan and Carpenter (1960) and Ong (1982), Schafer begins his text by reiterating the dominance of the eye and the visual over the ear and listening in modern Western cultures. In so doing, he draws further attention to the importance of the world of sound, an area that at the time had had been largely overlooked, especially in terms of how acoustic environments are altered through the introduction of, and increase in, noise from humans, their tools, and the steady spread of urbanisation. Schafer explains that his research focuses on the types of sounds that created, and exist within, different acoustic environments, and how the characteristics of these soundscapes were changing during the 1970s as a result of noise pollution. He argues that his work sought to identify environmental and sociological effects of urbanisation and

sound pollution upon the natural acoustic environments with a view to developing solutions to create and maintain ecologically balanced soundscapes that harmonise the relationship between humans and their sonic environments. He set out to increase awareness of the degradation of acoustic environments, and endeavoured to achieve this by providing education about different acoustic environments, noise pollution, and the preservation of sound environments and dying sounds through the recording and comparison of various soundscapes.

Furthermore, Schafer (1994) also broadens Carpenter and McLuhan's conceptualisation of acoustic space, describing it as being "an expression of the profile of sound over the landscape" (p. 3). From this definition emerged the concept of the 'soundscape', a term that has since been frequently used interchangeably with acoustic space. Schafer explains that the concept could be used to refer to "any acoustic field of study we may speak of. We may speak of a musical composition as a soundscape, or a radio program as a soundscape or an acoustic environment as a soundscape" (2007, p. 96). While the definition of a soundscape has its origins in McLuhan and Carpenter's concept of acoustic space, Schafer expands this definition as a means to more holistically understand "the relationship between [humans] and the sounds of [their] environment and what happens when those sounds change" (p. 3). Therefore, his focus is specifically on changes in the unmediated experience of exterior, natural acoustic environments. Schafer became synonymous with the term 'soundscape', because his research into changing acoustic environments was groundbreaking in that it opened the doors

for “whole new fields of discovery [as] his work left open the advancement of new language to describe acoustic occurrences as yet unexplained in our limited sonic vocabularies” (Krause, 2008, p. 73). For example, Schafer’s study formally identified and named key elements of soundscapes such as foreground, background and keynote sounds. This thesis draws from Schafer’s work, specifically the key elements of soundscapes that he classifies and discusses in his study, in order to explain and discuss shifts in the perception of sound and acoustic space facilitated by various acoustic prosthetic technologies for the ear from a phenomenological perspective.

Yet while further developing the concept of acoustic space and undertaking a practical approach to the study of acoustic environments, Schafer’s (1994) research focuses on the external soundscapes and how they are perceived naturally through the naked, unmediated ear. For example, Schafer examines the role of bird song as a defining sound of ‘nature’, and examines how the sounds of birds can dominate soundscapes in different locations, such as grassland in North America, by measuring the tonal qualities of different types of birds. Consequently, he does not consider how acoustic prosthetic technologies for the ear mediate sound, or how the use of these devices alter the perception of sound and acoustic space.

Furthering Schafer’s research, acoustic ecologist and former member of the WSP Barry Truax (2001) presents an interdisciplinary approach to the study of sound. Truax’s study makes a further contribution to how acoustic environments

are understood by drawing attention towards the interdependent relationship between the listener, sound, and their environment(s). A key point of difference from Schafer's research is that Truax also considers "the implications of electro-acoustic communication on the listening process, the community, and the possibilities for sound design" (p. xvii). In addition, Truax expands Schafer's definition of the soundscape to "encompass how individuals and society as a whole understand the acoustic environment through listening" (p. xvii).

In addition, Truax (2001) also argues that looking back to the writings of acousticians during the 19th century, specifically their sound experiments and observations about how far various sounds travelled, reveals "how far the modern scientific approach has led us away from everyday perception" (p. 3). Underscoring the fact that scientific approaches to sound often lack detail, and can therefore tend towards ambiguity, Truax reaffirms the importance of acknowledging the subtleties and complexities of how sound is perceived, and "how sound, in all of its forms and functions, defines the relationship of the individual, the community, and ultimately, a culture, to the environment and those within it" (p. 4).

Some elements of Truax's (2001) framework have been valuable to this thesis. For example, he asserts that his research provides a new approach to the study of sound, explaining that he applies the term 'acoustic communication' as it is the "most general way to describe all of the phenomena involving sound from a *human* perspective. After all, a scientist may study vibratory motion, but the individual experiences its effects as a form of communication" (p. xvii; emphasis in

original). To examine the dynamics of this relationship between humans and their acoustic environments from this perspective, Truax develops and applies an acoustic communication model to illustrate how sound operates as a form of communication, as opposed to the study of sound as a scientific event. At the centre of this model is the act of listening, as the communicational approach “does not deal with sounds in isolation from the cognitive processes that understand it” (p. 11). This basic model is intended to reveal the relationship between sound, the listener, and their acoustic environment(s). Furthermore, Truax stresses the importance of acknowledging the subtleties and complexities of how sound is perceived, and “how sound, in all of its forms and functions, defines the relationship of the individual, the community, and ultimately, a culture, to the environment and those within it” (p. 4). Truax’s model of acoustic communication has been valuable in Chapters Four, Five and Six, in which it serves to illustrate the interdependent relationship between the user of the acoustic prosthetic device, the sounds that they were able to perceive when using the device, and their surrounding environment from a ‘human’, or ‘lived’ perspective.

Also valuable for the analysis undertaken in this thesis is Truax’s acknowledgement of implications of noise and electro-acoustic technologies upon how the listener experiences the unique characteristics of their surrounding acoustic space(s). Acoustic space, he explains, is “constantly in flux, created moment by moment and variable to each listener” (2001, p. 1). He considers how the individual understands their environment through listening, and

acknowledges that these auditory encounters can be very different, as any two people do not experience acoustic space in exactly the same way. Truax employs his communication model to explore the implications of electro-acoustic communication upon acoustic environments, listening processes and social patterns of communication, for example, through the lens of radio. This exploratory process is valuable and helped shaped the approach to differing experiences of acoustic space through various electro-acoustic prosthetic technologies for the ear. This was important in order to underscore how the user's perception of sound and acoustic space could vary between prosthetic devices for the ear.

Yet despite considering several technologies, Truax (2001) only very briefly acknowledges the potential effects of acoustic prosthetic technologies for the ear on the experience of sound and how this affects the relationship between the listener and their immediate surroundings. He observes that binaural headphones provide the user with the ability to perceive some spatial information in the sounds they are listening to, and how the use of headphones alters the user's perception of hearing their own voice. Truax also briefly mentions that the use of headphones can cause a "schizophonic split" (p. 135) between electro-acoustic and natural acoustic environments. However, he fails to acknowledge how acoustic prosthetic technologies for the ear mediate sound, or their potential to alter the wearer's perception of sound and acoustic space. This thesis, on the other hand, while drawing from Truax's findings about the nature of the relationship between

the individual and their sonic environment, is concerned with presenting a historical phenomenology of acoustic space as experienced through different acoustic prosthetic devices. This contrasts with electro-acoustic technologies such as the telephone and radio, and the potential use of these technologies in the design of exterior soundscapes.

2.3.2 Sound localisation and a sense of acoustic space

In addition to research conducted within the field of acoustic ecology, such as the aforementioned studies conducted by Schafer (1994; 2007) and Truax (2001), there is a body of work that examines various facets of sound localisation. Sound localisation refers to our ability to detect the location and direction of sounds. It also considers how sound provides the listener with a sense of space, and “the processes and practices by which sound actually makes space, shaping and transforming experiences of spatiality [and] its capacities to affect and enable certain forms of embodied experience” (Reveill, 2016, p. 240). Therefore, the study of sound localisation also makes a contribution to extant research pertaining to acoustic space, as the experienced origin and directionality of individual sounds play a key role in the listener’s perception, and understanding of acoustic space and their sonic environment. Such studies include the examination of the acuity of sound localisation according to the source(s) of sound (Beglund & Sitte, 2005; Butler, Humanski & Musicant, 1990; Derey, Rauschecker & Formisano, 2017; Evans, 1998; Oldfield & Parker, 1984); the ability of hearing impaired individuals to detect

the localisation of sounds (Beggs & Foreman, 1980; Colletti, Fiorino, Carner & Rizzi, 1988; Freigang, Richter & RübSamen, 2015; Jaffe, Tirosh, Orion & Shanhone, 1986; Moore, 2014; Newton, 1983); assisting hearing impaired individuals to detect the directionality of sound (Gorman, 2014; Thiran & Clarke, 2003); the potential to perceive the direction of sounds through bone conduction (Asp & Reinfeldt, 2018) and the ability to detect the origin of sounds underwater (Cambi, Livi & Livi, 2017).

However, in spite of the interdisciplinary approach of such research, this body of literature is predominantly grounded in the fields of audition, psychology or science. Consequently, these studies approach sound as a form of energy as opposed to the perception of sound, and therefore focus upon factors such as pitch, timbre, volume, and signal to noise ratio. Although such studies offer some further insight into the intricacies of sound and how sound travels, they are not concerned with how the perception of sound is potentially altered through the use of prosthetic technologies for the ear or the historical phenomenology of acoustic space. While on occasion drawing from these studies to explain the fundamental elements of sound, and how sound is experienced as being directional, this study extends an examination of the mediated experience of sound and acoustic space from a phenomenological perspective. It does this in order to illuminate how the perception of acoustic space, and therefore user's experience of, and relationship to, their surrounding environment has been modified through the use of different acoustic prosthetic technologies across history.

There are some exceptions to this rule within the study of sound localisation, notably research conducted by neuroscientist and philosopher Casey O'Callaghan (2010), and acousticians Barry Blesser and Linda-Ruth Salter (2007). First, O'Callaghan's work in philosophy and psychology examines the phenomenology of sound localisation. He argues that hearing is fundamentally a locational mode of perception "with a robustly spatial phenomenology" (p. 123). O'Callaghan sets out to debunk phenomenologist Peter Strawson's (1959) claim that sound does not convey spatial information about the surrounding environment. He contends that acoustic phenomena "furnishes one with information about the location of things and happenings in one's environment" (p. 127) as spatial content is fundamental to auditory experience.

O'Callaghan's study provides valuable insight into the fundamental characteristics of the phenomenology of sound localisation that is applied in this study to inform how the perception of the directionality of sound functions. Furthermore, in a similar fashion to Truax (2001), O'Callaghan also briefly mentions how the use of headphones can affect the wearer's ability to determine the location of different sounds, commenting that "earphone listening differs from ordinary hearing in where sounds seem to come from because it differs in where sounds are heard to be" (p. 128). Yet his acknowledgement of one of the effects of headphones on the experience of sound is fleeting and is not developed beyond mere mention of the possibilities of headphones in reshaping the experience of the directionality of sound. O'Callaghan presents a strong argument that hearing is

inherently a locational mode of perception, and offers a discussion of how humans detect the directionality of sounds from the surrounding environment. However, this is the extent of his acknowledgement of how acoustic prosthetics influence the experience of sound and acoustic spatiality.

Second, Blesser and Salter (2007) also extend Schafer's (1994) research by providing further insight into how soundscapes are understood. They define a soundscape as being "a complex system that provides the means by which people connect to dynamic activities: it is the life of a space experienced by listening" (p. 1). They explore how sound can build a sense of space for the listener, and explain that "when listening to a soundscape, we are building an internal sense of a space. The soundscape embeds the listener in those activities that have an audible manifestation" (p. 1). Blesser and Salter also consider auditory spatial awareness, sound localisation, and how different architectural structures can affect the way that the spatiality of sound is experienced. They contend that in order to fully understand and appreciate the meaning of a soundscape it is essential to examine the interactions that occur between sound, place, culture, cognition and evolution. In a similar manner to O'Callaghan (2010), Blesser and Salter argue that sound provides the listener with locational information, and that a sense of self is dependant upon its sensory relationship to the world around them, as "sensory deprivation disconnects our internal reference frame from the physical and social environment" (p. 2). Yet despite offering important information pertaining to sound and a sense of space, Blesser and Salter do not take various acoustic

prosthetic technologies for the ear such as hearing aids or headphones into account, nor do they approach the topic of the spatiality of sound from a phenomenological perspective. Consequently, O’Callaghan’s and Blesser and Salter’s observations about the locational qualities of sound do not discuss in adequate depth how acoustic prosthetics affect and modify the user’s ability to detect the directionality of sound. Although this study refers to O’Callaghan’s and Blesser and Salter’s research, specifically how sound can instil the listener with a sense of space, this thesis is concerned with how different acoustic prosthetic technologies for the ear have historically altered how acoustic space is perceived by the user, and how this alters their relationship with their immediate physical environment.

Ethnomusicologist Vincent Andrisani (2010) also presents relevant work that examines soundscapes, specifically the displacement of sound through the use of electro-acoustic reproduction. The research focuses upon the ways in which auditory experiences that include the reproduction of electro-acoustic sound alter how time and place is conceived and understood by the listener. He argues that “the transportability of sound across time and space creates simulated soundscapes, which ultimately contributes to a shift in the identity of the unique acoustic characteristics of a community” (p. 1). Andrisani pays particular attention to the various attributes of the electrified soundscape, specifically the production of electro-acoustic sound and music making within the context of cross-cultural approaches to sound making and listening. He makes several interesting and

relevant observations regarding how various electro-acoustic technologies have affected the listener's familiarity with their surrounding soundscapes and how sound becomes integrated into socio-cultural environments in different locations, such as Cuba. Yet, Andrisani also fails to acknowledge how acoustic prosthetic technologies for the ear mediate sound, or how these devices alter the user's experience of their surrounding soundscape. This thesis, however, while drawing from some of Andrisani's general observations about the characteristics of electrified sound and soundscapes, is concerned with the phenomenological experience of interiorised acoustic space as mediated by acoustic prosthetics for the ear, rather than examining the exteriorised cultural changes brought about through electric sound reproduction technologies.

Acoustician and naturalist Michael Stocker (2013) also explores the issue of sound localisation, specifically how this contributes to the relationship between sound, ecology and the building of a sense of place for both humans and animals. His research stresses the integral role of hearing in the establishment of a sense of both space and place, and explains how it is formed through the information received through auditory cues from the surrounding acoustic environment. Stocker underscores the important role of the sense of hearing as a survival tool, as the ability to hear enables the listener to gauge the characteristics of their surroundings and their place within it. He explains that sound "allows us to perceive our environment in dimensions obscured from our vision, out of reach of our touch, and downwind from our sense of smell" (p. xviii). Furthermore, Stocker

examines the mechanics of what constitutes and creates sound and the way in which the human ear operates. He offers some relevant information and discussion regarding the importance of sound and hearing in how acoustic environments are perceived and understood, and how they contribute to a sense of space and place.

While discussing the significance of auditory awareness Stocker (2013) also briefly mentions the use of headphones from a physiological perspective. Specifically, he discusses how headphones can contribute to hearing loss, and can also prevent the listener from being able to hear auditory cues warning them of impending danger. Unfortunately, this physiological perspective is the full extent of Stocker's foray into the effects of acoustic prosthetic technologies for the ear upon the perception of sound and acoustic space. He does not consider, first, how the mediation of sound through acoustic prosthetic technologies for the ear shapes our sense of acoustic space, or second, the historical phenomenology of sound, a deficit which this study will address.

Although these studies conducted by O'Callaghan (2010), Blesser and Salter (2007), Andrisani (2010) and Stocker (2013) do supply important frameworks for thinking about the effects of sound and a sense of place, a widespread lack of reflection about the potential of acoustic prosthetic technologies to affect each of these factors is evident. This thesis addresses this oversight by examining the historical phenomenological effects of various acoustic prosthetic technologies for the ear on the experience of sound and perception of acoustic space. In doing so,

it underscores the implications of the mediation of sound through these devices and how they have affected not only the perception of sound and acoustic space, as well as the relationship between the user and their surrounding environment.

2.4 Existing literature on acoustic prosthetic technologies for the ear

Most of the studies examined in this chapter thus far have not considered the effects of acoustic prosthetic technologies for the ear, but rather more generic questions relating to acoustic space. This section provides an overview of extant literature that examines acoustic prosthetic technologies for the ear and auditory devices. This includes research undertaken within the fields of history, audiology, cultural studies and urban studies. However, while these studies provide a glimpse into how the use of acoustic prosthetic technologies for the ear might modify the experience of sound, there remains a paucity of scholarly material that directly addresses this subject matter. This small body of literature provides some insight into the early history of one group of acoustic prosthetics for the ear examined in this thesis: hearing aids. While these studies do not directly consider the effects of these personal auditory devices upon the historical phenomenology of sound or the perception of acoustic space, it is worth outlining them here.

Audiologist and hearing aid historian Kenneth Berger (1970) notes that prior to compiling his history, hearing aids had been dealt with only in a superfluous manner as the wider effects of the devices had not been given due attention or consideration. Incidentally, this observation adds further weight to

Bregman's (1990) earlier observation that there was a scarcity of research pertaining to audition prior to the 1960s. Berger's text, *The hearing aid: Its operation and development* (1970) traces the history of these acoustic devices from antiquity to the second half of the twentieth century. The text includes available images and information pertaining to hearing aids and their production. Berger also offers some speculation about how naturally occurring items may have been fashioned into aids for hearing prior to historical documentation. Nearly fifty years after it was first published, Berger's text remains one of the most comprehensive histories of hearing aids produced prior to the mid twentieth century. On the other hand, the text does not discuss models of hearing aids produced after the early 1960s, meaning that there are significant gaps related to electric and digital models in his text. Furthermore, while Berger does provide some indication of the levels of amplification that could be achieved through the application of the aids that appear in the text, he does not consider their phenomenological effects upon the mediation and experience of sound or acoustic space. This creates a deficit of information beyond physiological influence pertaining to hearing aids developed since the mid twentieth century in available research, in particular research that provides insight into the ways in which these devices mediated and altered the experience of sound for the user.

Historian Elisabeth Bennion's *Antique hearing devices* (1994) also traces the history of acoustic and early models of electric hearing aids up until the early twentieth century. She examines methods employed to extend the ear, and

therefore the sense of hearing, by six different types of hearing aids. These aids include hearing tubes, trumpets, concealed receptors, bone conduction instruments, early models of electric hearing aids, as well as instruments used to “increase the size and capacity of the natural [ear] mechanism” (p. 9). Bennion explores creative and clever attempts to find naturally occurring, or design, aids that provided some level of amplification for individuals suffering from hearing impairment. Berger’s (1970) and Bennion’s respective histories provide valuable insight into the early models of hearing aids, which this study draws from in the absence of relevant historical documentation. However, both texts are limited in scope as they deal only with aids produced prior to the mid-twentieth century. Furthermore, neither author considers the effect of these devices upon the perception of acoustic space, or approach hearing aids from a phenomenological perspective. Consequently, there is little insight into how these acoustic prosthetic technologies for the ear contributed to shifts in the way that acoustic space was experienced, and how this in turn affected the way in which the hearing aid user perceived and interacted with the world around them.

Audiologist Robert E. Sandlin’s *Handbook of hearing aid amplification* (1995) also provides a brief discussion of the historical development of hearing aids. Sandlin’s research is grounded in the field of audiology, and therefore presents a greater technical discussion of the levels of amplification possible through hearing aids than those offered by Berger (1970) and Bennion (1994). Thus, Sandlin provides some indication of whether or not various types of hearing aids were

effective in assisting the hearing impaired to distinguish sounds with greater acuity. This is of importance to this study as the historical documentation central to the methodology of this thesis regarding the ability of various aids to amplify sound, especially prior to the mid-twentieth century, is difficult to find. Sandlin's text was primarily written for audiologists and hearing health care professionals to assist in the fitting and customisation of hearing aids for differing degrees of hearing impairment. Yet this information also provides some insight, albeit limited, into how various hearing aids may have affected the user's ability to perceive sound, which in turn had a strong bearing upon their ensuing perception of acoustic space.

Additionally, the periods in the history of hearing aid development that Sandlin (1995) discusses are more extensive than those covered by Bennion (1994) and Berger (1970), as he also considers the electrification and digitisation of hearing aids technology in the late twentieth century. However, as Sandlin's research is essentially a study in audiology, there is no consideration or discussion of the historical phenomenology of sound. Examining the physical evolution of hearing aids, Mara Mills (2011) presents a very brief history of the miniaturisation of electronic components, and how this contributed to a reduction in the size of hearing aids. Changes in the shape and form of these devices meant that hearing aids could be worn and used in a discreet manner that did not draw attention to the user. However, while offering some insight into advances in electric hearing aid technology, Mills does not examine the phenomenological effects of these

prosthetics for the ear, or how they affected the user's experience of acoustic space. Consequently, despite providing some worthy information regarding how hearing aids instrumentally operate, none of these texts consider how hearing aids affect the user's perception of acoustic space or the relationship between the wearer and their surrounding environment. This thesis addresses this gap in the literature by presenting a history of hearing aids from antiquity to the present from a phenomenological perspective in order to identify their influence upon users' acoustic experience. Furthermore, this study also explores acoustic prosthetics technologies for the ear beyond hearing aids, specifically the stethoscope and headphones.

There is also a modest body of work conducted within the broad field of sound studies that provides a glimpse into individual experience of acoustic space when using acoustic prosthetic technologies for the ear from a historical perspective. For example, in *The audible past: Cultural origins of sound reproduction* (2003), technology and culture scholar Jonathan Sterne presents an historical account of the development of sound reproduction technologies from the early nineteenth to the early twentieth century, "where sound, hearing and listening are foundational to modern modes of knowledge, culture and social organisation" (p. 2). In this text, he poses a fundamental question: "if sound reproduction technologies changed the way we hear, where did they come from" (p. 1)? Sterne applies this question to trace the cultural origins of various sound reproduction technologies, including the phonograph, the telephone, the

stethoscope, and the gramophone, and examines how these technologies contributed to the emergence of new practices of listening.

Sound reproduction technologies, according to Sterne (2003), “are artefacts of vast transformations in the fundamental nature of sound, the human ear, the faculty of hearing, and practices of hearing that occurred over the long nineteenth century” (p. 2). In his exploration of the development of the stethoscope in the early nineteenth century Sterne makes some observations relevant to this study regarding the interiorisation of acoustic space that became evident through the use of the binaural stethoscope. He also offers some insight into the early history of headsets, and suggests that the benefits of using headphones was first picked up by radio operators and radio listeners to allow them to hear signals more clearly without the intrusion of environmental noise.

Through these observations Sterne proffers some important insight into the phenomenon of in-head localisation that was realised through the application of binaural prosthetic technologies for the ear; observations which this thesis draws from. Yet Sterne’s research into the development of technologies used for the purpose of sound reproduction is first and foremost conducted under the umbrella of cultural studies, and is therefore primarily concerned with the cultural implications of sound reproduction technologies. The text includes discussions of class distinction, urbanisation, and the rise of modernity through the lens of these different devices. While Sterne does include some brief insight into how these devices may have initially contributed to changes in individual experience of

acoustic space, he does not consider the phenomenological effects of these devices in sufficient depth. His research is very much limited to the late nineteenth and early twentieth centuries, and does not acknowledge how different types of headphones could potentially affect the wearer's perception of sound and acoustic space, or how the privatisation of auditory experience and acoustic space shifted over time.

This thesis addresses this gap, presenting a historical phenomenology of acoustic space through the examination of a wide range of different makes and models of acoustic prosthetic technologies for the ear, to extend Sterne's (2003) work on the significance of the headset and stethoscope upon their initial release. This study examines the nuances of acoustic space as perceived through a number of different acoustic prosthetic technologies across history, and how they not only affected the user's auditory experience, but also their relationship with the surrounding environment. Finally, as this thesis will show, there have been immense advances in acoustic prosthetic technologies since the period in which Sterne's research is grounded, specifically relevant to influences arising from changes in the mediated experience of acoustic space. These changes are in need of attention in light of new experience of acoustic space afforded by ever changing and developing digital acoustic prosthetic devices.

More recently, sound artist Charles Stankievich (2007) also briefly considers the phenomenon of the interiorisation of sound made possible through the binaural stethoscope and headphones. Drawing directly from Sterne's (2003)

research, Stankievich observes that “throughout the twentieth century, the concept of interiority has been treated with suspicion in certain areas of the science and philosophy” (p. 2). He argues that this scepticism is due to a lack of clarity surrounding what constitutes the ‘inside’ and the ‘outside’ of human experience. However, despite posing this important question, Stankievich instead turns his attention towards presenting case studies of how three sound artists have attempted to illustrate different auditory dimensions in their respective exhibitions. His primary point of focus, therefore, is not upon the perception and experience of sound and acoustic spaces through headphones or other forms of acoustic prosthetics for the ear. Rather, he examines the ways in which sound artists can manipulate the use of sound within art installations. In posing this important question regarding the boundaries of interiority and exteriority, Stankievich effectively opens a valuable discussion regarding the phenomenology of auditory experience and acoustic space. This discussion will be extended further in this thesis by tracing the historical phenomenology of sound mediated through various acoustic prosthetic devices and the different ways in which they affected the user’s perception of acoustic space.

In addition to Stankievich’s study, there is an existing body of literature that deals directly with the effects of headphones. However, a majority of this research falls under the banner of audiology, a field of science concerned with the physiology of hearing. Much of the extant literature pertaining to the use of headphones focuses upon physical effects of these acoustic prosthetics, specifically

how the prolonged use of these devices contribute to hearing loss (Berg, Ibrahim & Sandler, 2016; Catalano & Levin, 1985; Daniel, 2007; Higashi, Tanaka & Nakatoh, 2016; Schaette & McAlpine, 2011). For example, an early study conducted by Catalano and Levin (1985) examines the physical effects of the prolonged use of headphones upon the hearing mechanism in the ear. In a similar vein, Schaette and McAlpine (2011) explore the prevalence of tinnitus as a direct result of listening to music through headphones at excessive volumes. Daniel (2007) also identifies and discusses the risk factors for adolescents who voluntarily expose themselves to loud music, with a particular emphasis upon the effects upon hearing caused by headphones used with portable music players.

More recent studies, such as that conducted by Higashi, Tanaka and Nakatoh (2016), analyse possible methods that could reduce the risk of hearing impairment in adolescents and children by limiting the maximum volume levels attainable on headphones. Their research also examines whether or not headphone users are aware of the potential physical side effects of headphones, specifically how the apparatus can contribute to hearing loss. Nonetheless, in spite of presenting detailed insight into the physical effects of the prolonged use of headphones, the physiological focus of these studies is not relevant to this research as they do not relate to the historical phenomenology of sound and acoustic space as mediated by acoustic prosthetic technologies for the ear.

An exception is Heike Weber's (2010) sensori-social history of the use of earphones in West Germany from 1950-2010. In her study Weber pays particular

attention to how the use of earphones (or headphones) during this period contributed to a fragmentation of family life, and ultimately became a prominent feature of mobile urban lifestyles of the late twentieth and early twenty-first centuries. First and foremost, Weber examines the impact of earphones upon social life in West Germany during this period, and how these prosthetics for the ear brought about a form of mobile auditory privatisation, a phenomenon she refers to as “head-cocooning” (p. 340). Yet despite providing some worthy insight into how earphones historically affected family and social life, and how these acoustic prosthetic devices for the ear facilitated the formation of a ‘head-cocoon’ for private listening experiences, Weber does not explore how different types of headphones contributed to a reshaping of the user’s perception of acoustic space in any meaningful way. Nor does she consider the phenomenological effects of various types of headphones across history.

Further to the aforementioned studies which touch on various sensory and social implications of headphone use, there are several noteworthy studies have been conducted within the field of cultural studies and sociology that examine the functionality and socio-psychological effects of portable audio devices such as the Sony Walkman and the Apple iPod (Bove, 2003; Bull, 2000; Bull, 2007; Hosokawa, 1984; Kahney, 2005; Whittkower, 2008). Yet these studies approach headphones as a generic entity that operates as an aside to the music device itself, rather recognising them as important acoustic personal technologies with their own set of influences. Moreover, these studies focus upon the patterns of use of portable

music players as opposed to looking at the phenomenological effects of headphones, and their potential to alter the perception and experience of acoustic space for the user. For example, Bove (2003) provides a critique of the multiple functions of the iPod, and how the user can maximise the potential of the device. Kahney (2005) examines the development of the iPod, from its inception to commercial release, and how it altered the ways in which individuals could carry their music with them and consume it in their own personalised way. Philosopher Dylan E. Whittkower (2008), on the other hand, presents a study into the philosophical aspects of the iPod, and its rapid ascent to its place as a cultural commodity and icon. Whittkower's study also overlooks the integral role played by headphones in the creation of personalised and privatised auditory experiences afforded through the use of the iPod. Thus, his study lacks insight into the phenomenological effects of headphones upon the experience of acoustic space.

Further research into auditory devices by Hosokawa (1984) examines the cultural effects and the autonomy of arguably the world's first portable music player, the Sony Walkman. He places particular emphasis on the influence of the device within an urban context, specifically the construction of artificial spaces and interaction between users. Hosokawa analyses how the Walkman connects the act of walking with music and the role of the device as a type of 'secret theatre', observing that,

What surprised people when they saw the Walkman for the first time in their cities was the evident fact that they could know *whether* the Walkman user was listening to something, but not *what* he [sic] was listening to. Something was there, but it did *not appear*: it was secret” (p. 114; emphasis in original).

Here, he draws further attention to the issue of isolation of the user from other inhabitants of urban spaces, as it became unclear to bystanders what the Walkman user was listening to, thus arguably creating a sense of slightly anarchic secrecy. However, Hosokawa did not approach his study from a phenomenological standpoint, nor did he reference acoustic space in his discussion of the Walkman and its accompanying headphones. This contributes to the existing scarcity of research that acknowledges, first, the significance of headphones in their own right, and second, the integral role that these acoustic prosthetic devices play in shaping the wearer’s perception of sound and acoustic space.

Although Hosokawa’s attention lay with the Walkman, his observations have since been applied to other studies concerned with portable music players, such as Michael Bull’s studies *Sounding out the city* (2000) and *Sound moves* (2007), which explore the ways in which personal music players influence the user’s experience of, and interaction with, urban environments. The first, *Sounding out the city* (2000), examines the use of the Walkman, while the second, *Sound moves* (2007) considers the widespread use and popularity of the Apple

iPod. Both studies are based upon the collection of survey data from Walkman and iPod users. Bull gathered information from participants in order to track the listening habits of personal stereo users over a two-year period, and set out to analyse “the meaning of personal-stereo use” (2000, p. vii). Consequently, there is a strong emphasis on patterns of use and discussion of why people are drawn to these devices. He poses three questions at the outset of his study: “what is the nature and influence of the auditory in everyday life; what role does technology play in the construction of auditory experience, and what role do personal stereos play in the management of the everyday life of users” (2000, p. 2)? Here, Bull pays particular attention to the effects of the Walkman upon the “cognitive, aesthetic and moral significance that are all relational in so much as they inform us of the ways in which users relate to their surroundings, others and themselves” (p. 2). However, the stated intention was to “formulate a new moral geography of the city that places the management of contingency and the production of forms of interpersonal asymmetry at the centre of its account” (p. 2). He presents an ethnographic study examining the auditory experience of personal stereo users and contemporary urban life and ways in which their experience of the city is affected through the use of these devices by questioning how these personal auditory devices alter the user’s experience of self and place within urban environments.

Interestingly, Bull (2000) also acknowledges gaps within existing studies that look at auditory technologies and culture, in this instance in the field of urban

studies. He notes that “mainstream accounts of urban behaviour either fail to address how technology, namely the personal stereo, impacts upon these concerns or ignore the specific relational nature of auditory experience in the daily lives of people” (p. 2). Furthermore, Bull observes that prior to his own study into the bearing of the Walkman upon urban experience, there was an absence of contemporary accounts of the auditory nature of everyday experience in urban and cultural studies. Nevertheless, it is important to note that in both of Bull’s studies (2000, 2007) the role of headphones, in their own right, are given little attention other than merely as a component of Walkman and iPod. Therefore, there is no consideration of the nuances of different auditory experiences afforded by headphones, which in turn can have significant implications for the wearer’s experience of sound and perception of acoustic space.

Both studies are first and foremost based upon responses from the survey subjects, respectively drawing attention to individual and collective patterns of Walkman and iPod usage. Consequently, Bull (2000, 2007) does not approach his exploration of the effects of the Walkman and iPod from a historical or phenomenological perspective, factors which are key to this thesis. Headphones are merely treated as generic devices, rather than acknowledging that various makes and models of headphones can affect the user’s perception of sound and acoustic space in different ways. While referring to some of Bull’s findings, the historical phenomenological effects of

individual acoustic prosthetic technologies for the ear upon the perception of acoustic space are paramount to this thesis.

Although the research conducted by Berger (1970), Bennion (1994), Sandlin (1995), into the histories of hearing aids, and Sterne's (2003) study into the cultural implications of sound reproduction technologies provide valuable insight into the early histories of these acoustic prosthetic devices for the ear, further research into how these devices affected the user's perception of sound, acoustic space and their surrounding sonic environment is required. While addressing this deficit in extant scholarship, this thesis will also present a historical phenomenology of the evolution of these devices to the present. Furthermore, while there is an extant body of literature that examines the social and cultural impacts of personal music players such as the Walkman (Hosokawa, 1984) and the iPod (Bove, 2003; Bull, 2000, 2007; Kahney, 2005; Whittkower, 2008), these studies clearly illustrate the need for research into headphones as significant technological devices in their own right. This thesis will address this neglect in the consideration of headphones by examining the effects of these acoustic prosthetic technologies for the ear on the perception of sound and perception of acoustic space from an historical and phenomenological perspective. It so doing, it will illuminate the implications of the mediation of sound through personal auditory devices, and the role they played in re-tuning the mind's ear.

2.5 Phenomenologies of sound

Finally, the third body of work where one would reasonably expect to see some discussion about how various acoustic prosthetic technologies for the ear affect the perception of sound and space is the field of phenomenology.

Addressing existing research pertaining to the historical phenomenology of sound and acoustic space is germane to this thesis as phenomenology provides a means by which to explore the reality of auditory phenomena as a 'lived' experience.

Furthermore, the incorporation of a phenomenological perspective into this study affords the opportunity to illustrate how various prosthetic technologies for the ear altered the perception of acoustic space across history, and how this contributed to a re-tuning of the mind's ear.

A literal translation of the word 'phenomenology' reveals its meaning in the generic definition of 'the logos of phenomena', or that which appears or reveals itself to humankind (Bullington, 2013). The development of phenomenology as an approach to the study of philosophy is largely credited to philosophers Edmund Husserl (1965) and Martin Heidegger (2008). Husserl's work predominantly focuses on the phenomenology of essence, presence and structure. Husserl argues that intentionality lies at the centre of human attention and experience, and that it is only possible to understand these essences by bracketing, or suspending, existing assumptions about the nature of the outside world. This suspension, he contends, is necessary in order for individuals to analyse their own unique experiences. Heidegger, whose research continued from Husserl's body of work,

questions ontology and the role of being, and asserts that experience must be understood in relation to cultural and historical embeddedness. Husserl and Heidegger essentially lay the foundations for the study of phenomenology, which initially predominantly focused on scientific-related matters. Ihde (1979) notes that phenomenology has “in its own way has been interfaced with the sciences from its outset. Perhaps the most widely noted relation, due in part to Edmund Husserl's characterisation of the beginning steps of phenomenology as a descriptive psychology” (p. 1). However, over the last century it has evolved to become an interdisciplinary field of inquiry, as phenomenological research has come to include elements of a number of different fields of scholarship, for example, film, feminist studies, cultural studies, ethnography, geography, politics, science, human emotions, sociology, music, and of course, sound.

Over the last fifty years a growing body of literature has emerged that looks at the phenomenology of sound. These studies include research into sound and screen media (Batcho, 2014; Branigan, 1989; Cook, 2015); the phenomenology of music and melody (Cluett, 2006; Davismoon, 2016; Lewin, 1986; Palmieri, 2014); voice and auditory phenomenology (Di Bona, 2017; Pecora, 1985; Rosen, Jones, Chase, Grossman, Gin & Sharma, 2015); the political agency of sound (Berland, 1984; Reveill, 2016), and the phenomenology of listening (Blenkinsop & Pierson, 2013; Bodie & Crick, 2014; Ihde, 2007; Erlmann, 2004). However, despite contributing to the field of the phenomenology of sound, to date very little

scholarly attention has been paid to the perception of acoustic space through the lens of acoustic prosthetic technologies for the ear.

Arguably the most comprehensive study of the phenomenology of sound to date is phenomenologist Don Ihde's (2007) *Listening and voice: Phenomenologies of sound*. First published in 1976, Ihde aimed to present an "original phenomenology" (p. xi), rather than discussing the work of other phenomenologists such as Husserl and Heidegger. Instead, Ihde focuses upon auditory perception and the inclusion of various auditory technologies in human experience. In addition to introducing several key principles that explain the processes and different facets in hearing and the experience of sound, he provides a theoretical framework for the study of sound from several different perspectives, including the embodiment of acoustic devices and the construction of imagined auditory fields which can occur through the use of acoustic prosthetic technologies for the ear. The limited way in which he illustrates this process is through a momentary description of his own experience of using hearing aids and how hearing impairment, followed by the use of hearing aids, affected his ability to not only hear sound, but also the relationship with his surrounding acoustic environment. However, Ihde's description of his experience of sound mediated through hearing aids is very brief, and is used as an example rather than a comprehensive examination of the phenomenological effects of hearing aids in their own right. Nevertheless, Ihde's exploration into the phenomenology of sound informs this study, specifically the ways that this thesis approaches the

study of sound and the phenomenology of auditory experience, namely auditory space, through acoustic prosthetics (discussed in greater detail in Chapter Three).

There is a further body of work, albeit small, within the field of phenomenology that examines how hearing impaired individuals experience sound. For example, Catherine Aquino-Russell (2006) explores how people with a deficit in hearing perceive the lived experience of sound. This study describes the different experiences of hearing loss of seven individuals, specifically the ways in which the subjects gave and received messages via sound. However, while this study provides some worthy insight into the lived experience of impaired hearing, there is scant discussion of how hearing aids modified the subjects' experience of sound, and no mention of how they perceived acoustic space, with or without the use of hearing aids. A further study by Ingrid Jonsson and Birgitta Hedelin (2018) explores experiences of hearing loss for women between the ages of 36 – 56. The study is primarily concerned with how these women “keep in touch with life” (p. 111) while enduring a deficit in hearing. Again, while there is some fleeting discussion of the use of hearing aids, little attention is given to how these acoustic prosthetic devices altered the users' perception of sound and acoustic space.

Bruce Kent and Sandra Smith (2006) also present research into hearing impairment and the use of hearing aids. Their study examines how adolescent hearing aid users are perceived socially, and how impaired hearing in children can affect social, educational and emotional development. However, while the use of hearing aids is discussed, it is limited to the context of whether or not the use of an

aid for hearing is perceived as being 'normal' by the peers of the hearing impaired child. Consequently, there is no mention of how these acoustic prosthetics for the ear alter the user's experience of acoustic space. Although these studies raise some valid points in regards to the experience of impaired hearing, which will inform the discussion of hearing deficits in Chapter Four, this thesis is first and foremost concerned with how acoustic prosthetics technologies for the ear have historically altered the perception of sound and acoustic space.

Recent work from thespian Chris Wenn (2015) presents a phenomenology of theatrical performance through headphones. Presenting a case of study of a performance where the audience was required to wear headphones, Wenn asks what it is like to wear headphones as an audience member in a theatre. His study came about through an increase in the number of performances that "use the phenomenological potential of intimate, 'secret' listening as a theatrical element" (p. 1). However, although Wenn's work explores the use of headphones within this context, the discussion primarily focuses upon the dynamics and phenomenology of performance, rather than the nuances of acoustic space and sound localisation that can influence the listener's perception of their surrounding acoustic environment. Furthermore, he approaches headphones as generic acoustic prosthetic technologies, and therefore does not take into account the varied effects produced through the use of different types of headphones.

What is evident through a survey of existing bodies of work that consider the phenomenology of sound is that there is a shortage of available research

pertaining to acoustic space and sound mediated through acoustic prosthetic technologies for the ear. While Ihde (2007), Aquino-Russell (2006), Jonsson and Hedeline (2018) and Kent and Smith (2006) consider hearing impairment and the use of hearing aids, and Wenn (2015) examines the use of headphones within a theatrical context, it is immediately evident these areas would benefit from much greater consideration and exploration. Furthermore, none of these studies are historical, an addition that this thesis will make to the existing body of work. This is necessary in order to understand how acoustic prosthetic devices alter experience of sound and acoustic space, and how we understand and perceive the world around us. The need for further research is even more pivotal as the use of acoustic prosthetics becomes increasingly widespread, while offering wearers new and potentially influential experiences of sound and acoustic space.

Summary

This chapter discusses extant research that examines acoustic space, acoustic prosthetic technologies for the ear, and the phenomenology of sound. This review of literature has identified a number of gaps that currently exist in each of these areas. Although the reasons remain unclear, it is suggested that these oversights in existing research could be attributed to the dominance of the eye and the visual over the ear and the auditory that is evident in current bodies of knowledge. Additionally, it is possible that the close examination of acoustic prosthetic technologies for the ear has been overlooked on the grounds of these

devices, in particular headphones, being seen as fashionable technologies and therefore not worthy of serious consideration.

This thesis, however, argues that acoustic prosthetic technologies for the ear throughout history have modified the perception of acoustic space, which in turn has altered the relationship between the user and their acoustic environment and thus their sense of being in the world. Given their ubiquity, the effects of the use these devices reach far beyond the patterns of individual use, making these auditory devices important figures of attention in their own right. Acoustic prosthetic devices should no longer be considered generic devices as their purpose, function, capabilities, and - most importantly here - their effects are many and varied.

This literature review identifies and discusses several studies that have briefly touched on the effects of various prosthetic technologies for the ear. However, their treatment has been fleeting and overall fails to take into account the minutiae of these devices that can appreciably influence the user's perception of acoustic space. While this thesis will draw from some of this material, it also seeks to present a history of prosthetic technologies for the ear in order to explore the effect(s) of these devices on the user's perception and experience of acoustic space from a phenomenological perspective. This study questions and examines how acoustic prosthetic technologies for the ear have affected perceptions and experiences of sound and acoustic space. In light of the current development of new acoustic technologies and prosthetics for the ear that provide an array of

different and increasingly immersive auditory experiences, this field requires further research to order understand how these devices have not only historically altered the experience of acoustic space, but also the relationship between the user and their surrounding environment in a rapidly changing world of auditory experience.

CHAPTER THREE

Methodology and Method

3.1 Introduction

This study makes a contribution to the fields of media ecology, sound studies and phenomenology by presenting an historical exploration of acoustic prosthetic technologies for the ear and their influence in modifying and reshaping the user's perception of acoustic space. It does so by applying a hybrid methodology informed by media ecology, by media archaeology (especially as it is incarnated in Sigfried Giedion's (2013) anonymous history), and by the phenomenology of sound. This compound methodology has been used to ensure that this thesis provides a history not just of acoustic prosthetic devices in significant areas of development, but of the various effects that these technologies have upon how the user experienced acoustic space. Furthermore, the malleable nature of this approach affords this study the opportunity to present a history of acoustic prosthetic technologies from a trajectory that is not strictly linear. Instead, acoustic prosthetics are examined across three key areas of innovation and application—hearing aids, the stethoscope and headphones used for the purpose of auditory pleasure—in order to illuminate shifts in how individual devices from each of these groups mediated sound and altered the perception of sound, and therefore acoustic space.

This chapter examines the three methodological strategies that have contributed to the development of the composite approach applied in this thesis and discusses why this method was chosen. First, this chapter briefly discusses the field of media ecology and the study of media effects. It provides an overview of this field of research, and explains how media ecology informs this study. Second, it explores Sigfried Giedion's (2013) development of anonymous history, an approach that effectively foreshadowed the establishment of media archaeology, as a means by which to consider the social effects of mechanised tools and processes during the Industrial Revolution. Following this is an explanation of why and how anonymous history informs the approach applied in this thesis. Third, this chapter explains the integration of post-phenomenology in this study, guided by Maurice Merleau-Ponty (2013) and Don Ihde's (2007) theory of embodiment relations, in order to reveal and examine the relationship(s) between humans and their technologies, and the numerous ways that acoustic prosthetic devices have historically reshaped how acoustic space was experienced and perceived, and contributed to a re-tuning of the mind's ear. Finally, this chapter explains why and how this hybridised methodology informed the method applied in this thesis, and how the method was applied to compile an anonymous history of acoustic prosthetic technologies for the ear.

3.2 Media ecology

This thesis can be understood as an exercise in media ecology as it is concerned with studying the media environments created through the use of various acoustic prosthetic technologies for the ear. This study is further concerned with how acoustic prosthetic technologies have altered the user's perception of acoustic space, a concept founded within the field of media ecology. This raises the questions of what is media ecology and what is the purpose of media ecological research? As discussed earlier in Chapter Two, the human-made technologies that we encounter and use on a daily basis exert their own set of effects on the user. Media ecology, therefore, is concerned with the identification and examination of these effects to enhance our understanding of the implications of the use of various forms of media, whether it is a simple device such as a pencil, a mobile phone, or a computer. Media ecologist Dennis Cali (2017) argues that “with so much at stake, understanding how media function in altering environments warrants ever more scrutiny” (p. xvii).

There are a number of different definitions and conceptualisations of media ecology and how research within the field is undertaken. Cali (2017) observes that media ecology can be viewed and approached in a number of different ways—as a discipline, a meta-meme, a perspective, a metaphor, a theory group, and/or the study of media as environment(s). Arguably, media ecology is most widely understood as the latter, the study of media environments, whereby media and their ensuing effects create environment(s) that “shape their occupants”

(McLuhan, 2003, p. 27) by having an effect on human consciousness and experience in some way through the reshaping of environments. It is this premise that grounds and informs this study, as it argues that the introduction of a new medium, in this case acoustic prosthetic technologies for the ear, into an environment alters how that environment – acoustic space - is perceived.

As mentioned earlier in Chapter Two, as we create and shape the tools that we use, we are in turn deeply affected and influenced by these same technologies. The relationship between the human user and their technological device(s) gave rise to McLuhan's (2003) observation that 'the medium is the message', a phrase that has become synonymous not only with McLuhan but also the field of media ecology itself. McLuhan stressed that it should not be the media artefact itself that is the focal point of our attention, but rather the environment(s) created or augmented through the use of that technology. All too frequently it appears that we are unaware of the implications of these technologies upon our day-to-day life and behaviour. Yet the implications brought about by the use of these devices are frequently the main effects (Eastham, 2003). In order to understand how media affect humankind, it is necessary to attempt to understand the nature and extent of these effects.

A steady increase in both the popularity and reach of media ecology-based research over the last several decades has been seen as evidence of a "fascination with ecology of all kinds [being] tied in with the information explosion that has marked our age" (Ong, 2002, p. 6). Over the last sixty years elements of media

ecology have extended into a number of different disciplines. These include, but are not limited to, media studies, cultural studies, history, communication systems, anthropology, sensory studies, urban studies, linguistics, sound studies and popular culture, to name but a few. Media ecology, therefore, operates as a multi-disciplinary field that encourages the contributions of researchers from almost every area of scholarship (MEA, 2018; Nystrom, 1973; Strate, 2006). However, despite the interdisciplinary nature of this field of research, the fundamental purpose of and concerns have remained largely unchanged. Strate (2006) argues that media ecology has remained primarily interested in media, communication and understanding the human condition, as the human condition can only be understood within the context of our technological, biophysical and /or symbolic environments. Similarly, Cali (2017) notes that there remains a common thread that runs through media ecological studies, namely “to illuminate the context, the environment, out of which any given medium arises that the respective medium would, in turn, affect” (p. 239). In some respects media ecology can still be considered an emerging field of scholarship in light of the increasingly diverse interdisciplinary studies of the early twenty-first century, of which this study is one, presenting an innovative and hybridised approach to the study of media and their effects.

As research in media ecology has continued to proliferate, so too have the approaches applied under its auspices. Studies conducted under the banner of media ecology, including this thesis, share a common assumption—namely that

media alter the body and that the different environments facilitated through the use of our technologies are of interest and worthy of further exploration.

However, media ecology marks out less a methodological framework than an object of study. Cali (2017) argues that “the rhizomatic nature of media ecology resists the kind of tidy, linear process of analysis typically carried out when conducting rhetorical analysis or interpretive analysis of any kind” (p. 234), implying that media ecology accommodates a certain methodological flexibility. Strate (2006) explains that media ecology encourages independent thinking, and is “open to big ideas, to probes and explorations, to grand theories and philosophies, as it is open to the particulars of ethnographies, histories and descriptive research” (p. 2).

As an interdisciplinary field of scholarship, there are a number of different approaches that have been applied to research undertaken within media ecology, including histories of technology. As this thesis presents a history of several different, yet interrelated technologies, a practical methodological strategy informed by facets of media ecology, anonymous history and phenomenology was applied in this research in order to achieve two key aims. As discussed in Chapter One, the first is to examine the nuances of mediated experiences of acoustic space facilitated by various acoustic prosthetic technologies for the ear from antiquity to the present across three different key areas of development and application, namely hearing aids, the stethoscope and headphones. The second aim of this study is to examine how acoustic prosthetic devices affected the user’s perception

of sound and acoustic space, and how these perceptual shifts altered the relationship between the individual and their surrounding environment(s). This study draws on media ecology to achieve both these aims. As discussed earlier in section 2.2, studies in media ecology are primarily concerned with the examination of various media effects, and the environments that are created and shaped through the use of different human-made technologies. Therefore, as this thesis examines how various acoustic prosthetic devices for the ear alter and reshape the user's perception of sound and acoustic space, it too is concerned with media effects. Furthermore, the concept that drives this research, acoustic space, was established within the field of media ecology, and this thesis draws heavily on the definition of acoustic space developed by media ecologists Edmund Carpenter and Marshall McLuhan (1960) in order to compare and contrast historical shifts in the perception of acoustic space that eventuated through the use of auditory prosthetics.

However, as there is no clearly defined media ecological method that was suitable to achieve the aims of this research, this thesis draws from two different, yet complimentary, methodological strategies in order to construct a phenomenological history of acoustic space through the lens of acoustic prosthetic technologies for the ear: anonymous history and a phenomenology of sound. The construction of this innovative, hybridised methodology enables this research to contemplate how each instrument re-tuned the mind's ear by reshaping the user's perception of acoustic space.

3.3 Anonymous history

The first methodological strategy applied in this study is modelled on Sigfried Giedion's "anonymous history"—an approach later identified as a precursor for contemporary media archaeological approaches (Parikka, 2012; Mollela, 2002; Norwood, 2015). First published in 1948, Swiss art and architecture historian and cultural critic Giedion's *Mechanization takes command: A contribution to anonymous history* sets out the coordinates of "anonymous history," presenting an alternative history of the way in which the Industrial Revolution affected humankind and day-to-day life through an examination of the technologies and artefacts that contributed to processes of mechanisation. The primary focus of Giedion's research is the impact of mechanisation and the cultural assimilation of technology upon society and daily life, which was a growing concern both during and after World War II as "the war had provided intense questioning about what technology was doing to society, and to culture" (Mollela, 2002, p. 374). Giedion argues that technology and processes of mechanisation had brought about a split between human thought and feeling, implying similar dichotomies between science and art, reason and emotion, and form and function. He argues that if appropriately controlled and directed, technology could support human values rather than damaging or destroying them (Giedion, 2013; Molella, 2002). Therefore, he sought to find an equilibrium between humankind and their technologies in order to create and maintain what he considered to be a functional and healthy culture.

To achieve this, he developed a new way of writing history, constructing a unique historical methodology that is also adopted in this thesis. In *Mechanization takes command* (2013), for example, Giedion contends that by looking at everyday artefacts, no matter how small or seemingly insignificant, it is possible to reveal how they influenced human behaviour and contributed to the shaping of present day living. He argues that “for the historian, there are no banal things ... tools and objects are outgrowths of fundamental attitudes to the world” that have the potential to reveal the “general, guiding ideas of an epoch” (p. 4). Giedion’s approach to anonymous history, therefore, deals with “humble things” (p. 5) that had been overlooked and remained unacknowledged for their role in technological and cultural history, devices that have their own stories to tell. He stresses that that it is not possible to understand what is happening in the present without first looking to the past, observing that “even the sun is mirrored in a coffee spoon” (p. 5), as material objects are the manifestations of concepts that mirror the period and culture from which they came. Such is the case for acoustic prosthetic technologies for the ear. Foreshadowing the spirit of media archaeology, then, anonymous history is essentially “a history of that which hides itself” (Norwood, 2015, p. 4).

In compiling his anonymous history, Giedion (1948; 2013) effectively redefined the role and expectations of the historian, as he argues that researchers and writers of history are free to choose how they approach their material. Prior to the period in which Giedion was writing, history had predominantly been written

from either a political or economic perspective (Woolf, 2012; Lineham, personal communication, 19 March, 2014). Furthermore, historical narratives typically focused upon individuals and events of significance, as opposed to material objects. Giedion compiled his contribution to anonymous history during the early 1940s, when the authenticity and motives of political histories authorised by heads of state were starting to be questioned (Woolf, 2011). Anonymous history, therefore, effectively shifted away from these dominant modes of history that had been prevalent prior to the mid twentieth century. Defending his hermeneutic approach to the writing of history, Giedion explains that

Conceiving of history as constellations, the historian can claim one more freedom. He assumes the right to observe at close range certain phenomena, certain fragments of meaning, while omitting others from his field of attention...this freedom in handling proportion is no less necessary when one seeks to represent the meaning of historical complexes (p. 11).

Here Giedion argues that it is the historian's choice about how to approach their historical research, and what they choose to include or cast aside. For the purposes of this thesis, a representative group of acoustic prosthetic technologies was drawn from a multitude of devices. Giedion explains that he had learnt to seriously observe objects that has been largely overlooked or "of interest only to

the specialists...mere fragments listed from the life of a period can reveals its habits and feelings...one must have the courage to take small things and raise them to large dimensions” (p. 4). The key points of difference in Giedion’s method were, first, the examination of material objects, and second, the observation of the emergence of mechanisation from a “human standpoint” (2013, p. 4) by exploring the social implications of various technological artefacts. In doing so, he offered a fresh perspective of how the implementation of mechanisation affected humankind, and how it contributed to present day living.

Giedion (2013) developed his approach to anonymous history after discovering a lack of existing historical narratives and detailed descriptions regarding the historical development of the various tools that contributed to processes of mechanisation during the late eighteenth and early nineteenth centuries. He observed that there were significant gaps in historical records kept pertaining to these tools, and found that he was able to retrieve little, if any, documentation relating to events and the development of technologies such as the production line, despite these tools having had a significant impact upon life during this period. He explains,

An amazing historical blindness has prevented the preservation of important historical documents, of models, manufacturers records, catalogues, advertising leaflets, and so on. Public opinion in

general judges inventions and production exclusively from the point of view of their commercial success (p. v).

Giedion (2013) claims that the prevailing explanation, or rather excuse, for this lack of record keeping was that past had very little to do with an understanding of the present as “we never look backward. We only look forward; meaning the discarding of time, both past and future...Only the present day matters” (p. v).

Devices and practices that were not commercially successful at this time, or whose use had not been widespread, were frequently deemed to be unworthy of attention; such is the case with the taken-for-granted nature of many of the auditory devices examined in this thesis. Therefore, details about why these technologies were developed, how they operated, who used them and the ensuing effects of these devices were not recorded. Consequently, he found it necessary to go back to the devices themselves, as well as locate different forms of primary sources of information such as advertising material, pamphlets, blueprints and patents in order to compile a history of their development, asserting that it was not possible to understand the effects of mechanisation “without knowing, in outline at least, its evolution” (p .v). Giedion’s anonymous history, therefore, emerged as a practical means for writing a history of technology in the absence of more conventional forms of historical documentation.

Mechanization Takes Command (2013) demonstrates an alternative approach to the writing of the history of technology. Giedion achieves this

through the examination of the artefacts themselves and drawing together the scattering of relevant existing information in order to piece together the origins of various devices and how they were used. Furthermore, rather than focusing on a single industry or group of artefacts, Giedion presents case studies of a diverse range of objects, processes and industries, identifying how each contributed to processes of mechanisation and standardisation. He approaches each of the artefacts as ‘texts’ to be read, treating them as “outgrowths of fundamental attitudes to the world” (p. 3). These case studies examine a diverse range of devices and processes, from cups and spoons, to clothing, furniture, bread making and laundering machines. These studies are grouped into sections that focus on specific areas, such as the origins of mechanisation, the mechanisation of agriculture and the household in order to compare and contrast what was occurring in different areas during the same time. By looking at seemingly independent areas Giedion sought to reveal the ‘bigger picture’, specifically how these technologies contributed to the shaping of daily life and human behaviour.

Giedion’s approach to the writing of an anonymous history of technology can be considered an early branch of what is now known as media archaeology, and in some ways Giedion was a “media archaeologist *avant le lettre*” (Huhtamo and Parikka, 2011, p. 2). According to prominent media archaeologist Jussi Parikka (2012), media archaeology is “a heterogeneous set of theories and methods that investigate media history through its alternative roots, its forgotten paths, and neglected ideas and machines that are still useful when reflecting on the newness

of digital culture” (para. 3). In the spirit of Giedion’s anonymous history, studies in media archaeology also look to forgotten or neglected technological artefacts in order to shed further light upon the implications of their use and how they have influenced modern technologies. It endeavours to find something new about present technologies by looking to the past. The use of the term ‘archaeology’ implies a metaphorical type of excavation for relevant material, whereby the historian rummages through potential sources of information from textual, visual and auditory archives as well as collections of artefacts in order to reveal and understand how technologies not only contributed to the shaping of daily life, but also how they influenced technology in the present day. In a similar manner to Giedion (2013), media archaeology emphasises the discursive and material manifestations of culture and the development of non-teleological historical narratives of various technological artefacts. As an “historically tuned enterprise” (Huhtamo & Parikka, 2011, p. 2) media archaeology stresses the importance of paying attention to the role and effects of past media in order to draw attention to the complexities of contemporary media forms and the environments in which they are used, a feature which is key to this study.

Somewhat surprisingly, however, it appears that Giedion’s (1948; 2013) specific approach to the writing of anonymous history has not been widely applied in a practical manner. Although it has been claimed that media archaeology is grounded in Giedion’s anonymous history (Huhtamo and Parikka, 2012), to date media archaeological studies have not emulated the scope of Giedion’s research.

Furthermore, there is a distinct focus upon digital technologies in extant media archaeological research (Elsaesser, 2005; Ernst, 2013; Huhtamo, 2013; Parikka, 2007), rather than studies that look at a number of different technological devices across history, as undertaken by Giedion. Consequently, identifying research that has used Giedion's approach to examine technological artefacts is difficult, in spite of the fact that his study was lauded an influential text that had some bearing on the work of Marshall McLuhan (1962; 2003), as well as contributing to the establishment of the field of media archaeology. This thesis, however, applies a methodological strategy that is guided by Giedion's approach to the writing of anonymous history.

There are two key reasons why this study uses anonymous history. First, it provides a framework for presenting a non-linear history of different, but interconnected, technological artefacts in order to illuminate how the effects of these technologies shifted over time, how they and altered the user's perception of acoustic space. Second, anonymous history is used in an environment of a paucity of historical documentation pertaining to the use of acoustic prosthetics for the ear, specifically prior to the mid twentieth century. Thus, Giedion's approach is suitable for the aims of this study due to the lack of extant historical narratives or detailed recorded material that details the development, use and lived experience of acoustic prosthetic devices. In a similar manner to Giedion, this study therefore turns to other forms of archival material. Sources include medical journal articles, advertising material, newspaper articles, letters, information from manufacturers,

and existing accounts of the use of acoustic prosthetics in order to piece together the implications and effects of prosthetic technologies for the ear and how they might have restructured the user's perception of acoustic space across history.

Second, this study does not seek to present an all-encompassing, comprehensive history of acoustic prosthetic technologies for the ear. Rather, in a similar vein to Giedion's (2013) anonymous history, it examines specific groups of devices that are identified as having the most significant impact upon how acoustic space was perceived: hearing aids and the stethoscope – which were used to enhance auditory acuity, and headphones used for the purpose of auditory pleasure. As this study examines these different, yet interrelated groups of acoustic prosthetics separately, it does not present a linear history per se, but rather compares and contrasts how and why these devices were used, and how each of them contributed to shifts in how acoustic space was perceived by the user. By presenting the anonymous history of acoustic space in this format, it is possible to reveal what was occurring in different areas at the same time, and how the technological reshaping of acoustic space affected different modes of life.

3.4 Post-phenomenology and embodiment

This thesis offers further insight into the effects of acoustic prosthetic technologies for the ear, particularly upon the user's perception of acoustic space and their experience of, and relationship to, their surrounding environment. It does this by expanding on Giedion's anonymous history through the integration of

a phenomenological approach in order to facilitate a more robust discussion of how these devices modified the perception, and therefore the lived experience, of sound and acoustic space for the user.

The second methodological strategy applied by this study is an approach to post-phenomenology informed by Maurice Merleau-Ponty's (2013) and Don Ihde's (2007) theories of embodiment relations. The integration of phenomenology with compiling an anonymous history of acoustic space through the lens of acoustic prosthetic technologies for the ear affords this study the ability to not only trace the evolution of these devices, but to examine in depth the nuances of the diverse range of experiences of acoustic space that they facilitated. This matters because various forms of acoustic prosthetics had significant implications for the user's lived experience of sound, as well as their relationship to the world around them.

Phenomenology is a broad field, and a number of different approaches can be applied to studies concerned with human perception. However, it can be argued that phenomenological methods share a common goal in that they aim to "describe, understand and interpret the meanings and experience of human life" (Bloor & Wood, 2006, p. 1). Phenomenology uses description as opposed to analysis, specifically the direct description of experience. Ihde (2007) elaborates that phenomenology undertakes

Intense examination on experience in its multi-faceted, complex, and essential forms. Nothing is easier than a "phenomenology",

because each person has [their] experience and may reflect on it. Nothing is more “familiar” than our own experience, and nothing is closer to ourselves...But nothing is harder than a phenomenology, precisely because the very familiarity of our experience makes it hide itself from us (p. 5).

A literal translation of the word ‘phenomenology’ reveals its meaning as ‘the logos of phenomena’, or that which appears or reveals itself to humankind (Bullington, 2013). The development of phenomenology as an approach to the study of philosophy is largely credited to philosophers Edmund Husserl (1965) and Martin Heidegger, whose seminal text *Being and time* was first published in 1927. Husserl’s work predominantly focuses on the phenomenology of essence, presence and structure. He argues that intentionality lies at the centre of human attention and experience, and that it is only possible to understand these essences by bracketing, or suspending existing assumptions about the nature of the outside world. This suspension is necessary in order for the individual to analyse their individual experiences. Heidegger, whose research continued on from Husserl’s body of work, questions ontology and the role of being, and asserts that experience must be understood in relation to cultural and historical embeddedness.

However, it was the work of French philosopher Maurice Merleau-Ponty, in particular his groundbreaking work *The phenomenology of perception* (1945) which was influenced by Husserl and Heidegger, from which the phenomenology of

embodiment emerged. Phenomenology, according to Merleau-Ponty, is “the study of essences and accordingly its every problem is an attempt to define an essence, the essence of perception, or the essence of consciousness [which] encompasses accounts of space, time and the world as lived” (p. 59). In his influential work, the *Phenomenology of perception*, first published in 1945, Merleau-Ponty argues that the primacy of perception is of the utmost importance. He explains that the body plays an integral role in this process as the body essentially symbolises “existence because it brings it into being and actualises it” (2013, p. 164). Merleau-Ponty contends that the human body should be approached as a *subject* in its own right, and as such, the human subject is embodied. Phenomenology thus provides a perspective from 'within', using subjectivity as the basis for explaining the world. The intentionality involves looking at an object by 'inhabiting it', and from this 'habitation', understanding the things that are presented through the experience. From this perspective, there are no 'objective' things with fixed forms and properties; rather, a world of extension and subject arises.

Merleau-Ponty (2013) developed the concept of the “embodiment relation” to describe the way in which artefacts act as an extension of the body, and how this in turn influences individual experience and perception of the environment and the world around them. Arguably, his most well-known example is the embodiment of a feathered hat, whereby the wearer of the hat orientates themselves with their immediate physical space and interacts in that space in light of the feather, which essentially becomes an extension of the wearer’s body.

Similarly, Marshall McLuhan (2003) believed that media extended the body and at least one of the senses, and in doing so mediated the users experience of their environment(s) and the world. Yet while Merleau-Ponty examines perception through the lens of the embodiment of certain items, he does not consider the use of technological artefacts.

Post-phenomenology is a revised form of phenomenology developed by Ihde (2007) that is founded upon the work of Husserl (1965), Heidegger (2008) and Merleau-Ponty (2013). However, unlike traditional approaches to phenomenology post-phenomenology is, according to Ihde (2009), a “deliberate adaptation or change in phenomenology that reflects historical changes in the twentieth and twenty-first centuries” (p. 5). An integral shift in the focus of post-phenomenology is that it is primarily concerned with studies of technology, specifically the embodiment of different forms of technology and how they alter the user’s perception of the world. The field of post-phenomenology is dominated by the work of Ihde, who effectively established this philosophical perspective. According to Rosenberger & Verbeek (2015), post-phenomenological inquiries are

[P]osed from an embodied and situated perspective, refer to practical problems, and are empirically oriented...post-phenomenology adds a focus upon case studies of human-technology relations. Through this combination of traditions and interests, the post-phenomenological perspective has developed a

unique set of insights into technology, and applies these ideas to practical cases of usage (p. 1).

The primary mode of research conducted within post-phenomenology is the application of theoretical frameworks that have emerged from the work of Ihde. He adapted concepts from the phenomenological tradition that are applied in a practical manner to describe the intricacies of the relationship(s) between technology and their human user. Rosenberger & Verbeek (2015) explain that researchers who apply a post-phenomenological approach to their studies “refine and expand on Ihde’s framework, and then apply these ideas to a wide range of issues” (p. 9). This thesis applies Ihde’s concept of the embodiment relation in order to reveal how various acoustic prosthetic technologies became embodied, and how the establishment of an embodiment relation between the wearer and device altered the user’s perception of acoustic space.

An embodiment relation, according to Ihde (2007) is a form of existential relationship that is formed between humans and their technologies. He describes an embodiment relation as the way in which various technologies come to be taken into the body and therefore become factored into the individual’s experience of the world, as it becomes a medium through which the surrounding environment is perceived. Ihde elaborates that “such technologies characteristically ‘withdraw’ upon use, becoming experientially quasi-transparent to the user. This occurs with, for instance, the blind man’s stick, telescopes, and

tools like the hammer, all of which become a phenomenological part of the human user” (p. 4). To illustrate the nature of this relationship between the human user and their technology, Ihde provides an example of the relationship that is formed by a pair of eyeglasses to the user. He explains “the I-glasses-world” relationship, through the normalisation of experiencing the world through the eyeglasses, comes to be rewritten as “(I-glasses)-world” (1990, p. 72). The glasses, therefore, become an extension of the body; a medium through which the user perceives and experiences the world around them.

When an embodiment relation occurs the user takes the technology into their experience “in a particular way by way of perceiving through such technologies and through the reflexive transformation of [their] perceptual and body sense” (Ihde, 2007, p. 72). Consequently, as the user becomes increasingly accustomed to viewing the world through their glasses and this becomes a normalised practice, the technology – in this case the glasses – become transparent and the fact that the user views the world *through* the glasses “recedes into the background of awareness” (p. 73). Such mediated perception is different from unaided perception as the sensory information that is received by the individual has been pre-processed, or modified, by the device. Technological artefacts such as glasses, telescopes, and probes, therefore, become engaged in an interdependent relationship with the body of the user. Therefore, the use of such devices are not perceived as objects within the user’s surrounding environment, but instead become a means through which the user perceives, experiences and

acts upon their environment. In comparison, a majority of the physical objects that we encounter within our various environments, objects such as trees and furniture, are objects that are perceived in themselves, as they “do not normally function as objects through which the environment is perceived and acted on” (Brey, 2000, p. 1). Yet despite the impact that the process of the embodiment of a mediating device can have upon the perception of their environment, the user often remains largely unaware of the ensuing effects.

Similarly, in his examination of the relationship between technology and perception, Sacasas (2012) argues

That by which we see remains unseen...[whereby] ubiquitous realities tend to fade from view. They are, paradoxically, too pervasive to be noticed...It is these very realities, hiding in front of our noses as the cliché has it, which most profoundly shape our experience. Very often, these ever-present, unnoticed realities are technological realities (para. 7).

Whereas media archaeology looks at marginalised and forgotten technological artefacts, phenomenology seeks to reveal, explore and describe how technology alters our perception of the world, an implication of the use of various technologies that often remain hidden. This thesis, therefore, applies a post-phenomenological approach informed by Ihde’s (1979; 2007) concept of

embodiment relations in order to describe in depth, and draw further attention to, the intricacies of the perception of acoustic space mediated by different acoustic prosthetic technologies for the ear across different periods.

This thesis approaches the study of the phenomenology of acoustic space from a subjective point of view. It applies Ihde's (1979; 2007) post-phenomenological theory of embodiment relations as a methodological strategy in order to examine how an embodiment relation was established between the user and their acoustic prosthetic device, and how this in turn altered how they perceived acoustic space. This approach is applied in this thesis for two key reasons. First, it affords the opportunity to describe how the various acoustic prosthetic technologies for the ear impacted and/or altered the experience of sound and acoustic space. Second, it also provides a means through which to offer insight into how the user is likely to have perceived acoustic space when using the device, based upon accounts of the mediation of sound and acoustic space. Used in conjunction with archival documentation that provides information pertaining to these of the use of these devices where possible, this approach reveals the complexities and essence(s) of differing experiences of sound and perceptions of acoustic space facilitated through the use of various acoustic prosthetic technologies for the ear.

3.5 Method

The interdisciplinary method introduced above was applied in this thesis to answer the three questions posed by this research: “what effect(s) have acoustic prosthetic technologies for the ear had upon the user’s perception of acoustic space?”, “how have these devices influenced a shift in the user’s mediated perception of acoustic space over time?”, and “how have changes in the experience of acoustic space altered the relationship between the individual and their environment(s)?”

In the early stages of research for this thesis, academic contributions to the fields of media ecology and sound studies were consulted in order to identify the user’s perspective of the experience of sound through prosthetic technologies for the ear. There was a paucity of historical accounts of the use of hearing aids and headphones, specifically the effects that they had upon the user’s experience of sound and sense of acoustic space. Similarly, after a further search of research conducted within the field of medicine over a two-month period, it was also clear that there was a scarcity of first-hand historical accounts of how the physician experienced acoustic space when applying the stethoscope to the body of the patient.

I then decided to further refine the scope of my research, because as discussed earlier in section 3.3, Giedion asserts that it is at the discretion of the historian about which facets of history they choose to focus on, or cast aside. Just as Giedion selected technologies he believed had the most profound implications

for daily life, I shifted the focus of my research to identify specific areas of innovation and influence within the development of acoustic prosthetic technologies for the ear in order to illustrate how these devices affected the auditory experience of the user. By using Carpenter and McLuhan's (1960), Ong's (1982) and Schafer's (1994) definitions of acoustic space and auditory environments, talking with individuals who use hearing aids, stethoscopes and/or headphones on an almost daily basis, and reading about the physical, social and cultural implications of acoustic prosthetic technologies for the ear, over the period of six months three specific groups of devices were identified as being sites of significant innovation and influence: hearing aids (developed to ameliorate impaired hearing), the stethoscope (applied to improve the diagnostic capabilities of the physician), and headphones (used to afford privatised experiences of sound and auditory pleasure).

Given the plethora of different makes and models of hearing aids, stethoscopes, and headphones that have been produced over the last two centuries, it was not possible within the scope of this study to consider every device. Rather, once the three groups of representative acoustic prosthetics to be examined in this study had been identified, it was important to trace their historical evolution in order to determine whether it was possible that the devices in each of these groups had altered the user's perception of sound and acoustic space in a significant and/or meaningful way. A broad and intensive search for archival information pertaining to each of the three different groups of prosthetics

was undertaken in 2015 over a twelve-month period. The primary purpose of this search was to, first, identify *why* these devices had been invented; second, *who* they were intended to be used by, and finally, *how* that mediated sound may have been experienced by the user.

This research was undertaken by identifying relevant textbooks on acoustic space, sound, and personal auditory devices such as the Walkman and iPod. In addition, at least half of the information identified during this period was found by identifying and accessing online material such as databases of academic journals in medicine, media ecology, sound studies and phenomenology, alongside digitalised museum collections of hearing aids and stethoscopes. It became evident that I needed to also scour other potential sources of pertinent information, just as Giedion (1948; 2013) had done. These sources included antique medical device websites, patents, treatises, newspaper articles, trade magazines, letters to the editors of journals and newspapers, biographical accounts from hearing impaired individuals, print advertisements, user guides sourced directly from hearing aid and headphone manufacturers, and medical journals from the nineteenth and early twentieth century available via the Internetarchive.

Particular emphasis was placed on locating archival material which detailed the ways in which sound was experienced through different types of hearing aids, the stethoscope and headphones, and information about how these mediated auditory experiences differed from how sound was experienced through the naked, unmediated ear. This process confirmed the original decision to focus on these

three devices as reflecting the effects on users' perceptions of acoustic space across time. However, I found that despite being able to identify some worthy material pertaining to each of the three groups of acoustic prosthetics discussed in this thesis, there was evidence of a scarcity of historical accounts about *how* the user experienced sound through the three devices selected for analysis. It then became evident that it was necessary to integrate a second methodological strategy into the approach applied in this thesis in order to, first, illustrate and provide further insight into the experience of sound afforded through the use of various acoustic prosthetic devices from a human perspective, and second, answer the three questions posed by this thesis. In order to achieve this outcome, I decided that it was necessary to spend some three months reading and becoming familiar with the phenomenological study of sound, in particular Don Ihde's (1979; 2007) post-phenomenological theory of the embodiment of technological artefacts, specifically how the formation of an embodiment relation between the human user and their device alters how the user perceives the world in some way.

I chose to integrate this phenomenological approach as it enabled the examination of how acoustic prosthetics altered the user's experience of sound and acoustic space, which somewhat compensated for the absence of relevant historical documents to support my discussion. In addition, this historical phenomenological approach also allowed me to explore the nuances of the 'lived' experience of sound and acoustic space as central to this study, in part from drawing upon my own experiences of using various acoustic prosthetic

technologies for the ear. Duly, a further two months were dedicated to exploring the possibility of how the concept of the embodiment relations could be applied to each acoustic devices examined in this thesis in order to illuminate how these prosthetic technologies for the ear altered the user's experience of sound, acoustic space, and their environment, as well as drawing attention to shifts in the perception of acoustic space across history.

It is, however, important to acknowledge that certain tensions arise through the integration of these different approaches into the methodological framework applied in this study. The use of anonymous history and phenomenology in this thesis draws attention to the paradoxical nature of these two theories. Anonymous history, as discussed earlier in section 3.3, is primarily concerned with the examination of existing historical documentation and inanimate objects in order to reveal the impact(s) that these devices had upon daily life in both the past and the present. Consequently, anonymous history essentially captures historical experiences that are not that of the self. Phenomenology, on the other hand, focuses upon 'lived' experience and the essence of perception (Ihde, 2007; Merleau-Ponty, 2013). As discussed in section 3.4, phenomenology is essentially based upon first-hand descriptions of how the world presents itself to humankind (Bullington, 2013). Furthermore, phenomenology typically rejects objectivity in favour of subjective first-hand accounts of the experience of different phenomena. Consequently, a tension arises by bringing these two theories together as it is not possible to have first-hand access to historical experience(s).

Yet in spite of this conflict, this study uses anonymous history and phenomenology in such a way whereby these two approaches ultimately compliment each other, as combining the two provides a means through which to conduct a form of historical phenomenology. As discussed earlier in section 3.4, anonymous history and phenomenology are integrated into the study applied in this thesis in order to achieve the aims of this research, namely to trace the evolution of acoustic prosthetic technologies for the ear in order to reveal the nuances of different mediated experiences of acoustic space across history.

As Curran and Kearney (2012) explain, “if phenomenology can be characterised as the study of sense experience from a first person point of view, then *historical phenomenology* can be characterised as the study of sense experience during a specific historical past” (p. 353). Within the scope of this study, insights into sensory experience, specifically the perception of sound and acoustic space, are garnered through existing historical accounts wherever possible, as “texts represent bodily experience” (Smith, 2000, p. 326). For example, similar approaches to historical phenomenology have been applied in recent years within the realm of Shakespeare studies, whereby Shakespeare’s texts are analysed in order to reveal how human sensory experiences were described and understood at the time in which he was writing. Such analysis thus enables researchers to compare differences in experience and emotions between the past and the present. In a similar vein, this study also draws from texts in the form of first-hand

historical accounts of the use of various forms of acoustic devices wherever possible, namely hearing aids, the stethoscope and headphones.

These subjective, historical narratives not only provide valuable insight into not only how the user experienced sound through the use of these devices, but also how different forms of acoustic prosthetics altered the user's sense of hearing, and ultimately their experience of acoustic space. For example, anonymous history examines the physicality of various objects, such as a spoon or a vacuum cleaner, and explains how the invention and use of everyday objects impacted day-to-day life during a particular epoch. The addition of phenomenology, however, provides a way to consider and explore the nuances of mediated experiences of sound across different periods. By integrating a phenomenological perspective, it is not only possible to examine *how* various acoustic prosthetic devices reproduced sound, but also what how sound, and therefore acoustic space, were perceived by the user.

While this hybridised approach provides a practical means by through which provide valuable insight into how acoustic prosthetic technologies altered the experience of sound and acoustic space, the limitations of this approach must also be acknowledged. The primary challenge of applying this methodological framework was that was not always possible to find historical documentation and/or narratives that described the use of each of the acoustic prosthetic devices examined in this thesis. In such cases, it was necessary to speculate about the possible effects that these devices had upon the user's experience of sound and

acoustic space based upon the physical attributes of the device itself in conjunction with other forms of historical documentation such as advertisements. However, in such cases whereby the description of the user's experience of sound and acoustic space is predominantly based upon speculation have been clearly signposted to the reader.

Summary

This thesis presents a study informed by media ecology that traces an anonymous history of acoustic space through the lens of acoustic prosthetic technologies for the ear. This research applies an innovative interdisciplinary method informed by media archaeology, specifically Giedion's (2013) approach to anonymous history, and an approach to post-phenomenology informed by Ihde's (1979; 2007) theory of embodiment relations. In doing so it presents an historical phenomenology of acoustic space. As this chapter has discussed, the integration of these approaches into this study's method affords the opportunity to not only trace the history of acoustic prosthetic technologies across key areas of innovation and application, but to also provide insight into how each of these acoustic devices reshaped the perception of acoustic space for the wearer.

In the spirit of media archaeology, in particular anonymous history, this study takes an unconventional approach to the writing of a history of technology. It does not follow a strict linear structure, but rather explores the development and use of acoustic prosthetic devices across three key areas of innovation: hearing

aids, the stethoscope, and the use of headphones for the primary purpose of auditory pleasure. In so doing, this study also draws attention to why each of these sites have been identified as playing an integral role in the technological evolution of acoustic prosthetic devices, and the ways in which they mediated, and therefore altered, the perception of acoustic space for the user.

The integration of this novel approach to the study of acoustic space through the lens of prosthetics for the ear also enables this research to add to the existing body of knowledge pertaining to acoustic space and auditory prosthetics. It does this by drawing further attention to the influence of these devices on not only the perception of sound and acoustic space, but also on the user's perception of the world around them, through a 're-tuning' of the mind's ear. Furthermore, this methodological strategy also affords a means by which to consider how the mediated perception of acoustic space has shifted over time, and how the changes in the ways in which the mediated perception of acoustic space altered the user's experience of, and relationship to, their surrounding environment. Finally, the development of the method applied in this thesis also makes a potential contribution by offering a practical approach for future historical research that considers the influence of media in instances where archival documentation is limited.

CHAPTER FOUR

A phenomenological anonymous history of hearing aids

4.1 Introduction

Hearing aids are acoustic prosthetic technologies for the ear that have the potential to alter the perception and experience of sound and acoustic space for individuals with impaired hearing. Worn in, around or behind the ear, hearing aids assist, or enhance, the user's ability to hear sounds they might not clearly perceive through the weakened, unaided ear. To date, hearing aids have been used as devices that enable individuals with a deficit in hearing to increase their level of participation in daily activities by helping to lessen "the specific problems faced by hearing impaired people and so improve their life quality" (Dillon, 2012, p. 2).

Hearing aid historian Neil Bauman argues that the primary purpose of hearing aids has essentially remained unchanged despite significant advances in audio technology, as "people are still the same as they were 150 years ago. They want to hear better without drawing attention to themselves" (personal communication, 2 November 2017). According to audiologist Robert Sandlin (1995) the efficiency and capabilities of these acoustic technologies for the ear have increased exponentially over the last fifty years with advances in electronic and digital technology. Indeed, considerable technological progress in the capacity of hearing aids to reproduce sound has not only enhanced the wearer's ability to perceive sounds more clearly through amplification and sound processing technologies, but has also made it

possible for the user to curate customised experiences of sound. This, in turn, has further changed the ways in which acoustic space is perceived.

Despite the ubiquity of hearing aids in Western society, and an abundance of scholarship (Bennion, 1994; Berger, 1970; Dillon, 2012; Goldenberg, 1996; Kranz, 1941; Sandlin, 1995; Schaub, 2008; Simko, 1986; Tate, 2013; Tobin, 1997; Valente, 2002), existing research has largely neglected to reflect on the phenomenological effects of these prosthetic technologies for the ear, in particular their influence on the construction, perception and experience of acoustic space. That is to say, literature has overlooked, first, how hearing aids alter the user's perception of sound, and second, the ways in which these prosthetic devices have evolved to facilitate and modify the perception of acoustic space. Largely undertaken within the fields of medicine and audiology, such research has primarily focused upon thresholds of auditory acuity and hearing loss, approaches to matching the most suitable aid to the patient, and the capacity for hearing aids to amplify and reproduce certain acoustic frequencies. Indeed, as previously noted in Chapter Two, Bregman (1990) observes that "if you were to pick up a general textbook on perception written before 1965 and leaf through it, you would not find any great concern with the perceptual or ecological questions about audition" (p. 1). While phenomenologist Don Ihde (2007) briefly touches on the embodied experience of wearing hearing aids in his study of the phenomenology of sound, his discussion is brief, limited to his own experience of digital hearing aids prior to 2007. Consequently, research conducted to date has paid little regard to the ways in

which the technological evolution of hearing aids over the last two hundred years has contributed, first, to changing modes in the mediated perception of sound, or second, the extent of these changes upon the user's perception of acoustic space.

This oversight is a problem, as until research is conducted to address these shortcomings it will not be possible to fully move beyond the notion of the mind-body dualism, argued by Rene Descartes (1983), whereby the mind and the body are considered to be distinctly separate from one another (Almog, 2002; Baker & Morris, 2005; Braider, 2012; Clarke, 2003; Ryle, 2018). The mind-body problem holds that “the mind is an entirely immaterial thing without any extension in it whatsoever, and, conversely, the body is an entirely material thing without any thinking in it at all” (Skirry, 2005, p. 5). By approaching the effects of hearing aids from a phenomenological perspective, it could equally be argued that this is not the case as an embodiment relationship is formed between the wearer and their device, effectively changing the way that they experience, and interact, with the world around them.

While affording the potential to make sounds louder and provide a direct pathway for that sound to the ear, hearing aids also likely shift the user's perceptual access to their immediate acoustic environment. Drawing on this insight, this chapter re-reads these devices historically from antiquity to the present. It argues that as hearing aid technology has continued to progress, devices that were ostensibly designed to connect hearing impaired individuals to the world paradoxically became devices that isolated the wearer in a singular, customised auditory world of their own making. In doing so, it illustrates that the wider

significance of hearing aids does not lie solely in their technical ability to augment the ear and sense of hearing through amplification, but also in the ways that they modify the user's perception of acoustic space.

As this chapter will show, hearing aids served historically to alter the experience of acoustic space through, first, changing the ways in which these devices collected and reproduced acoustic information, and second, by providing the user with an intrinsically directional experience of sound. This was made possible as aids for hearing enable the wearer to recover, to varying degrees, the capability to experience a more robust and balanced experience of sound, and detect the directionality and localisation of sounds while relieving a sense of auditory displacement. When we listen we not only “learn about the character of the things and happenings around [us] but also where they are in the surrounding environment” (O’Callaghan, 2010, p. 123). Therefore, the sounds that we hear “furnish [us] with spatial information about our surrounding environment” (p. 123).

When sound is mediated and amplified through an acoustic device such as a hearing aid, this provides the user with, first, a more comprehensive impression of their immediate acoustic environment, and second, potentially enables them to hear sounds from a greater distance, thus broadening the depth of their perception of acoustic space. Moreover, recent advances in hearing aid technology have seen the introduction of devices that place the wearer in greater control of their auditory experience. Personally programmable options integrated into modern hearing aids enable the user to create a personalised experience of sound, ultimately resulting in

a user-modified perception of acoustic space that places the user within a customised, and isolated, acoustic space of their own design.

This chapter explores the historical shifts in the effects of hearing aids upon users' perception of acoustic space across three key phases of their evolution: acoustic, electric and digital hearing aids. In so doing, it follows the historical development of hearing aids from rudimentary acoustic devices to the technologically advanced digital hearing aids of today. It is important to note, however, that this chapter does not set out to provide an all-encompassing history of hearing aids. Rather, it focuses upon different types of aids that had a significant bearing upon the user's access to, and perception of, acoustic space. Furthermore, the primary point of focus is not the physiology of the impaired ear, or upon the mechanics of the hearing aids discussed. Instead, the purpose of this chapter is to identify *what* effects hearing aids had upon the user's experience of acoustic space(s).

Through the lens of Ihde's (2007) theory of embodiment relations, which examines the process of habituation, this chapter will explore how an embodiment relation was formed between the user and their device, which in turn affected the user's perception of their surrounding sonic landscape and, ultimately, acoustic space. As discussed in Chapter Three, an embodiment relation, according to Ihde (2007) takes place when a technological artefact becomes a medium through which the individual perceives their world. As the use of a device becomes habitual they become quasi-transparent to the individual as the user becomes

accustomed to the presence of the device, thus significantly altering how the user perceives acoustic space as well the 'lived experience of sound, and therefore their sense of being in the world. In addition, this chapter also applies David Howes' (2005) paradigm of sensory emplacement and displacement, which holds that if one or more of the senses is cut off or withdraws in some way, the individual's experience and perception of their surroundings is therefore significantly altered. When applied to hearing aids, this model provides a means through which to consider, first, how these devices that were designed to connect individuals with a deficit in hearing to the world, paradoxically evolved to become instruments that isolate the wearer in a singular, personalised auditory world of their own making.

First, this chapter traces the earliest known references to efforts to fashion devices to aid impaired hearing from the classical period to the seventeenth century, and considers how rudimentary aids for hearing may have altered how the user experienced their acoustic environment. Second, it follows the historical evolution of non-electric hearing aids, specifically how these hearing aids were designed to maximise the amplification of sound, and the ensuing effects this had upon the experience of acoustic space. It also examines how attempts to miniaturise and conceal the use of instruments to assist hearing influenced the user's perception of their surrounding acoustic space, which also effectively marked the beginning of a process of the transparent embodiment of hearing aids. The chapter then explores the changes in the capabilities of hearing aids that came about through electrification, especially how the inclusion of various settings and

functions within the aid enabled the user to create customised experiences of sound, specifically how digital hearing aids afforded the user control over their auditory experience. It pays particular attention to the nature of the embodiment relation that takes place between the user and their digital aid, and how the creation of a personalised acoustic experience can contribute to a greater sense of auditory displacement. Through this examination of the effects of hearing aids from a historical and phenomenological perspective, this chapter offers further insight into how these prosthetic technologies for the ear, in assisting an impaired sense of hearing, have altered the experience of acoustic space, and therefore contributed to a re-tuning of the mind's ear.

4.2 Hearing and impairment

Sound matters. Our sense of hearing not only helps us detect and decipher acoustic signals moving through space, but also helps us to grasp the contours of the space(s) that we perceive and inhabit. Sound operates as the interface between the individual and the spaces in which they exist, facilitating communication and the development of relationships with the environment and others (O'Callaghan, 2010; Stocker, 2013; Truax, 2001). Auditory cues provide the listener with a plethora of information about their surrounding environment. As sound studies scholar Vincent Andrisani (2010) argues, the study of acoustic space must also take into account the individual's ability to perceive auditory information. Andrisani argues that the term acoustic space should

Not only [refer] to the sound of the environment, but perhaps more significantly, to the manner in which relationships are created or neglected through the use of the aural modality. Accordingly, the focus of acoustic space is not on the nature of the acoustic environment per se; rather, it endeavours to address the perceptual capacity of the individual and the extent to which one is attuned to their acoustic environment. Acoustic space thus represents a listener-centred exercise in cognition that draws attention to the level of information exchange between the individual and the environment on the basis of perceptual engagement (p. 2).

This raises the question of how acoustic space is experienced by those with a weakened sense of hearing, specifically how a deficit in hearing contributes to how the individual experiences and perceives the world around them. The perception of acoustic space is fundamentally different for individuals with a hearing impairment in comparison to those who are of able hearing. Impaired hearing refers to the incapacity of the ear to receive and process sound clearly resulting in a diminished ability to detect sound (Nordqvist, 2017; Schafer, 1994; Schaub, 2008). This occurs due to a shortfall in the acuity of hearing sound in one or both ears.

There are different types of hearing loss (conductive, sensorineural or mixed (Schaub, 2008; National Foundation for the Deaf, 2017)), indicating different degrees of auditory weakness. The severity of hearing impairment can range from

mild to severe, each affecting the ability to process sound and the perception of acoustic space in slightly different ways. Mild to moderate hearing impairment result in the individual's inability to hear and decipher speech and faint sounds. In turn, this has a bearing on their capacity to communicate efficiently with others as well as affecting a sense of space. Severe hearing impairment, on the other hand, implies acute deafness, which is the incapacity to detect sound (Schaub, 2008; Scheuenke, Schulte & Schumacher, 2010), leaving the individual with little to no awareness of, or ability to navigate, their acoustic environment(s). Furthermore, hearing loss encompasses more than simply the attenuation of sound; it also involves the distortion of sound (Kuk & Korhonen, 2014). For hearing impaired individuals, sounds can become muffled, meaning that they have difficulty differentiating between various sounds, which often results in the individual experiencing a cacophony of indistinguishable noise.

An impaired sense of hearing can have a substantial impact on the perception of acoustic space. While a hearing aid that is correctly fitted by an acoustician may assist in the correction of a loss of hearing sensitivity it is much more difficult, and in some cases impossible, to correct a physical deformation or disease of the inner ear. In more severe cases of hearing loss, the distortion of sound by the ear mechanism can result in the brain being unable to process sound signals, leading to a confusing auditory experience (Kuk & Korhonen, 2014), affecting the ability to detect individual sounds. Consequently, a deficit in hearing interrupts the relationship of the individual to their surrounding acoustic space.

The inability to clearly hear the sounds of the immediate auditory environment means that the 'horizonless' and 'boundless' spatial characteristics of acoustic space, as described by McLuhan and Carpenter (1960), no longer apply. Instead, the perception of acoustic space shrinks and becomes confined within the significantly narrowed limits of the individual's ability to detect sound. In the case of hearing impaired individuals, therefore, only sounds of a certain volume and within close proximity to the listener can be perceived. Even then these sounds may be distorted to some degree.

Without the ability to clearly detect the origin and directionality of the sounds of the proximate acoustic environment, the individual's aptitude to measure the shape, size, and compactness of the environment, and ultimately their sense of place within, is compromised (Stocker, 2013). According to Truax (2006) the human perception of acoustic space is largely reliant upon how, or *if*, we are able to interpret the acoustic cues that occur within our environment(s), as it is the perception of this sonic information that creates a sense of acoustic space. For example, German composer Ludwig van Beethoven suffered from a form of degenerative hearing loss from his early thirties until his death in 1827. He considered his affliction to be particularly cruel given his profession, and wrote to friends on several occasions describing the impact that his loss of hearing had upon his perception of sound. In one instance he wrote, "Often I can scarcely hear any one speaking to me; the tone yes, but not the actual words. Yet as soon as any one shouts, it is unbearable" (Beethoven, Kalischer & Hull, 1972, p. 20). From this

description it appears that at the time the letter was written, as is the case with many individuals with a moderate to severe hearing impairment, exposure to loud noises caused Beethoven physical pain, with his ears becoming increasingly sensitive to loud sounds. While he was still able to detect some sound Beethoven indicates that he experienced sonic phenomena as a kind of homogenous mass that was either very distorted, painfully intrusive, or both. These sonic signifiers refused to disappear into their signifieds; rather they lingered oppressively. This not only hindered his ability to communicate but also effectively cut him off from the product of his own works as he became profoundly aware of the confines of his acoustic space.

Iconic American writer and activist Helen Keller also provides some insight into the experience of acoustic space in the face of profound deafness. Having been rendered both deaf and blind as an infant, Keller evocatively describes how the complications of deafness can reach far beyond a physical inability to hear. She explains

The problems of deafness are deeper and more complex, if not more important, than those of blindness. Deafness is a much worse misfortune. For it means the loss of the most vital stimulus – the sound of the voice that brings language, sets thoughts astir, and keeps us in the intellectual company of man [sic] (Keller, 2016, p. 47).

While underscoring the widespread importance placed on vision as the dominant human sense, Keller laments her inability to hear the sounds of the human voice and the mental stimulus of conversation. She gestures towards a feeling of displacement from her surroundings, as her relationship with acoustic space, unlike that of able-hearing individuals, is one of exclusion. The misfortune that she speaks of is not simply a severely reduced capacity to hear the human voice but also her exclusion from the experience of acoustic space and the ability to maintain a relationship with her environment, and others, through sound. These accounts given by Beethoven and Keller indicate that the experience of sound, and therefore acoustic space, is markedly different from that of individuals of able hearing. Our reliance on the ability to hear is such that the impacts of impaired hearing can be extreme. The diminished ability to clearly perceive sound creates a different reality for the individual, contributing to a sense of displacement and exclusion from their encompassing acoustic environment.

As Beethoven's and Keller's respective accounts also suggest, the experience of acoustic space for the profoundly deaf is more complex and complicated than for those with mild or moderate degrees of deafness. In many cases the moderately deaf may be able to identify the presence of sound in the form of the vibrations of louder noises occurring within their physical environment, however, "profound deafness excludes all sound contact" (Le Breton, 2017, p. 92). In such cases, the individual is unable to hear via air conduction (although they may be able to detect the occurrence of loud sounds from their surrounding environment through bone

conduction). Yet depending on when the profoundly deaf individual was rendered deaf, they may be able to recall the memory of certain sounds. Le Breton argues that “the age at which deafness sets in is a decisive element in the individual’s development, either opening or closing the door onto language and, especially, onto knowledge of the world’s possible sounds” (p. 92). Therefore, this gateway into the world of sounds was largely reliant upon whether or not the individual was old enough to remember the sounds they had experienced or not. Ihde (2007), following Merleau-Ponty’s (2013) claim that perception is the primary mode in which the world is revealed to us, argues that the imagination is dependant upon perception. Therefore, in order to imagine the different elements of our surrounding environment we must have first perceived them. In the case of profoundly deaf individuals, such as Helen Keller, the memories of the characteristics of different sounds may allow the individual to ‘hear’ imagined sounds as their psyche recalls the memory of auditory phenomena that they once experienced. In such instances it was possible for the hearing impaired to perceive a phantom acoustic space made possible through the auditory imagination, an acoustic space populated by recollected, rather than real-time, sounds.

Therefore, for those among the profoundly deaf who had been able to hear at some point in their life, this phantom acoustic space is perceived as being interior rather than exterior. In other words, acoustic space is not experienced as stretching out indefinitely in every direction. Rather, a perceived interior acoustic space, which Ihde (2007) refers to as the auditory imagination, operates as the

foundation of their experience of an apparent acoustic space. While everyone who has experienced sound in some capacity has an auditory imagination, in profoundly deaf individuals who once had the capacity to hear, this phenomenon may be amplified as it becomes their primary source of sonic reference. Perhaps the most common experience of the auditory imagination at play is inner speech, a form of thinking that occurs when we read or think to ourselves. In this instance the auditory imagination entails us hearing our own voice in our head, an inwards voice confined to our own imagined interior acoustic space. This acoustic phenomenon is perceived by profoundly deaf individuals with some memories of the characteristics of sound. Berendt (1988) notes that composers often practice what he refers to as inwards listening, whereby they can imagine the notes they write in their head, and how they sound together to form a piece of music. It appears likely that such a method was used by Beethoven as his hearing continued to deteriorate in later life, as he was able to recall the different notes and sounds produced by his piano and could 'hear' them in the interior acoustic space of the mind as he played through his auditory imagination.

It appears that the experience of acoustic space for the profoundly deaf prior to the late twentieth century was largely defined by the extent of their auditory imagination, as there were no hearing aids suitable to ameliorate acute deafness. Yet, for individuals with a mild to moderate hearing impairment who possessed some ability to detect and experience their encompassing acoustic environment,

the use of a prosthetic offered the potential for greater auditory access to their immediate external acoustic space.

4.3 The early history of hearing aids

The long history of the use of aids to assist hearing underscores the importance placed on the ability to clearly perceive the sonic details of acoustic space. In response to the phenomenological and personal strains of hearing impairment, there have been a number of attempts to restore some degree of hearing through the crafting of various instruments to augment the impaired ear. The use of an assortment of objects to relieve a shortfall in hearing can be traced back several millennia (Berger, 1970, Bennion, 1994; Bauman 2017). Yet unfortunately much of the early history of prosthetics for the ear used for these purposes remains undocumented, making it extremely difficult to develop a reliable account of when the first hearing aids were developed, and how effective they were in aiding a deficit in hearing (Berger, 1970). Consequently, much of the early history of the development and use of prosthetics for the ear used to aid hearing is open to speculation. Despite this lack of verifiable information, consideration of the physical attributes of various instruments used to assist hearing can provide some insight into, first, how the device delivered sound to the ear, and second, how the device may have affected the user's perception of sound and acoustic space.

There appears to be a consensus amongst historians, predominantly led by the research of hearing aid historian Kenneth Berger (1970), that it is probable that one of the first methods of extending the ear and the sense of hearing was not through the use of a prosthetic per se, but rather the practice of cupping the hand to the ear in an attempt to make weak sounds louder (Berger, 1970; Brosch and Pirsig, 2003; Mylonakis and Martini, 2017; Stephens and Goodwin, 1984). This practice used the hand to physically extend the ear in a rudimentary effort to direct sound waves into the ear canal more proficiently and provide some amplification of sound. De Boer (1982) tested the effectiveness of this method by using a mannequin to measure levels of amplification. The study found that cupping the hand behind the ear is capable of amplifying sound between 1000 - 3000 Hz, depending on how the hand is held. These findings are consistent with other studies conducted to determine the effectiveness of placing the hand behind the ear to aid hearing (Barr-Hamilton, 1983; Yule, 2014). By affording some amplification of sound it appears that this method had the potential to assist those with mild hearing loss to slightly more acoustic detail from their acoustic space, in particular from the foreground of the surrounding acoustic environment. However, in the case of individuals with moderate to severe hearing loss, it is likely that this method would have served only to make the experience of already stifled and indistinguishable sounds louder, thus intensifying an already confusing and potentially unpleasant auditory experience. Berger suggests that the practice of cupping the hand to the ear may have in fact operated on a much more basic level,

in that it provided a visual cue to the speaker to raise their voice. Yet regardless of whether or not this method for extending the ear was indeed effective, it indicated the need for an instrument to facilitate communication and allocate the hearing impaired individual enhanced accessibility to their immediate sonic environment and the details of their surrounding acoustic space.

Enduring attempts to remedy a deficit in auditory acuity in order for the hearing impaired individual to perceive the characteristics and detail of acoustic space appears to have led to the use of naturally occurring objects such as animal horns and large seashells as an early form of prosthetic for the ear (Berger, 1970). Several centuries BCE (Before Common Era) the Greeks appear to have used a number of different shells that had been hardened with paint that could have been used as a primitive type of acoustic horn or hearing aid (Berger, 1970; Montague 2014). Bronze instruments shaped like funnels with a spiral tube at the end were also located near Pompeii, and may have been used by the Romans in a similar manner (Berger, 1970). It appears that such objects could have been mildly effective to assist hearing, providing moderate amplification of sound and potentially increasing the user's ability to hear the sounds around them (De Boer, 1982; Filer, Ross & Wiener, 1945). While this may have endowed the user with enhanced auditory access to their surrounding acoustic space, it is likely that this was achieved almost exclusively through the amplification of sounds within close proximity to the individual rather than providing a means for the user to be able to detect the acoustic minutiae of their environment.

An unobstructed and developed sense of hearing in antiquity was of immense importance for two key reasons. First, it made it possible for the individual to communicate and maintain a relationship with others and their immediate acoustic environment, and second, the sense of hearing was an integral tool for the individual's survival (Stocker, 2013). As noted by Blesser and Salter (2007),

In tribal societies where survival was a continuous struggle against invisible and dangerous events, soundscapes were frequently more relevant than landscapes. Whereas landscapes can be comparatively static, sometimes almost lifeless, soundscapes require activities to produce sonic events. From an evolutionary perspective, hearing events made a critically important contribution to survival... Because events might signal danger, soundscapes were an early warning system (p. 3).

The capacity to detect the sounds of the circumambient environment was essential for continued endurance and existence as the inability to sense sound could ultimately result in injury or death. It is probable, therefore, that this dependence upon auditory acuity directly contributed to the development of some of the earliest aids for hearing in an attempt to provide the hearing impaired individual with a device that could grant them greater accessibility to the world of sound. This, in turn, enhanced their awareness and consciousness of acoustic space as well

as contributing to a continued relationship between the individual and their environment. Furthermore, it is also possible aids were also utilised by those with normal hearing in order to provide enhanced auditory acuity by augmenting the ear's natural capacity to detect the minutiae of their immediate sonic space.

References to the use of rudimentary tools to amplify sound and boost accessibility to acoustic space can be traced back to classical works of Greek literature. Such references provide some insight, albeit fleeting, into how instruments used to aid the ear and sense of hearing may have evolved and been used. The first of these references appears in Homer's *The Iliad* (circa 850 BCE), which describes the use of a bronze trumpet to carry the voice across distance:

High in the rampart rais'd his voice aloud;
With her own shout Minerva sells the sound,
Troy starts astonish'd, and the shores rebound.
As the loud trumpet's brazen mouth from far
With shrilling clangor sounds the alarm of war (Pope, 2013, p. 18).

The instrument described above, a speaking trumpet, was not a prosthetic for the ear per se, but rather an instrument used to amplify sound by projecting the voice of the speaker over a larger space. Effectively an early form of megaphone, the user spoke into the narrow end of the trumpet and the voice was amplified as it travelled through the device and was projected from the opening. Speaking

trumpets, which initially appear to have been utilised by sailors, were predominantly used to communicate between ships or army units.

Although not a dedicated aid for hearing, the speaking trumpet remains worthy of attention because of its ability to amplify sound. Berger (1970) suggests it is possible that “the first fabricated hearing aid was a primitive musical trumpet which someone accidentally found to provide improvement in sensitivity to sound when the small end was held at the ear” (p. 8). It is possible that the speaking trumpet was used as an instrument to, first, provide a direct pathway for sound to reach the ear, and second, to afford some amplification of sound for the user. Unfortunately, however, there is no evidence to confirm this. In a similar manner to the practice of cupping the hand behind the ear, by reversing the speaking trumpet it appears probable that the user would have been able to hear speech at close proximity more clearly. Yet it is unlikely that the reversal of the speaking trumpet act as a primitive aid for hearing would have had any impact upon the user’s ability to detect sounds occurring at a greater distance. The speaking trumpet is also relevant as it is possible that the device may have acted as a precursor to the first hearing aids developed specifically to afford improved auditory acuity.

Classical Greek literature also provides a tale of the use of a type of prosthetic for the ear fashioned to manipulate the experience of acoustic space. In Homer’s *The Odyssey* (c. 800 BCE) Odysseus deliberately impaired his crews’ sense of hearing by fashioning a rudimentary device that would block out

potentially dangerous sound. In order to stop his sailors from hearing, and being tempted by, the singing of the Sirens, he plugs the ears of his crew with beeswax:

I took a large wheel of wax and cut it up small with my sword.
Then I kneaded the wax in my string hands till it became soft,
which it soon did between the kneading and the rays of the sun-god
of Hyperion. Then I stopped the ears of all my men and they bound
me hands and feet to the mast as I stood upright on the crosspiece;
but they went on rowing themselves. When we had got within
earshot of the land, and the ship was going at a good rate, the
Sirens saw that we were getting in shore and began their singing
(Pope, 2008, Book XII, para 15).



Figure 4.1: Painting by J.M. Woodhouse depicting the passage of Odysseus' vessel through the Strait of Messina, where he ties himself to the mast of his boat in an attempt to stop being lured to the shore by the songs of the Sirens.

Reprinted from The National Gallery of Victoria. Retrieved 5 October 2017 from <https://www.ngv.vic.gov.au/essay/j-w-waterhouses-ulysses-and-the-sirens-breaking-tradition-and-revealing-fears-2/>

This appears to be the earliest existing reference to the use of a prosthetic for the ear used to block out extraneous sound. This deliberate manipulation of the perception of acoustic space effectively foreshadows the development of noise cancelling acoustic technologies in the late twentieth century that eliminate unwanted or undesirable sounds from the surrounding soundscape. Furthermore, the effect of this rudimentary prosthetic for the ear upon the perception of acoustic space appears to have been the same as the use of earplugs. As the opening to the ear canal was blocked so that sound could not enter the ear, the user's ensuing experience of acoustic space would have been similar to the aforementioned auditory imagination experienced by the profoundly deaf. Furthermore, it is possible that this description of a sound-blocking device essentially marked the beginning of attempts to control the experience of sound in acoustic space through the use of a prosthetic. Yet despite sporadic literary references to specific instruments to amplify or shut out sound that date back several millennia, existing documentation of the invention and application of hearing aids appears to only date back to the sixteenth century.

This paucity in historical records may, at least in part, be attributed to widespread stigma surrounding the deaf and hearing impaired. Individuals with a loss of hearing were widely thought of as being deformed, disabled, and old, and were frequently labelled as invalids and even ungodly, as some believed that the deaf must have defied God in some way to have been struck with a physical disability (Bennion, 1994; Berger, 1970). Indeed, The Bible includes several

passages that could be interpreted as individuals being struck deaf and dumb for their sins. For example, Exodus 4:11 reads “The Lord said to him, who has made man’s mouth? or who makes him mute or deaf, or seeing or blind? Is it not I, the Lord?”, suggesting that deafness was a punishment bestowed by God for failing to heed his words. Similarly, a passage in Luke 1:20 states “And behold, you shall be silent and unable to speak until the day when these things take place, because you did not believe my words, which will be fulfilled in their proper time”. Yet in the face of widespread fear and ridicule of the deaf, there were sporadic attempts to alleviate the burdens of impaired hearing.

During the Scientific Revolution, which took place between the sixteenth and eighteenth centuries, there appears to have been a growth in interest in the anatomy of the human ear and ongoing attempts to understand both how the ear operates and causes of deafness. Cockayne (2003) argues that by 1560 both the senses of hearing and sight were regarded as particularly valuable, for example, “in the Anglican church the ability to hear was a paramount skill, necessary to absorb the word of God, which was now muttered in the vernacular tongue” (p. 496). This period also saw attempts to educate the deaf and dumb by various religious orders, including Benedictine monks in Spain. It is against this backdrop that one of the earliest records of the fashioning of a dedicated hearing aid emerge, although it appears that this device was not intended to be used by hearing impaired individuals, but rather to surpass the natural auditory capacity of those with normal hearing. In *Magiae Naturalis*, originally published in 1588, Italian

physician, scientist and cryptographer Giambattista Porta (also known as Giovanni Battista della Porta and John Baptist Porta) describes instruments carved from porous wood to resemble the ears of animals renowned for their exceptional sense of hearing. He explains

We must consider the ears of all living creatures, that hear best. For this is confirmed in the principles of natural philosophy, that when any new things are to be invented, nature must be searched, and followed. Therefore to consider of animals, that have the quickest hearing, we must think of those that are most fearful. For nature takes care for their safety, that as they have no great strength. Yet they might exceed others in hearing, and save themselves by flight. As the Hare, Coney, Hart, the Ass, Ox, and the like. These creatures have great ears, and always open toward their foreheads. And the open passages are to carry the sound from the place whence it comes (Porta, 2011, Chapter V, p. 122).

It was Porta's intention that his auditory prosthetics provide the user with acute hearing abilities with a view to surpassing the natural hearing thresholds of humans. If Porta's device had proved to be successful, the user would have been able to experience sound in the same way as the animals that the ears were designed to emulate. The likelihood of this happening, however, was remote at

best. Attempting to recreate such a heightened sense of sound and acoustic space would have been virtually impossible to achieve without the use of modern digital technology. Unfortunately there does not appear to be any record of whether or not Porta put his hypothetical prosthetic design into practice. While Porta may have been able to create an inanimate representation of the physical attributes of the outer ear of animals such as the hare and the fox, these inventions lacked the inner ear mechanism of the animals in question. As such, they would not have been able to reproduce higher frequencies of sound, nor would they have been attuned to the directionality of sounds within a given acoustic environment, factors that play an integral role in the perception of sound and acoustic space.

Philosopher and scientist Francis Bacon also described his idea for a prosthetic for the ear designed to enhance the user's ability to hear and perceive sound, and therefore acoustic space, with greater clarity. In *Sylva sylvarum: A natural history*, first published in 1627, Bacon stresses the need for a device to assist the hearing impaired. He details a type of instrument, to which he refers as 'ear spectacles', drawing a comparison between the functions of a pair of eyeglasses and an aid for hearing. Bacon explains:

Let it be tried, for the help of hearing... to make an instrument like a tunnel; the narrow part whereof may be the bigness of the hole of the ear; and the broader end much larger, like a bell at the skirts... And let the narrow end of it be set against the ear; and

mark whether any sound... will not be heard distinctly from further distance than without that instrument; being (as it were) an ear-spectacle (Bacon, 1841, p. 44).

As eyeglasses assist those with impaired vision to bring the world into greater clarity, so these acoustic devices would enable the world of sound to be brought into auditory focus for the hearing impaired. Furthermore, he implies that such a device would enable sounds that could not be detected by the healthy, naked ear to be detectable, and this is reminiscent of Porta's prosthetic animal ears. Despite the visual and auditory apparatus of the human body operating in very different ways, Bacon appears convinced that these ear spectacles would be of practical assistance. He states that he heard that in Spain there existed "an instrument in use to be set to the ear that helpeth somewhat those that are thick of hearing" (p. 44), that would perform a similar function to that of the device that he envisions. As such, Bacon's proposed eye-spectacles would have amplified the sounds of acoustic space, thus affording the user with a richer auditory experience, allowing them to hear sounds that the unaided, impaired ear(s) could not.

Attempts to ameliorate the deficit in hearing acuity experienced by hearing impaired individuals also involved sporadic attempts to use bone conduction. One of the earliest existing references to bone conduction comes from physician and anatomist Andreas Vesalius (1515 – 1564), who identifies and discusses bone conduction in his book *De humani corporis fabrica* (*On the fabric of the human*

body) (1543), which examines the temporal bones of the human skull. Similarly, Gabrielle Fallopio (Fallopius) (1532 - 1562) and Bartolomeo Eustachi (Eustachius) (1514 -1574), for whom the Eustachian tube of the inner ear was named, also identified bone conduction in their respective studies into human anatomy (Staab, 2015). A more comprehensive explanation of the diagnosis of hearing impairment through the application of bone conduction was recorded by Italian physician, philosopher and mathematician Girolamo Cardano, (also known as Girolamo Cappivaccio) (1523 – 1589), who in *De Subtilitate* (1550) identifies the possible use of bone conduction as a means for diagnosing forms of hearing loss. He describes a technique for transmitting sound into the ear by biting down on one end of a wooden rod while the other end was placed on the strings of a zither as they vibrated. If the individual was able to detect a sound, their deafness was diagnosed as a disorder or disease of the tympanic membrane. On the other hand, if unable to detect any sound, they were diagnosed with a disorder of the labyrinth of the ear (Berger, 1970; Staab, 1985). Interestingly, it appears that Beethoven would, many years later, use a similar method to hear the sounds of his piano by biting down on a wooden rod and placing the other end on the piano, allowing him to hear his compositions to some degree when his air conduction hearing aids no longer worked (Cooper, 2000), thus providing him with a degree of access to his immediate acoustic space. However, Beethoven’s experience of this auditory space would have been one-dimensional, as he would have only been able to detect the sounds made by the piano as he played.

Early methods for hearing sound via bone conduction produced a different experience of acoustic space for the listener than perceiving sound through air conduction. First, the transmission of sound through bone conduction produces lower frequencies, resulting in a lower and flatter experience of sound (Bowers, Ravicz, & Rosowski, 2017). Second, by applying the method used by Beethoven, whereby the individual bites down on a rod or wooden stick resting in the source of sound, the user would have only been able to hear the sounds that were transmitted through the rod. Consequently, however, only one source of sound could be perceived at a time, and the types of sound that could be detected through this practice would have also been significantly limited, as the wooden rod had to be simultaneously touching both the source of sound and the teeth of the user. Thus the user's ability to perceive acoustic space would have been very narrow in scope, affording the opportunity to perceive one or two sounds that occurred within very close physical proximity to the individual. In contrast to Carpenter and McLuhan's (1960), Ong's (2002) and Schafer's (1994) respective explanations of the characteristics of acoustic space, the user's ensuing experience of acoustic space would have lacked spatiality and been one-dimensional rather than providing the impression of sound coming from multiple directions at once. Yet without the use of a wooden rod or similar instrument the individual would have remained ensconced in a world of either virtual silence or a homogenous mass of noise, effectively isolated from their surrounding acoustic space and the world of sounds.

Despite these sporadic historical references to prosthetics for the ear used to alleviate hearing loss, some of which date back millennia, it appears hearing aids were not readily available for use until the early eighteenth century. A contributing factor to the limited availability of hearing aids may be due to a scarcity of knowledge concerning the physiology of the ear prior to the Renaissance (Berger, 1970). The lack of information pertaining to the anatomy of the ear can in part be attributed to the inability to access the temporal bone of the skull during this period, in conjunction with the widespread belief that the human body should not be subjected to dissection (Hachmeister, 2003). Therefore, it was not until the scientific revolution of the sixteenth and seventeenth centuries that the organ of the ear was described in any detail by anatomists and physicians Verslius and Fallopio. Up until this point there was minimal understanding of how the ear actually functioned, and therefore the various causes and implications of hearing impairment were simply not understood (Bennion, 1994; Berger, 1970; Cockayne, 2003).

It seems that it was not until there was greater knowledge of how the inner ear functioned that the production of dedicated hearing aids to assist the hearing impaired truly began. Clearly, however, even in the early sixteenth century the perceptual and social isolation of hearing loss pre-empted considerable work in the augmentation of the ear and the sense of hearing. Attempts to develop prosthetics for the ear to remedy the inability to perceive sound and acoustic space, in conjunction with the limited capacity for communication experienced by hearing

impaired individuals, signalled the importance of the ability to hear in forming and maintaining a relationship between the individual and their surrounding soundscape.

4.4 Hearing aids and acoustic space

Different types of hearing aids provide the user with varying perceptions of acoustic space. Prior to the mass production of devices to assist impaired hearing in the early nineteenth century hearing aids, such as those discussed earlier in section 4.3, had predominantly been made to order. The size of the aid varied depending on the individual needs of the user. For example, individuals with mild forms of hearing loss typically used smaller instruments, whereas those with a moderate or severe deficit in hearing used larger devices to assist their ability to perceive sound and access their encompassing sonic environment. Yet as the commercial production of hearing aids commenced in the early nineteenth century increasing numbers of different makes and models of hearing aids in a variety of shapes and sizes became available. The effectiveness of these non-electric aids, developed during what Berger (1970) refers to as the Acoustic era, to amplify and reproduce sound, was almost entirely dependent upon the design and physicality of the instrument. As the hearing impaired could now choose from a range of aids designed for slightly different purposes and hearing abilities, they were no longer restricted to the use of a single aid to be used for all acoustic situations and spaces.

There were four primary types of non-electric hearing aids during the nineteenth and early twentieth centuries: ear trumpets, conversation tubes, ear inserts and auricles (Bauman, 2017; Berger, 1970), each of which was capable of providing a different experience of sound and acoustic space for the user. The first of these devices, the ear trumpet, was the most widely used type of hearing aid during the nineteenth century (as shown in Figures 4.2 and 4.3). Also known as the ear horn or acoustic horn, ear trumpets were tubular shaped instruments that quite literally extended the ear. The ear trumpet had three primary functions: first, to provide a direct pathway for sound to reach the ear of the user; second, to amplify sound as it travelled from one end of the device to the other, and third, to shield the ear from potentially distracting and unwanted ambient noise.



Figure 4.2: An early type of ear trumpet, possibly dating back to the early nineteenth century, fashioned from a hollowed out bison horn. This was a customary shape and style of trumpet during this period.
Reprinted from Bernard Becker Medical Museum. Retrieved 9 March 2016 from <https://www.hearingaidmuseum.com/gallery/NonElectric/EarTrumpets/Long%20Trumpets/info/bison.htm>



Figure 4.3: A telescoping tube ear trumpet. This was a common style of trumpet used from the mid-nineteenth to the early twentieth century.
Reprinted from: Bernard Becker Medical Museum. Retrieved 9 March 2016 from <https://www.hearingaidmuseum.com/gallery/NonElectric/EarTrumpets/Long%20Trumpets/info/connicaltin.htm>

When used, the narrow end of the ear trumpet was inserted into the opening of the ear canal, or held to the outer ear with the wider end pointed outwards in order to capture ambient sound. As sound energy travelled through the ear trumpet, it was amplified as it passed from one end of the device to the other. However, while providing a contained pathway for sound to reach the ear, the ear trumpet also shut out a majority of ambient noise, therefore only providing the wearer with a very limited impression of the surrounding auditory environment, in that they would have only been able to hear the sounds from the direction in which the device was pointed.

The way in which the ear trumpet was used also had a very strong bearing on the user's perception of acoustic space. As ear trumpets were uni-directional devices they were only capable of capturing sound from one small portion of the acoustic environment at a time. They were unable to emulate the effect of hearing sound from 360 degrees. Rather, they were capable only of collecting and

reproducing a mere fraction of the sonic phenomena of acoustic space. This space was approximately 70-90 degrees in size. As Kuk and Korhonen (2014) have noted, the ability to determine the direction in which a sound originates within a three-dimensional space is key to a “more natural and comfortable listening experience” (para. 1), and the process of being able to perceive the characteristics of a given acoustic space. This raises the question of the perception of the directionality and distinctiveness of sound within acoustic space. Ihde (2007) explains that while the visual field is perceived as being a space in front of the individual,

The spatiality of the auditory field displays a different character. It is clear that within the auditory field we may speak of the direction of a given sound (it comes from behind me) and of particular sounds we may perceive as being near or far from us. But as a field, we must say that it *surrounds* us. I am immersed in the auditory field that displays no definite boundaries such as those of vision. The sound field, unlike the visual field which remains in front of me, displays an indefinite space in all directions from me (p. 207).

Here, Ihde describes the experience of auditory spatiality for the able hearing, whereby sound encompasses the individual and thus, they can determine the directions from where those sounds originate. On the other hand, in the case of those whose experience of the acoustic environment was mediated by the ear trumpet, acoustic space would have resembled that of the visual field Ihde depicts

above, in that their mediation of acoustic space came from the direction in which the ear trumpet was pointed. The user's ensuing experience of acoustic space resembled the kind of directionality Ihde associates with vision. As we turn our head in order to look in different directions, the ear trumpet user had to point the end of the trumpet in the desired direction in order to capture sounds from a particular point within their surrounding acoustic environment.

Although the ear trumpet wearer was not limited to the acoustic signals from a particular area of their acoustic space, they had to prioritise which direction they wished to receive information from, whether it was from someone speaking next to them, or turning their device towards a different source of sound. American writer Nathaniel Hawthorne (1871) describes the way in which English author Harriet Martineau used her ear trumpet, a device she became synonymous with, referring to it as a 'new organ' that was used as an extension of her body:

All the while she talks and she moves the bowl of her ear trumpet from one auditor to another so that it becomes quite an organ of intelligence and sympathy between her and yourself. The ear trumpet seems a sensible part of her, like the antennae of some insects. If you have any little remark to make, you drop it in and she helps you to make remarks by this delicate little appeal of the trumpet, as she slightly directs it towards you, and if you have nothing to say, the appeal is not so strong enough to embarrass you (p. 116).

From Hawthorne's account it appears that Martineau used her ear trumpet in very close proximity to those with whom she was communicating. As Bauman (2017) points out, ear trumpets were most effective when they were used in propinquity to the speaker. Thus, the closer the speaker was to the opening of the ear trumpet, the more successful Martineau was in the way that she would manipulate the use of her ear trumpet. She was extremely shrewd in utilising a simple yet effective method to maximise the potential of the trumpet to amplify sound, as well as using the device to control her experience of acoustic space. In addition, she subtly used her ear trumpet to direct and take charge of conversations by changing the direction in which the ear trumpet was pointed. By manoeuvring the receptor of the ear trumpet towards the desired source of sound, Martineau was effectively extending her ear, and therefore her body into her surrounding acoustic space in order to access the sounds within her immediate proximity that she wished to hear (as demonstrated in Figure 4.4). Yet due to the directional nature of the ear trumpet, Martineau's experience of acoustic space would have consisted of the voice of the speaker, and perhaps an indistinguishable, muffled hum of background noise, sounds that were too far away for the ear trumpet to amplify or clarify. Consequently, her perceived acoustic space was also one-dimensional in that it was dominated by speech coming from a single direction.



Figure 4.4: A photograph of Mary Greg (wife of Samuel Greg Jnr, whose father was British politician Samuel Greg) directing the receptor of her ear trumpet towards her daughter in a manner similar to that used by Harriet Martineau (c. 1900).

Reprinted from Manchester Art Gallery. Retrieved on 19 March 2018 from <http://manchesterartgallery.org/spotlight/the-mary-greg-collection>

Some models of ear trumpet, however, were capable of broadening the user's experience of acoustic space to some degree. Ear trumpets that featured a wider opening and resonator, such as the type used by Martineau and Mary Greg (as shown above in Figure 4.4), typically provided greater levels of amplification and could be used to detect sounds from a slightly further distance (Berger, 1970; Bennion, 1994). In a discussion of the benefits of short ear trumpets Curtis (1836) argues, "in some cases it is found to be of considerable benefit, [but] it is useless ever to expect to hear so well with a short trumpet, however excellent, as with a long one...the longer the trumpet, the greater will be its power" (p. 182). As sound was amplified there was a greater chance of the weakened ear being able to detect sounds that the unaided ear could not. As shown in Figure 4.5 below, there was a significant difference in the size of small and long ear trumpets.

Figure 4.5: An illustration that appeared in an 1900 catalogue of the different styles of ear trumpet produced by G. Tiemann and Co. New York. Different ear trumpets were suited to the differing needs of users and the environment in which they were to be predominantly used. Reprinted from Getty Images. Retrieved 21 March 2015 from <https://www.gettyimages.ca/detail/news-photo/illustration-of-a-variety-of-ear-trumpets-from-g-tiemann-news-photo/170465875>

Smaller ear trumpets, however, were intended to be used by those with mild hearing loss, and were predominantly used in more confined spaces such as the home or for hearing sounds within close proximity to the user, namely speech. These trumpets typically measured from 15-25cm. For example, the London Dome style of ear trumpet (as shown in Figures 4.6 and 4.7), named due to its resemblance to St Paul's Cathedral in London, was able to provide greater levels of amplification than generic models of ear trumpet.



Figures 4.6 and 4.7: An example of a brass London Dome ear trumpet with a parabolic resonator. Reprinted with permission from The Hearing Aid Museum. Retrieved 19 March 2015 from <https://www.hearingaidmuseum.com/gallery/Non-Electric/EarTrumpets/Short%20Trumpets/info/londondomesmall.htm>

Produced from the 1880s until the early twentieth century, the London Dome ear trumpet featured a wider opening that allowed acoustic information from a slightly broader segment of the surrounding space to enter the device. In addition, the wider resonator enabled a slightly greater amplification of sound. However, like generic styles of ear trumpet, the user's perception of acoustic space remained fragmented and one-dimensional, as they would have only been able to detect sounds within close range and from a single area of their surrounding acoustic space. In addition, amplification of sound alone did not fully restore the user's ability to localise sounds, and therefore did not reinstate their capacity to experience their surrounding acoustic space due to the uni-directional nature of the device.

Further, while ear trumpets with a wider opening, such as the London Dome trumpet, could be used in an attempt to detect sounds at a distance they could also potentially pick up too much ambient noise, contributing to an experience of acoustic space that had lost most of its definition and become a homogenous mass. This effect could make the use of a London Dome or large ear trumpet in certain environments problematic, and in some cases left hearing impaired individuals reluctant to use an ear trumpet as they found the resulting acoustic experience to be more confusing and disorienting than hearing sound through the naked, impaired ear (Berger, 1970; Bennion, 1994). Moreover, due to the size and the length of a majority of ear trumpets – which typically measured between 15 and 30cm - there was a discontinuity between the surrounding soundscape and the

sounds reproduced by the ear trumpet. As sound travelled through the trumpet to the ear of the user, the resonance of that sound could be altered, depending on the material that the ear trumpet was made from. Consequently, as most ear trumpets were fashioned from metal, the user typically experienced the sounds produced by the device as being dull and flat, as ear trumpets were only capable of producing a relatively small spectrum of sounds.

A further hindrance to the user's capacity to clearly ascertain the directionality of sounds, and therefore the characteristics of their acoustic space, was that ear trumpets were monaural devices. This meant that ear trumpets could aid only a single ear at a time. While it was physically possible to hold an ear trumpet to each ear in an attempt to retrieve a more balanced, binaural experience of sound, this would have been impractical as the user would not have been able to use either of their hands or arms while holding the ear trumpets to their head. Furthermore, ear trumpets were typically made from metals and could be cumbersome and heavy to hold, meaning that it would have been physically demanding, not to mention uncomfortable, to hold an ear trumpet to each ear, even for a short period of time. While the monaural nature of the ear trumpet may not have been a significant issue for individuals with uni-lateral hearing impairment, it is likely to have resulted in an lop-sided experience of sound and acoustic space for those with bi-lateral hearing loss, leaving them to navigate between compromised hearing in one ear and amplified sound in the other. As discussed earlier, sound comes to us from 360 degrees, therefore the user would

have been able to perceive the louder sounds that occurred within their surroundings, but would have remained unable to tell where they came from. Despite providing some strengthening of sound for the aided ear, the capacity of the ear trumpet to afford the user enhanced access to their immediate acoustic space remained narrow.

Ultimately, this was likely to have contributed to a significant sense of displacement on the part of the user, as while they were able to hear the voice of the speaker through the device, the ambient sounds of their surrounding environment were largely eliminated from their auditory experience. Stocker (2013) explains that hearing, perhaps more than any of the other senses, “is the perception of inclusion. When we lose it, it erodes our sense of participation. We are sensually woven into our surroundings and our community in the fabric of sound” (p. 24). Consequently, the user could have potentially become further isolated from the sounds of their encompassing acoustic environment, sounds that bind a community together and provide the individual with a sense of space and belonging. The result was a potentially disorienting experience as the individual struggled to overcome both a deficit in hearing as well as the inability to orient themselves within their environment because of their inability to localise sound. It is possible that the shortfall in accessing the outer reaches of their encompassing acoustic space may have left the individual with a sense of unknown entities encroaching upon them. Therefore, the individual’s ensuing experience of acoustic

space was one where only a very small part of the surrounding acoustic space could be detected with any clarity.

Conversely, the conversation tube, another form of acoustic hearing aid, was intended to focus the user's perception of acoustic space so tightly as to eliminate all sounds other than that of the voice of an interlocutor. Patented in 1819 by German optics manufacturer Johann A. Duncker, the conversation tube was designed to be "suited to the most obstinate cases of deafness" (as shown in Figures 4.8 and 4.9), providing those with moderate to severe hearing loss an unobstructed pathway for sound to travel from the mouth of the speaker to the ear of the listener while shutting out potentially distracting ambient noise.

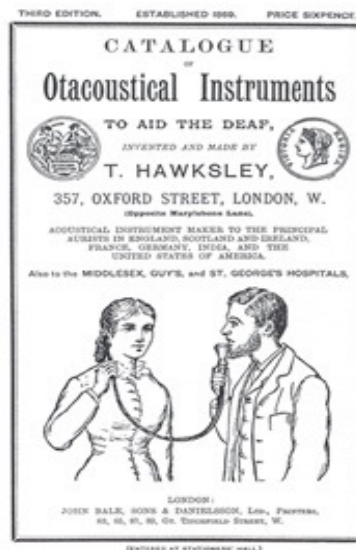


Figure 4.8: The front cover of a catalogue for hearing aid manufacturer T. Hawksley that features a drawing of one of their conversation tubes in use (c. 1900). Reprinted with permission from The Hearing Aid Museum. Retrieved 20 March 2015 from https://www.hearingaidmuseum.com/gallery/General_Info/GenInfoNonElect/info/generalinfo-conversationtubes.htm



Figure 4.9: A hard rubber conversation tube, c 1880.
Reprinted with permission from The Hearing Aid Museum. Retrieved 20 March 2015 from <https://www.hearingaidmuseum.com/gallery/Non-Electric/ConversationTubes/info/HardRubberConversationTube.htm>

The conversation tube assisted the listener's experience of sound in several ways. First, as the opening was held close to the mouth of the speaker they were able to speak in a normal tone and volume, meaning that the sound of the voice would be more distinct by lessening distortion, while also reducing the potential for discomfort in sensitive ears. Second, it afforded the speaker and listener the opportunity to converse discreetly rather than the speaker having to shout in order to be heard. (It was a common occurrence for people to raise their voice when speaking to someone using a hearing aid, which could result in the experience of sound becoming physically uncomfortable for the listener, or the voice becoming distorted as the hearing device amplified sound as it travelled from the opening of the trumpet to the ear of the user). Finally, the conversation tube also eliminated a majority of potentially distracting background noise that may have further compromised the listener's ability to hear (Bauman, 2017).

However, the key implication of blocking out ambient noise was the further narrowing of the listener's already compromised experience of their acoustic space.

Therefore, in the case of individuals with severely impaired hearing, the experience of acoustic space would have consisted solely of the human voice, as background noise was almost entirely, if not completely, eliminated. Consequently, the boundaries of perceived acoustic space would have only reached as far as the conversation tube stretched. The conversation tube may have - at least in part - given the listener a feeling of inclusion by enabling them to hear speech and participate in spoken communication, while it also potentially empowered them to silently direct and control a conversation (Mills, 2011). In this sense, the conversation tube can be considered a device of inclusion in that it provided the user with the opportunity to join social activities, whereas hearing impaired individuals who did not use an aid often felt disenfranchised (Esmail, 2013). Howes and Classen (2013) argue that we make sense of the world through all of our senses, and through the technologies that extend our bodies. When one of the senses is impaired, whether physically or by using a technological device, or both, our experience and understanding of the world is altered. The conversation tube, while providing a direct path for sound to travel from the speaker's mouth to the ear of the listener, it also virtually eliminated the user's ability to detect any of the sounds of their surrounding soundscape from at least one ear.

While non-electric hearing aids had the propensity to increase the ability to detect ambient sound and speech through amplification, they could also further complicate the listening experience for the user. In turn, this raises the issue of the embodiment of these acoustic prosthetic technologies for the ear. As discussed in

Chapter Three, when a hearing aid, or any technology for that matter, is used, the wearer undergoes what Ihde (2007) refers to as an ‘embodiment relation’, in that as we invent our technologies, they in turn re-invent the human user by reshaping how we perceive and understand the world around us. Ihde’s argument extends Merleau-Ponty’s (2013) observations regarding the embodiment of various devices by directly applying them to technological artefacts. As discussed earlier in Section 4.1, the primary purpose of hearing aids is to ameliorate a deficit in hearing to some degree. However, as Ihde points out, in order for this correction to take place an embodiment relation must transpire between the device and the wearer. Returning to the example of eyeglasses, as discussed in Chapter Three, Ihde explains

Putting on glasses does not simply “snap” vision of the world into its new simply corrected sighting. Instead, one has to “learn” and bodily accommodate to wearing glasses. Phenomenologically, seeing is a whole body experience. There are discernable changes in depth and motile perceptions, one is aware of this in the simple act of walking...these mediating technologies produce a repeatable distorting effect that is quite perceivable. But, in my experience, and in those who have related theirs to me as well, embodying new eyeglasses to the point where they are nearly functionally “invisible” is a very quick process – taking maybe a day or two at most (p. 244).

Here, Ihde argues that the process of embodiment that takes place between the wearer can be complicated, as the establishment of an embodiment relation between the user and their device is more straightforward in some instances than in others.

In the case of Harriet Martineau, for example, it appears that the use of an ear trumpet had become habitual and she had become proficient at using it to her auditory advantage. It is possible that an embodiment relation took place between Martineau and her device as Hawthorne (1871) refers to it as a “sensible part of her” (p. 116), likening her ear trumpet to the antennae of insects, and therefore an extension of her physical body despite the difficulty in an embodiment relation taking place between a hearing aid and its user. In Martineau’s case the embodiment relationship that was established was a positive one that granted her the opportunity to extend her sense of hearing and take part in social activities and conversation. Ihde (2007) explains, “I relate to my environment, my “world”, by means of such technologies and if they are well functioning then experientially they are taken into my very sense of bodily experience” (p. 244). Martineau’s ear trumpet, therefore, operated as an opening on to the world, a device that mediated her experience of her environment.

Conversely, it is possible that attempts to bring the acoustic environment into ‘focus’ could just as easily result in a confusing auditory experience, that is, in a failed embodiment relation. In some cases the hearing impaired individual

abandoned the use of hearing aids altogether due to difficulties becoming attuned to their new mediated experience of sound (Berger, 1970). As acoustic aids were not capable of reproducing a natural listening experience of sound, or restoring their sense of hearing, the user had to compromise on their auditory experience. Consequently, despite the acoustic gains possible through the use of an ear trumpet, many hearing impaired individuals were reluctant, or simply refused, to use them as they could further mire the perception of sound and acoustic space. This could occur if the user was uncomfortable using the device, if the amplification of sound made possible through the aid made the experience of sound physically uncomfortable, or if they found that the device made the detection of different sounds more difficult than listening through the unaided ear. The hard of hearing, therefore, often chose to remain in a world of distorted sound, or even virtual silence, rather than having to endure an increasingly complicated experience of sound and the surrounding acoustic environment (Berger, 1970; Esmail, 2013).

4.5 Hearing aids and social stigma

Widespread social stigma surrounding the deaf was also significant in individual relationships to the surrounding soundscape, as it also contributed to many hearing impaired individuals opting to endure unaided, impaired hearing rather than facing ridicule for using a hearing aid (Bauman, 2017; Berger, 1970; Pullin, 2009). As mentioned earlier in section 4.3, hearing impaired and deaf

individuals were frequently labelled as being deformed or invalids (Berger, 1970). Consequently, individuals with damaged hearing often avoided using a hearing aid in public for fear of their disability becoming visible to others. Cockayne (2003) notes, however, that “it is difficult to assess the sentiments of those afflicted by hearing loss, most especially the profoundly congenitally deaf, as they left scant records” (p. 497). Yet it appears that social stigma surrounding hearing impaired individuals played a significant role in the evolution of the physicality, and therefore the functionality, of hearing aids. Esmail (2013) observes that such attitudes were widespread in Europe during the Victorian era. Similarly, it appears that stigma concerning hearing impairment, or any disability for that matter, were also present in New Zealand during the nineteenth century.

According to the New Zealand Office for Disability Issues (ODI), physical disabilities were considered to be “a problem inherent in individuals” throughout much of the twentieth century. If anyone had a physical abnormality, something was deemed to be wrong with them. There was also the misconception that disabilities could be “cured or at least contained” (2016, para 6). It seems that throughout much of the nineteenth century people with some form of disability or mental impairment were widely considered to be weaker, less valuable members of society. Such stereotypes were the catalyst for widespread ridicule surrounding the use of hearing aids (Bauman, 2017; Berger, 1970; Esmail, 2013). The use of an ear trumpet or conversation tube was immediately obvious because of their size and the way they were held to the head, thus drawing attention to the user’s

impairment. Thus, many individuals considered it preferable to endure a loss in hearing ability and displacement from their acoustic environment, rather than facing derision should they be seen using a hearing aid (Pullin, 2009).

Creative and ambitious attempts to disguise and hide the use of hearing aids, in some instances, had the potential to modify the user's ability to perceive a broader area of their surrounding acoustic space. In many respects, the evolution of instruments to assist hearing has been a succession of devices designed to be disguised or hidden, either in clothing or on the body itself (Pullin, 2009). From the early nineteenth century a number of hearing devices were reduced in size and incorporated into a range of everyday items, such as eyeglasses, hats, walking canes chairs and vases in an attempt to conceal their true function (Bauman, 2017; Mills, 2011; Pullin, 2009). One of the earliest examples of a concealed hearing aid was the acoustic fan (as illustrated in Figure 4.10), which was a form of assisted hearing device that integrated an ear trumpet into an accessory for women, providing a slightly more elegant, and therefore socially acceptable, alternative to an ear trumpet.



Figure 4.10: An image of the acoustic fan in use from a hearing aid catalogue from T. Hawksley hearing aid manufactures of London. Reprinted with permission from Bernard Becker Medical Library. Retrieved 30 March 2015 from <http://beckerexhibits.wustl.edu/did/19thcent/index.htm>

As the acoustic fan was held behind the ear, the earpiece of the attached trumpet was inserted into the ear. The attached fan served to hide the use of the trumpet. It seems that the acoustic fan was capable of achieving similar levels of amplification as the practice of cupping the hand behind the ear (Bauman, 2017). In a similar manner to the ear trumpet, the capacity of the fan to enhance the user's experience of sound and accessibility to acoustic space was principally dependent upon the size of the attached ear trumpet; the larger the ear trumpet the greater the capacity for amplification. It is likely that it achieved similar results to the ear trumpet if used correctly, thus probably granting some moderate amplification of sound in the foreground of the user's acoustic space.

Like the ear trumpet, the acoustic fan was a uni-directional and monaural device, thus limiting the user's auditory perception to sounds within close proximity, such as speech. Yet when the acoustic fan was fully open (as shown in Figure 4.12), it is possible that the fan not only worked to disguise the use of an ear

trumpet, but also worked as a type of ‘sound collector’ in its own right. When held behind the ear, it is likely that sound waves could hit, and be directed into the ear, by the fan itself. As the surface of the fan was much wider than the opening of the ear trumpet (as shown in Figure 4.11), the fan potentially ‘collected’ more acoustic information than the ear trumpet, thus providing the user with slightly more acoustic detail from the sounds occurring within close a slightly larger space. Yet in spite of this, it appears unlikely that the fan would have enabled the user to clearly hear sounds from more than a few metres away, meaning that their perception of acoustic space remained confined to a relatively small portion of their broader acoustic surroundings, as opposed to facilitating the impression of multi-directional sound.



Figure 4.11: An acoustic fan with ear trumpet attached to the right side of the device. Reprinted from Antique Hearing Aids. Retrieved 2 October 2018 from <http://www.antiquescientifica.com/ANTIQUE%20EAR%20TRUMPETS.htm>

Although the acoustic fan served to disguise the use of an ear trumpet while amplifying sound to some degree, the innovative incorporation of hearing devices into furniture had a significant bearing on the accessibility and perception of

acoustic space for the user. The Acoustic Throne was one of the most elaborate examples; it married a hearing aid with a chair. Furthermore, this device was indicative of the lengths that individuals would go to in order to conceal a hearing impairment. Made for King Goia of Portugal in 1819, the throne consisted of hollowed armrests through which sound travelled to the resonator located in the seat of the throne (as shown in Figure 4.12). A hearing tube was connected to one end of the resonator, with the other placed in the ear of the King as he sat on the throne. In 1836, John Curtis noted in his *Treatise on the physiology and pathology of the ear* that the acoustic throne was “intended for the benefit and use of the incurable deaf... so that the person sitting in it may hear distinctly” (p. 177).

While a novel and ambitious form of hearing aid, there were several implications that arose from its use. First, the acoustic throne would have impacted the King’s access to his surrounding acoustic space as its capacity to reproduce ambient sound was restricted by its monaural and directional nature. Second, due to the location of the sound collectors, the range of sounds that entered the device was limited to sounds that could be detected at knee-level. As such, the King’s experience of sound would have largely consisted of the voices of those who knelt before the throne as well as sounds that resonated from the floor and created an echoing effect, thereby resulting in a distorted experience of acoustic space. Finally, the possibility of an embodiment relation would have been virtually impossible given the acoustic limitations of the device.



Figure 4.12: The King Goa Acoustic Throne. Note the discreet earpiece hanging over the back of the chair.

Reprinted with permission from The Bernard Becker Medical Museum. Retrieved 1 April 2015 from http://beckerexhibits.wustl.edu/did/win_19th/kingoa.htm

A widespread trend towards the miniaturisation of hearing aids in the nineteenth century also had ramifications for the wearer's perception of the encompassing acoustic environment. It seems that this reduction in the size of hearing aids meant that for the first time these devices could be worn on the body. As such, the use of binaural prosthetics for the ear became feasible. This marked an important milestone in the historical development of hearing aids as individuals with bi-lateral hearing loss had the potential to aid hearing in both ears instead of only one. One of the first examples of miniaturised binaural hearing aids was ear inserts (as shown in Figures 4.13). Also known as ear pinna, ear inserts were essentially tiny ear trumpets, measuring approximately 1.5cm long, and worn in the outer ear. Like the ear trumpet, ear inserts were intended to amplify sound as it

travelled through the device while providing a direct pathway for that sound to reach the ear canal.

Ear inserts could be worn discreetly while offering a potential solution for individuals suffering from bilateral hearing loss, with the possibility of a more balanced, and natural, experience of sound as opposed to aiding one ear but not the other. These acoustic prosthetics could enhance the perception of sound for individuals whose hearing impairment was caused by collapsed ear canals, as the pinna physically held the canal open, allowing sound to enter the ear. However, despite offering a binaural solution to hearing impairment, it appears that the ear pinna could have had a negligible effect upon the user's ability to perceive sound, and therefore acoustic space. While these devices could be used binaurally, the small size of the opening to the device appears to have enabled very little acoustic information from the user's surrounding acoustic environment to enter the device. Consequently, it is possible that the user may have ultimately heard less than they would have if they had instead used an ear trumpet. Rather than enhancing the user's ability to perceive the acoustic details of their surrounding environment, the user was instead unlikely to have been able to hear any sounds occurring more than a metre or two away from them.



Figure 4.13: A pair of silver ear inserts (c. 1890)
Reprinted with permission from The Hearing Aid Museum. Retrieved 30 November 2017 from <https://www.hearingaidmuseum.com/gallery/Non-Electric/EarInserts/info/pinnainsertsmall.htm>

Auricles were another type of hearing aid that sought to combine access to a binaural listening experience with invisibility. Also known as aurolese-phones or barrel headbands, auricles were also developed in the first half of the nineteenth century. Worn on the head auricles were used primarily by women as they could be easily disguised by the user's hair or adorned with lace and ribbons to camouflage their true purpose (as shown in Figure 4.14). The trumpets or barrels that collected sound were positioned behind the ear in order to collect ambient sound, with the tip of the scoops inserted into the ear of the user (Bauman, 2017; Becker, 2015; Berger, 1970).

Figure 4.14: A print advertisement for auricle hearing aids from T. Hawksley and Son catalogue (date unknown).

Reprinted from The Bernard Becker Medical Museum. Retrieved 20 July 2015 from http://beckerexhibits.wustl.edu/did/win_19th/THauricles.htm

An advertisement for auricles that featured in a catalogue from hearing aid manufacturer T. Hawksley and Sons (as shown in Figure 4.14) claims that the auricle was “a very powerful form of hearing instrument [as] the principle is a metal cone having a large sound collector doubled on itself”. Although there does not appear to be any recorded evidence of the experience of wearing an auricle, the size of the trumpets or barrels on the device seem likely to have provided greater levels of amplification than were possible through the ear inserts, predominantly because the resonators of the aurolese phones were larger, and therefore were able to collect more acoustic information from the surrounding acoustic environment. Additionally, these devices could be worn on either one (as shown in Figure 4.15) or both ears. In the case of binaural auricles, the user was afforded with greater auditory access, and therefore a more detailed experience of their surrounding

acoustic space that potentially enabled them to detect sounds from two areas of the acoustic environment instead of just one.



Figure 4.15: A monaural auricle designed to look like a flower. Reprinted with permission from The Hearing Aid Museum. Retrieved 18 May 2016 from http://beckerexhibits.wustl.edu/did/win_19th/703101.htm

However, despite facilitating the binaural experience of sound, auricles were also directional auditory devices in that each earpiece could only collect sound from one direction. The direction in which the device was pointed differed slightly between models, but they typically collected sound from directly in front, or slightly to the side of, the wearer. Unlike ear trumpets, which could be pointed towards sources of sound occurring in almost any direction, the auricles remained set in place, and the direction in which they were pointed could not be easily adjusted. Therefore, the user had to position their head and body in the direction of the sounds they wished to hear.

The directionality of the auricles, therefore, had a bearing on the opportunity for an embodiment relation to take place between the user and their device. Although aurolose phones had the potential to influence the way the user

perceived their world of sound, the ability to achieve a symbiotic bond with their acoustic device was difficult. On one hand, this relationship would have developed somewhat due to the binaural function of the hearing aid. On the other, however, it was also restricted due to the directionality of the sound mediated by the aid, thus limiting the means through which the individual experienced and acted on their circumambient acoustic space, as they were still only able to perceive a mere fraction of their acoustic environment, rather than experiencing their surrounding acoustic space as being spherical as sound travelled to them from every direction simultaneously, as described by Carpenter and McLuhan (1960) and Schafer (1994).

The development of the acoustic urn hearing aid, however, provided a semi-practical solution to the issue of the directional experience of sound and acoustic space by facilitating the effect of hearing sound from 360 degrees. The acoustic urn was a unique acoustic prosthetic device in the early nineteenth century, as it appears to have been the first, and only, hearing aid available at the time that was designed to emulate the natural experience of being able to hear sound from every direction simultaneously.

Figure 4.16: An acoustic urn, produced circa 1820. Flowers were placed on the top of the urn in a modest attempt to disguise its function.

Reprinted from Bernard Becker Medical Museum. Retrieved from <http://beckerexhibits.wustl.edu/did/index.htm>

Also known as a vase receptor, acoustic urns were made during the first half of the nineteenth century (as shown in Figure 4.16). Designed to be placed on a table, the device featured multiple openings around the circumference to collect sound from each direction of the room in which it was situated. A tube with an earpiece was connected to the resonator in the centre of the urn, which the user would place to their ear in order to hear the amplified sounds of their surrounding acoustic space. While offering a creative solution to the limitations of directional hearing aids, the acoustic urn also meant that the user had to make compromises in regards to, first, their acoustic experience, and second, being seen using an aid in public settings. The listening tube itself was not easily hidden from view, despite sporadic attempts to conceal it with napkins when placed on a dining table. In addition, acoustic urns were not intended to be portable, meaning that as the user had to remain close to the urn their acoustic experience was confined to the space in which the

urn was located. Third, unlike ear inserts and auricles, the acoustic urn was monaural, once again restricting the user's mediated experience of their acoustic environment to a single ear.

While the acoustic urn had the potential to afford the user greater auditory access to the world around them, they could also complicate the perception of the surrounding acoustic space if the user had difficulty determining the directionality of the sounds produced by the device. As argued by Kuk and Korhonen (2014), awareness of the localisation of sounds “allows the listener to turn toward the sound source and use the additional visual cues to enhance communication in adverse listening conditions” (p. 23). Despite the fact that the urn could collect and reproduce sound from 360 degrees, if the user had their back to a particular source of sound and did not perceive the accompanying visual cues, their ensuing experience of their surrounding acoustic environment may have been confusing and disorienting.

This potentially muddled acoustic experience may have been further exacerbated by the ‘cocktail party effect’, whereby in order to focus on a particular sound the listener would have to effectively train the brain to focus on one particular sound or group of sounds while shutting all other ambient noise out (Truax, 2001; Ihde, 2007). This listening practice is not easily attained and can take some time to master. Consequently, once again, the opportunity of the formation of an embodiment relation between the listener and their hearing aid was stifled on account of it being a monaural, non-portable device. In spite of presenting what

may have been the world's first example of an acoustic prosthetic device capable of mediating surround-sound, ultimately it seems that the acoustic urn was likely to have produced a confusing auditory experience for listeners struggling with a sense of hearing that was already impaired.

Pullin (2009) argues that the history of hearing aids illustrates a series of compromises on the part of the user. While some models of hearing aids enhanced the user's accessibility to their surrounding acoustic space, some concession did indeed have to be made on the part of the user regarding other areas of their auditory experience, whether it was portability, visibility of the aid, or deciding between monaural or binaural sound. While the diverse range of hearing aids that emerged during the acoustic era provided hearing impaired individuals with a number of different options and methods for both literally and figuratively extending their ear(s) and sense of hearing, the capacity of acoustic aids to enhance the user's accessibility to their surrounding acoustic space remained not only limited but complicated. This was largely due to the fact that whether or not acoustic aids were successful in assisting a deficit in hearing was dependent upon, first, the device's ability to amplify sound, and second, the breadth of acoustic space the devices was able to capture. As a result, the user had relatively little control over their mediated experience of sound and acoustic space. Conversely, the electrification of hearing aids marked the dawn of a new era in the functionality and effectiveness of hearing aids, affording hearing impaired individuals new forms

of mediated auditory experiences and, in some cases, greater access to the world of sound around them.

4.6 The electrification of hearing aids

The electrification of hearing aids at the beginning of the twentieth century not only altered the way in which sound was mediated and transmitted to the user, but in turn, their perception of acoustic space. However, the path to auditory acuity through the use of an electric hearing aid was not straightforward. The integration of a battery to power these acoustic prosthetics meant that electric hearing aids were able to provide greater levels of amplification than their non-electric counterparts, enabling those with moderate to severe hearing impairment the opportunity to improve their hearing capacity to some extent, possibly for the first time. Non-electric aids, on the other hand, were only suitable for use by those with mild to moderate hearing loss. Furthermore, later models of electric aids produced from the mid twentieth century also empowered the wearer through the capacity to assert some control over their experience of sound, and in turn their perception of acoustic space.

The catalyst for the integration of power into hearing aids was the invention of another acoustic technology that could transmit sound across distance from one acoustic space to another: the telephone. Alexander Graham Bell's invention, developed in 1876, was revolutionary in its capacity to power sound reproduction (Sterne, 2003). Interestingly, American inventor Thomas Edison, who was himself

hearing impaired, found that Bell's device did not meet his needs as the microphone in the telephone receiver could not amplify sound to a level sufficient for him to hear clearly. To address this shortfall in amplification, in 1878 Edison developed the carbon transmitter, which in addition to providing greater amplification for Bell's telephone receiver, was also adapted and integrated into the first electric carbon hearing aids.

The ability to achieve greater levels of amplification meant that carbon hearing aids could aid individuals with mild to moderate hearing loss to increase their capacity to perceive the surrounding acoustic environment by making sound louder. The first model of carbon hearing aid, produced by American inventor and hearing aid manufacturer Miller Reese Hutchinson in 1902, became the prototype for a majority of carbon aids produced between 1905 and 1910 (Bauman, 2017; Sandlin, 1995). Early models consisted of four key pieces: a carbon microphone, a portable magnetic receiver that used an electrical current to amplify sound, a battery, and cables that connected all of the parts together (as shown in Figure 4.17). The earpiece was attached to a band that was worn on the head, with the microphone attached to the clothing of the wearer. In spite of these components, early models of carbon hearing aids did not include any means of controlling volume, meaning that the user was largely at the mercy of device's capacity to amplify and transmit sound. While up to four additional microphones could be added to the aid to facilitate greater levels of amplification, there was no way to

reduce the level of sound emitted by the device if it exceeded the user's needs, thus making it difficult for the user to achieve a suitable and comfortable level of sound.

As discussed earlier in section 4.4, an impairment in hearing does not just refer to a reduction in the capacity to hear sound, but can also involve physical discomfort in the inner ear when exposed to loud noises. Therefore, in cases where the sound transmitted by the carbon aid was too loud for the individual needs of the user, it could potentially cause physical discomfort as well as distorted experience of sound, resulting in a confusing mediated auditory experience. Consequently, the carbon aid only allowed the wearer to perceive a small part of their surrounding space. Even then the wearer's perception of acoustic space lacked clarity, as they were not able to clearly distinguish sounds from a distance, meaning that their perceived acoustic space was not boundless, but limited to sounds that occurred in close proximity.



Figure 4.17: The Acousticon Model A carbon hearing aid, produced c. 1905. Although the battery pack (far left) on this model was compact, the microphone (right) was large. Reprinted with permission from The Hearing Aid Museum. Retrieved 4 April 2015 from <https://www.hearingaidmuseum.com/gallery/Carbon/Acousticon/preview/acousticonmodela1L.htm>

Contributing to an already problematic experience of sound, the frequency response of the microphone in carbon hearing aids was very limited. This meant that the range of different tones that the aid was capable of producing was insufficient to emulate the sounds of the surrounding acoustic environment, resulting in a very flat, muffled and potentially distorted experience of sound for the user (Bauman, 2017). Whereas those with able hearing can detect sounds that are both high and low in pitch, such as birds singing or the rumble of a large truck as it drives past, carbon hearing aids only had the capacity to reproduce mid-range sounds. Consequently, high and low tones picked up by the microphone became distorted, resulting in a misshapen experience of sound and acoustic space whereby some sounds merged together to become indistinguishable from one another. Consequently, the user did not detect sounds coming from multiple directions, as Carpenter and McLuhan (1960) and Schafer (1994) indicate in their respective definitions of acoustic space. Rather, it appears that the user potentially perceived their acoustic environment as a distorted mass of sounds of a mid-range tone.

A further factor that complicated the user's perception of sound and acoustic space through a carbon hearing aid was the unit that housed the battery and microphone had to remain upright when in use (Bauman, 2016). Even then, they remained prone to distortion, specifically cracking and noisy interference due to the movement of the carbon granules against the diaphragm within the aid. Ultimately, this brought about a distracting and unpleasant auditory experience for the user (Berger, 1970; Bauman, 2016). This tendency towards acoustic interference

again stymied the establishment of transparency or an embodiment relation forming between the wearer and the device due to the high level of acoustic distortion and obstruction produced by carbon hearing aids, and difficulties in a period of habituation taking place due to the auditory interference experienced by the user through the device. Consequently, the aid was not able to effectively or efficiently operate as a mediator of sound as it produced an unfavourable pre-processed experience of acoustic space that had been significantly disrupted and warped. Unsurprisingly, in light of these performance issues, carbon hearing aids did not prove to be particularly popular. Many hearing impaired individuals continued to use non-electric aids, or again chose to forego the use of a hearing aid altogether, as even the naked ear produced a less complicated and conflicted representation of the surrounding sonic environment. The unaided ear was not subject to the unpleasant static and crackle of auditory interference produced by these early electric carbon hearing aids.

The invention of the vacuum tube facilitated a less complicated auditory experience for the user in that these electric aids were capable of providing greater amplification and clarity of sound. This enabled the user to perceive the surrounding soundscape with enhanced acuity and acoustic detail, as sounds that they may not have been able to perceive through a carbon aid became evident through the use of a vacuum tube aid. Although created by American inventor Lee De Forest in 1906, it was not until the early 1920s that the Western Electric Company of New York successfully integrated a vacuum tube into a hearing aid

(Becker, 2015). The function of the vacuum tube was to control the flow of current between two electrodes within the airtight tube (Bauman, 2016; Sandlin, 1995), which in a hearing aid not only facilitated higher levels of sound amplification, up to 70dB, but also greater frequency response. Unlike carbon devices, vacuum tube hearing aids could offer greater clarity and depth of sound, as they were able to reproduce a wider spectrum of sounds. In turn, the integration of vacuum tubes into the device reduced the levels of interference and distortion of sound that had been prevalent in carbon aids, thus more closely emulating the wearer's surrounding acoustic environment and enriching the wearer's experience of acoustic space. For example, as vacuum tube hearing aids had the capacity to produce a wider range of sounds, it appears that users were able to detect some of the acoustic minutiae of their soundscape, such as sounds occurring further away, or the sound of music playing in another room, sounds that had previously been indistinguishable through carbon aids. Therefore, the wearer's perception of acoustic space was effectively extended, as their auditory experience was no longer confined to a relatively small, distorted and muffled world of sound.

Another distinguishing feature of vacuum tube hearing aids was that later models provided the wearer with the ability, albeit small, to customise how the aid reproduced sound. These models of vacuum tube aids featured volume control, thus enabling the wearer to set the volume to a level that suited their individual needs, rather than being a generic 'one size fits all' instrument. Thus, arguably for the first time, the hearing aid user was able to enjoy a more comfortable and

detailed representation of their surrounding acoustic environment that enhanced their ability to perceive greater sonic minutiae of the circumambient acoustic space. The potential of vacuum tube hearing aids to afford the wearer with enhanced auditory acuity and access to their surrounding acoustic space is illustrated in a print advertisement for the Paravox hearing aid (as shown in Figure 4.18,) produced by Paraphone Hearing Aids, Inc of Cleveland, which appeared in 1947.



Figure 4.18: ‘HEARzone’ print advertisement for the Paravox hearing aid from 1947 Reprinted with permission from The Hearing Aid Museum. Retrieved 16 June 2017 from <https://www.hearingaidmuseum.com/gallery/Vacuum%20Tube/Paravox/index-paravox.htm>

The image above clearly demonstrates the experience of sound, and the limitations in the perception of acoustic space endured by hearing impaired individuals. The bubble that appears around the gentleman’s head represents the boundaries of his

acoustic space, illuminating his inability to clearly hear sounds that take place outside of that bubble. The advertisement reads: “WHATS THAT? He would scream. Poor Harry, nice fellow, but his “usual HEARzone” is so restricted that he just can’t hear well. Nervous, irritable, he screamed his way, until he, too, got a Paravox”. The ‘HEARzone’, according to the advertisement, is “the distance beyond which ordinary conversation becomes unintelligible, hard to understand”. As such, the HEARzone can be considered as representing the confines of the individual’s unmediated acoustic space, while the Paravox promised to “electrically expand the “usual HEARzone” so that reasonable hearing is possible. Thus, the advertisement implies that by using the Paravox hearing aid, Harry’s acoustic bubble was essentially burst as the device widened his perception of both sound and acoustic space, potentially affording him the ability to not only clearly hear the voices of people speaking to him, but the acoustic minutiae of his immediate acoustic surroundings.

The quality of sound reproduction achieved by vacuum tube hearing aids also laid the foundations for the establishment of an embodiment relation to take place between the user and their electric hearing aid. As discussed earlier, “embodied artefacts change our relation to the world, sometimes even profoundly” (Brey, 200, p. 1). Whereas carbon hearing aids, for example, could distort the user’s understanding and experience of their world, the vacuum tube hearing aid, on the other hand, eliminated much of the auditory interference that was prevalent in carbon hearing aids. Therefore, as a medium through which the user perceived

and experienced their auditory world, the vacuum tube hearing aid enabled greater transparency. Ihde (1990) explains that in the process of an embodiment relation, “I take the technologies into my experiencing in a particular way of perceiving through such technologies and through the reflexive transformation of my perceptual and body sense” (p. 72). In the case of the vacuum tube hearing aid, the presence of the device withdrew as the user became increasingly accustomed to using it. This process, which was unlikely to be achievable through a carbon aid, was more straightforward with the vacuum tube aid as it reproduced much higher quality sound, and therefore enabled the wearer to hear greater acoustic detail from their surrounding acoustic space. Whereas the carbon aid had provided distorted and flat sound, the vacuum tube aid allowed the user to hear sound with much greater clarity, such as the ability to distinguish individual sounds in noisier environments, voices from a distance, as well as some sounds from the further reaches of their acoustic environment, such as the sound of traffic in the distance, thus affording the user enhanced auditory access to the world of sounds around them.

Yet in spite of facilitating greater auditory access to their surrounding soundscape, vacuum tube hearing aids also had their own set of drawbacks for the user. For example, early models were heavy and cumbersome, weighing almost 30kg, and the receiver attached to the main unit required the user to hold it up to their ear. This meant that the device was not deemed to be portable and was primarily restricted to use within the domestic setting (Bauman, 2016). However,

this was a temporary hurdle as Western Electric produced an updated model in 1924 that weighed just 4kgs (see Figure 4.19), which was far more practical as it could be carried and used in a number of different settings outside of the home.

Figure 4.19: A Precision Electric Co. vacuum tube Table hearing aid, 1948
Reprinted from Bernard Becker Medical Museum. Retrieved 16 June 2017 from http://beckerexhibits.wustl.edu/did/win_20th/703179.htm

Throughout the 1920s there remained a steadily growing demand for hearing aids that were small and discreet enough to be hidden on the body (Pullin, 2009). The development of miniature vacuum tubes by Raytheon in the late 1920s made the further reduction in the size of hearing aids possible. These aids were fully portable and small enough to be largely concealed from view in a shirt pocket, making them considerably smaller than previous models (Bauman, 2016). This meant that the user could take their hearing aid almost anywhere, providing them auditory access to acoustic spaces they may not have been previously able to experience. As a result, the mediated ear was able to venture into environments

where it had previously been denied access for lack of an adequate acoustic mediating device.

Further advances in audio technology in the 1930s not only produced wearable hearing aids, but also enabled the production of high-fidelity sound, granting the user even greater authenticity in their acoustic space. For example, the Sonotone vacuum tube hearing aid (as shown in Figure 4.20 below), released by the Aurex Corporation of Chicago in 1938, saw the receiver and amplifier of the aid integrated into a small single unit that was either attached to the user's clothes or strapped to the upper leg, with a small cable connecting the unit to the earpiece that could be hidden under the clothing (Bauman, 2016).



Figure 4.20: An advertisement for the Sonotone vacuum tube hearing aid showing how it could be worn on the body.

Reprinted with permission from Bernard Becker Medical Museum. Retrieved 16 June 2017 from <http://beckerexhibits.wustl.edu/did/20thcent/part2.htm>

The inclusion of custom ear moulds to ensure that the earpiece snugly fit the user's ear also had some bearing upon their experience of sound and acoustic space. Aside from personalising the hearing aid earpiece and providing the wearer with a more comfortable fit, this seemingly small aesthetic feature enhanced acoustic experience, as only the sound that was transmitted by the hearing aid entered the ear, thus eliminating potential acoustic interference from ambient noise. In conjunction with adjustable volume settings, the wearer was effectively given greater control of their acoustic experience. This also meant that vacuum tube hearing aids were suitable for individuals from mild to severe hearing loss for what appears to be the first time, due to the levels of amplification that could be achieved by the device.

After the initial introduction of vacuum tube aids into the marketplace, hearing aid manufacturers, such as the Zenith Radio Corporation, began to produce a range of vacuum tube aids for varying degrees of hearing loss. For example, an advertisement for the Zenith Neutral-Colour Earphone and Cord (1945) (as shown in Figure 4.21), while underscoring the invisibility of their new neutral-coloured aid, boasted three types of aids for “practically every type of correctable hearing loss”. The first, the Model A-2-A, was designed for people with “average” hearing loss and featured volume range and the promise of greater “clarity” of sound. The Model A-3-A, on the other hand, was said to provide “tremendous reserve volume to assure complete clarity and tone quality under the most difficult conditions”.

New Thousands Now Wear a Hearing Aid

Thanks to the
NEW ZENITH NEUTRAL-COLOR EARPHONE and CORD



18 MICROPHONE
Model A-2-A-1947

A New Zenith Model for Practically Every Type of Correctable Hearing Loss

1 Model A-2-A... Improved standard Zenith for persons with average hearing loss. Patented "Pencil Tube" design - clarity, volume range, with low battery consumption. Complete, ready-to-wear, only \$44.

2 Model B-2-A... New Bone-Conduction Zenith. Powerful precision instrument for the very few who cannot be helped by an air-conduction aid. Exclusive "Super Mount" Headband automatically wears when pressure exceeds normal adjustment. Complete, ready-to-wear, only \$56.

...Have you tried
Its New "Look of Youth" on You?

ZENITH has done it again... has brought to America's hard-hearing another sensational advancement that is encouraging near thousands to discover the blessings of a hearing aid.

When the famous Zenith Radionic Hearing Aid was introduced, the cost of better hearing was brought within reach of all. And now — with the new Neutral-Color Earphone and Cord — Zenith brings a new "look of youth" to the hearing aid... a long-desired new standard of *smart appearance* that enables you to wear a hearing aid with poise and confidence.

This Zenith ensemble is so inconspicuous that it is making the hearing aid more popular than ever!

As little noticeable as eyeglasses! Yes... gone is the old black button and coil. In its place is a streamlined, complex-coated plastic earphone... light in weight, comfortable. And a translucent plastic cord that is perspiration-proof, fray-proof, kink-proof... gives less friction or clothing noise than any fabric-covered cord.

Ask the Zenith-franchised dispenser near you for a *free* demonstration of the smart looking, superbly performing Zenith Radionic Hearing Aid. No obligation! Observe how the new Neutral-Color Earphone and Cord complements your complexion.

Now too, your choice of light or dark coat! Amplifiers come in a choice of colors at no extra cost. Ask to see the Luxurious Broad Amplifier that harmonizes with dark clothing. The Panel Cordless Amplifier that harmonizes and blends with light-color and sheer apparel.

CANADIANS! The Zenith Radionic Hearing Aid *only* Corporation is a truly *Original-Style Equipment* only — at \$10 (Canadian currency). No extra charge for shipping, customs or taxes. Write, Zenith, 601 Dickson Avenue, Chicago 39, Illinois. Please attach *one* *free* literature about Zenith, and enclose with name and address of nearest Zenith dispenser.

Name _____
Address _____
City _____ State _____
 Physician, check here for special literature.

NEW ZENITH
RADIO
HEARING AIDS
(All 3 models operate
with standard 240-
cycle, 45-watt, 100-
milliampere
battery and amplifier)

BY THE MARKERS OF
ZENITH RADIO
RADIO PRODUCTS EXCLUSIVELY
WORLD'S LEADING MANUFACTURER

ZENITH RADIO CORPORATION, CHICAGO, ILLINOIS
copyright 1947, zenith radio corp.

Figure 4.21: A print advertisement for Zenith vacuum tube hearing aids from 1945. Reprinted from Bernard Becker Medical Museum. Retrieved 16 June 2017 from http://beckerexhibits.wustl.edu/did/win_20th/703334.htm

Yet in spite of auditory advantages that they helped to facilitate, the way in which the device was used and worn on the body, could markedly impact the quality of sound transmitted to the ear of the user. The most significant issue was that as the microphone for vacuum tube aids was worn on or under the clothing or in a pocket, the microphone could be prone to picking up the sound of fabric rustling, subsequently causing an auditory obstruction. The ensuing result was sound punctuated with a crackling or crunching noise, or interference that sounded like static. In cases where this occurred, higher frequency sounds would have been either obscured or drowned out by this noise. As a result, the user became distracted as their auditory attention was drawn away from the sounds of their surrounding environment transmitted through the aid, sounds that they could no longer clearly differentiate. Consequently, this device, which was

intended to connect the hearing impaired to the world around them could potentially return the user to the experience of a distorted acoustic space that lacked clarity and the ability to clearly distinguish between different sounds.

In such cases of auditory interference the establishment of an embodiment relation between the user and their hearing aid was difficult to attain. Despite making significant advances in the quality of sound produced by prosthetic technologies for the ear, vacuum tube hearing aids reached an impasse in the late 1940s. This was because it was impossible to make them any smaller, and as such the components of the hearing could not be minimised further (Berger, 1970; Bauman, 2016). Yet the desire for a more compact, wearable hearing aid capable of producing high fidelity sound and greater auditory awareness, which would in turn enhance the user's perception of their surrounding soundscape was very much in demand.

The integration of the transistor into hearing aids in the late 1940s marked another significant turning point in the experience of acoustic space with their capacity to produce high-fidelity sound. By reproducing greater clarity of sound, transistor aids provided the wearer with the potential to identify the directionality of acoustic information. The capacity to detect the origin of sounds broadened the wearer's perception of their immediate acoustic environment as the aid produced a greater spectrum, and therefore depth, of sounds. Invented by Bell Telephone Laboratories (BTL) in 1948, hearing aids were the first commercially produced consumer device to use the new transistor technologies. Transistor hearing aids

proved their capacity to reproduce sound so effectively that by 1952 BTL were mass producing transistors and selling them to a number of other hearing aid companies (Bauman, 2016). One of the first transistor hearing aids, the Sonotone Model 1010 (as shown in Figure 4.22), was released in December 1952 and became the first electric hearing aid that could be worn discreetly in the ear.



Figure 4.22: The Sonotone 1010 transistor hearing aid (1952). Reprinted with permission from The Hearing Aid Museum. Retrieved 30 September 2018 from <https://www.hearingaidmuseum.com/gallery/Transistor%20Body/Sonotone/info/sonotone1010.htm>

Early models of transistor hearing aids were, like vacuum tube aids, worn on the body. However, the battery pack was much smaller than its vacuum tube counterpart, and could easily be placed in a shirt pocket or carried. A small earpiece was attached to the battery pack by a thin cord, which could be hidden under clothing. By 1956, the components of the transistor hearing aid had been further miniaturised to the extent that the entirety of the aid could be worn in and behind the ear, obsolescing the battery compartment, as well as the cord that connected the two components. One of the earliest of these Behind The Ear (BTE)

hearing aids, the Acousticon Model A-600 Privat-Ear (as shown in Figure 4.23,) was developed by Dictograph Products Inc. hearing aid manufacturers of New York in 1958. This change in the physicality of BTE hearing aids had a significant bearing upon the wearer's perception of acoustic space as it eliminated the potential for distortion that had occurred with carbon and vacuum tube aids.



Figure 4.23: The Acousticon Model A-600 Privat-Ear, produced in 1958, was one of the earliest models of behind the ear transistor hearing aids. Reprinted with permission from the Hearing Aid Museum. Retrieved on 15 August 2018 from [https://www.hearingaidmuseum.com/gallery/Transistor%20\(Ear\)/BTE/Acousticon/info/acousticon_a600.htm](https://www.hearingaidmuseum.com/gallery/Transistor%20(Ear)/BTE/Acousticon/info/acousticon_a600.htm)

A BTE aid could be comfortably and discreetly worn in each ear if required, thus enabling a more balanced binaural auditory experience that imitated natural hearing as the sound received by both ears was mediated by identical devices. However, as Ihde (2007) notes, it was not until the 1980s that hearing aid wearers were encouraged by acousticians to wear an aid in each ear, whether they had impaired hearing in both ears or not, to achieve a more equalised auditory experience.

The wearable nature of the aid, in conjunction with the opportunity for mediated binaural hearing, further assisted in the developing of an embodiment relation between the wearer and their device(s). First, their experience of sound became fuller as the user was able to detect a wider spectrum of sounds, and second, as the aids sat in the ear, after a period of adjustment the wearer could easily become accustomed to their newfound auditory experience. This process was reminiscent of an individual becoming accustomed to wearing eyeglasses, whereby after an initial settling in period, the use of the device became habitual, providing the wearer with a new auditory opening to the world of sounds around them.

Advertisements for transistor hearing aids that appeared from the early 1950s made a plethora of promises to wearers of hearing aids, proclaiming that by using one of these aids they would be able to experience new dimensions in sound. For example, in a print advertisement for miniaturised transistor hearing aids produced by Beltone (date unknown) (as shown in Figure 4.24), the text declares, “I was deaf! Now I hear like a girl of 20”, simply by using the Beltone ‘Electronic Ear’ transistor hearing aid. The text continues “imagine hearing yourself *clearly* again – even when people *whisper!* Now, thanks to Beltone’s new Electronic Ear, thousands are recapturing the hearing power in a way that they never dreamed of. A way that *hides* deafness – yet brings amazing new *clarity* of sound”.



Figure 4.24: A print advertisement for the Beltone Electronic Ear transistor hearing aid (date unknown).

Reprinted from the Bernard Becker Medical Museum. Retrieved 14 July 2018 from <http://beckerexhibits.wustl.edu/did/advert/part3.htm>

Transistor hearing aids provided increased amplification and frequency response over and above the capacity of a standard vacuum tube hearing aid. Also contributing to an enhanced experience of the soundscape was that the BTE hearing aid was an open aid, which allowed the ear canal to remain partially open to ambient noise. This was important as it prevented the muffled effect of some sounds and occlusion, which can be experienced when listening to yourself speak when the ears are blocked or covered. This small feature was of great significance for hearing aid users as these transistor aids not only eliminated the distortion of sound and acoustic feedback that had plagued previous models of electric hearing

aids, but also endowed the user with the most acoustically detailed experience of sound, and therefore enhanced acoustic space.

Additionally, more advanced types of BTE aids also included automatic gain control, whereby the device was able to detect the difference in sound levels and determine which sounds needed to be amplified or reduced, such as speech or loud music, and correct them accordingly to suit the user's personal auditory requirements. This feature in itself granted the user an additional degree of control over their auditory experience by reducing the perception of potentially distracting ambient noise. The user was able to manually adjust the settings on the device depending on the acoustic environment in which they were located, and the sounds they wished to experience, or alternatively, eliminate. However, in turn, the ability to modify their auditory experience could impact the wearer's perception of acoustic space as some sounds were dulled while others were amplified. This often meant that the acoustic information that was most audible through the device were sounds in the foreground, such as speech, whereas sounds in the background of the immediate acoustic space became softer, lacking the sharpness of those closer to the user.

Arguably the most groundbreaking feature of transistor hearing aids that distinguished them from their predecessors was the integration of directional microphones. With inclusion of multiple miniature microphones into the device, wearers were afforded the power to detect the direction of different sounds within their soundscape with greater precision. This effect was enhanced considerably as

an aid was worn in both ears, thus providing a 'matching' auditory experience in each ear. In turn, this had a considerable impact upon the user's sense of space, as they were able to perceive the localisation of sounds with greater accuracy than had previously been possible through any hearing aid. This also broadened the scope of the user's perception of acoustic space, as they were able to detect sound coming from more than a single direction. Therefore, rather than experiencing a sense of displacement from their acoustic environment and physical surroundings, the user was able to experience a greater degree of emplacement within their physical environment, by restoring, to some degree, their auditory spatial awareness, as well as a typical relationship with their surroundings.

As discussed earlier, feelings of displacement occur when one or more of the senses is unable to detect sensory stimuli from the surrounding environment. Sensory stimuli informs the individual of the characteristics of their immediate setting and instils a sense of space. Feelings of emplacement, the opposite of displacement, occur when the individual has the capability to sense what is going on around them, and understand where they are situated in that space (Howes and Classen, 2013). In the case of the use of transistor hearing aids, upon ameliorating the sense of hearing, a sense of space was restored to some degree, as well as the re-establishment of the relationship between the individual and their surrounding soundscape. It is recognised that the extent of the hearing impaired individual's restored sense of emplacement was often largely determined by their degree of hearing loss and the capacity of their hearing aid. The restoration of some sense of

the directionality of sounds within the individual's auditory space made possible by these additional microphones was groundbreaking for users of hearing aid technology, as well as the continued growth of the hearing impaired individual's awareness of the depth, and characteristics, of their immediate acoustic environment.

As the transistor hearing aid could be worn in or around the ear, and produced high fidelity sound, the habitual use of the aid and the formation of an embodiment relation between the user and their device appears to have been more straightforward than was possible with any other previous type of hearing aid. This can be attributed to, first, the level of auditory information that the aid was able to receive and reproduce for the user, and second, a significant reduction in the instances of auditory interference produced by the aid itself. This is because the device's microphones were integrated into the unit and were worn behind the ear, rather than being hidden under clothing. Thus, the use of the BTE transistor hearing aid, after a period of adjustment, could become transparent for the wearer, meaning that after they became accustomed to the device, they were no longer aware that they were wearing it as it was taken into their very sense of bodily experience (Ihde, 2007). Whereas the wearer of carbon and vacuum tube aids experienced a 'fringe' awareness in that they remained conscious of the fact that they were wearing an aid due to their physicality and tendency towards audio distortion. However, with BTE transistor aids the wearer's fringe awareness dissipated as the aid provided them with greater clarity of sound than had

previously been achieved through hearing aids, and therefore enhanced access to their acoustic environment.

Towards the end of the 1980s, however, hearing aid companies were beginning to experiment with digital signal-processing computer chips in an attempt to create even smaller, and technologically superior, hearing aids that were not only capable of reproducing ambient sounds, but also enabling the wearer to design and modify their own individualised experiences of sound and acoustic space.

4.7 Digital Hearing Aids

The digitalisation of hearing aids effectively marked the beginning of a distinct shift from hearing aids as an instrument used to obtain greater auditory acuity and contact with the surrounding environment, to devices that enabled customised and individualised experiences of the acoustic world. Digital hearing aids offered new experiences of the soundscape for the hearing impaired that had not previously been possible through acoustic or electronic devices. From the early 1990s onwards transistor hearing aids that processed sound using analogue technology were quickly obsolesced by digital aids which utilise a digital processor to reproduce sound (Kates, 2008; Schaub, 2011). Digital hearing aids are predominantly distinguished by how they are worn, specifically behind the ear, in the ear, and cochlea implant aids, as shown in Figure 4.25 below.



Figure 4.25: A behind-the-ear digital hearing aid. Reprinted from Hearing Direct US. Retrieved 14 November 2018 from <https://www.hearingdirect.com/p-640s-digital-hearing-aid.html>

Yet regardless of bodily position, digital aids feature the same five primary components: a microphone, receiver, amplifier, microchip, and battery. A majority of modern digital hearing aids are now so small that they can be worn either in the opening of the ear canal or directly behind the ear without being detected (as shown in Figure 4.26).



Figure 4.26: A miniaturised digital hearing aid designed to be worn in the ear and remain hidden. Reprinted from Hearing Direct US. Retrieved 14 November 2018 from <https://www.hearingdirect.com/us/hd-250-digital-hearing-aid.html>

The microphone, which is located on the outside of the hearing aid, detects sounds from multiple directions of the user's surrounding environment. Therefore, whereas previous types of hearing aids were only capable of providing directional sound, digital aids can reproduce sound from a number of different directions, affording the user with the ability to hear the characteristics of a much larger part of their surrounding acoustic space. These sounds are picked up by the microphone and converted into digital signals, which are then strengthened by the amplifier.

Furthermore, the incorporation of Wide Dynamic Range Compression (WDRC) eliminates acoustic feedback and sound interference, thus providing an experience of acoustic space that emulates a 'natural' hearing experience, as opposed to one characterised by, or prone to, distortion. Therefore, the user's ensuing experience of sound is markedly different to that of any previous hearing aid as digital hearing aids have much greater frequency response. This enables the reproduction of a broader spectrum of sounds than had previously been possible. In turn, this affords the user the opportunity to hear at least some of the minutiae of their immediate acoustic environment, for example, the sounds of birds singing or the sound of wind in the trees. Furthermore, WDRC also assists in producing greater sharpness and clarity of sound, meaning that the user is able to easily distinguish between one sound and another, while also enabling the ability to determine the direction of individual sounds. This means that for possibly the first time in the history of hearing aids, the user is able to clearly articulate the

characteristics of their circumambient acoustic space. Ultimately, this affords the user with first, a much more detailed experience of their circumambient acoustic environment, and second, greater auditory depth perception through the device's capacity to capture and reproduce the directionality and distance of sound.

The development of programmable digital hearing aids at the dawn of the new millennium was progressive with the capability of providing the user with different experiences of their acoustic space. The inclusion of a programmable microchip into this new generation of digital aids enabled the device to process up to 40 million instructions per second (Kates, 2008; Schaub, 2008). This meant that digital aids were able to process acoustic information obtained from the user's surrounding soundscape at a speed infinitely faster than any previous type of hearing aid. As the microchip contained within the aid is able to process millions of acoustic cues simultaneously, the issue of acoustic feedback or distortion caused by the processor of the aid has been eliminated. In conjunction with adaptive filtering of high and low sound frequencies, and flexible programming capabilities, it became possible for the first time to programme a hearing aid to precisely meet the needs of the user in not just one, but multiple different acoustic situations and environments (Kates, 2008).

The integration of multiple tiny directional microphones into digital hearing aids is integral to their capacity to enhance the wearer's ability to clearly decipher different sounds to detect the origin and localisation of auditory information. While some later models of transistor hearing aids had included directional

microphones, considerable advances in sound technology, not to mention a substantial reduction in size of the necessary components, enabled the directional sound function of digital aids to become far more comprehensive. The ensuing result has been that digital aids are able to more closely emulate the natural hearing experience of hearing sound from every direction, thus providing the user with a much more detailed experience of their surrounding acoustic space. As these directional microphones are more powerful than those used in transistor aids, they are capable of picking up sounds from a greater distance, which means that the user's perception of their surrounding acoustic space stretches further than had been possible through any previous acoustic or electric hearing aid. As a result, the user is effectively able to restore some ability to experience the effect of surround sound, that is, the ability to perceive sound as coming from multiple directions at once.

This inclusive auditory experience made possible through the use of a digital hearing aid enables the user to regain a sense of emplacement within their immediate physical environment. The user is able to hear sounds from multiple directions, as opposed to only being able to detect sounds from one particular part of the surrounding acoustic space. Furthermore, as discussed in section 4.2, hearing impaired individuals have historically been marginalised as first, they were frequently considered to be disabled, and second, many hearing impaired individuals were not able to fully participate in social activities as they were unable to hear. However, in the case of the digital hearing aid, the user is no longer

excluded from their surrounding acoustic space, but can instead perceive themselves as being in the centre of their own acoustic space as they can detect sound coming to them from 360 degrees.

Furthermore, the inclusion of a tiny microchip within digital hearing aids means that they are programmable, and therefore the settings of the device can be altered to meet the user's specific needs in different acoustic environments. Previous types of electric hearing aids were designed to detect sound, convert it into an electrical signal, amplify it, and then send it into the ear canal, with little to no scope for the personalisation of the sound produced by the device. These aids, therefore, operated on a generic level in that only minimal, if any, changes could be made to the sound produced by the device other than possibly being able to adjust the volume and gain settings. Digital hearing aids, on the other hand, are designed to operate according to the needs and specifications of the user in different acoustic environments (Staab, 1985). In so doing, the user has the ability to change the ways in which they experience auditory information, and therefore acoustic space.

While a majority of earlier types of hearing aids were developed to enhance the user's the ability to access their surrounding acoustic environment, the digital hearing aid user can now manipulate the way(s) in which they experience that space. Interestingly, one of the greatest limitations of early models of hearing aids, as discussed throughout this chapter, was that they were only capable of providing uni-directional sound. While digital hearing aids have the ability to provide the

user with a mediated experience of surround sound, they are also able to alter the settings of the aid to detect and reproduce sound from a single direction. While this function can be utilised to reduce exposure to loud and distracting noises (Edwards, 2007), it also significantly impacts the user's perception of acoustic space, as they are now only aware of sounds coming from one direction, which essentially reverts back to the user only being able to detect a part of their surrounding acoustic space.

Digital hearing aids can have a significant bearing upon the user's perception of both sound and acoustic space. Changes to how the user experiences auditory phenomena is possible as digital aids contain a number of different settings to not only meet the auditory requirements of the user, but also their personal preferences. When first being fitted by an audiologist, the digital hearing aid is paired with a specialised computer program that sets the levels of the aid according to the hearing abilities of the user, including the individual's capacity to detect sound, and the environments in which the device is to be used (Kates, 2008; Schaub, 2008). This may include settings that amplify speech while minimising background ambient noise, and settings suitable for hearing phone conversations or listening to music. For example, one of the advantages of the individual being able to change the settings of their digital aid is to avoid the 'cocktail party effect', whereby in conference or reception settings background conversations and other noise intrude and overwhelm the ability to hear what conversants are saying (Ihde, 2007; Truax, 2001). The user, therefore, is able to alter how the aid reproduces

acoustic information, effectively manipulating their perception of sound and placing them in control of their auditory experience to create a highly customised and individualised experience of acoustic space. Furthermore, digital hearing aids also have the capacity to be connected with other digital devices such as mobile phones, televisions and digital media devices through Bluetooth technology. In such instances, the hearing aid ceases to operate exclusively as a device that assists a deficit in hearing by facilitating auditory access to the user's surrounding soundscape. Rather, the hearing aid evolves into a instrument that isolates the user in a singular, customised auditory world of their own making as they are free to choose the source of sounds that they want to listen to, for example, sound from a mobile phone or portable music player.

The programmability of digital hearing aids, in conjunction with their capacity to be paired with other digital media devices, reveals that the function of hearing aids has become paradoxical. This is apparent in that hearing aids no longer solely operate as devices that facilitate an auditory connection to the world, but have instead evolved to become instruments of isolation, enabling the user to construct their own personalised acoustic experience, rather than operating as devices that reproduce the sounds of the surrounding sonic environment. Therefore, the digital hearing aid user now has the ability to assert control over their experience of sound, and therefore acoustic space, by selecting what they do, or do not, hear. As this chapter has shown, the long history of attempts to fashion instruments to assist the hearing impaired alleviate at least some of the burden of a

shortfall in hearing that stretches back millennia. These devices were designed specifically to extend the ear and the sense of hearing in the hope of enhancing the user's ability to detect the sounds of their immediate environment and partake in communication, social activities, and day-to-day life. The primary function of hearing aids, therefore, was to provide the user with greater auditory access to the world around them. Yet in the face of digital hearing aid technology, it appears that this is changing, as the user is now able to take control of how they perceive sound, and therefore acoustic space. For example, if the user chooses to listen to music through their hearing aid as opposed to listening to the sounds around them, they are effectively displacing themselves from their surrounding acoustic environment.

Consequently, this has significant implications for the digital hearing aid user in terms of their experience - and sense of - space. When digital aids are used in conjunction with other digital devices such as mobile phones and portable music players, the user creates their private and personalised acoustic space. In such instances, the functionality of the hearing aid is altered; it is no longer used to provide access to the surrounding acoustic environment, but rather the sounds transmitted from the device that it is paired with. Therefore, the user ceases to be aware of the sounds around them. By listening to a source of sound that is completely independent from their surrounding environment, the user is effectively displacing themselves from their immediate surroundings, as they are no longer privy to the acoustic information around them as their auditory attention

is turned inwards towards the sounds transmitted from the device connected to their aid, rather than outwards into the world. Consequently, their experience of sound is not one that binds them to their community and their surrounding soundscape, but one that isolates them from the world around them as they enter their own individualised acoustic space and world of sound.

The ability to switch between settings for different acoustic environments in turn has an impact upon the establishment of an embodiment relation between the user and their aid. While wearing any aid requires a period of adjustment for the user to become accustomed to their augmented sense of hearing (Ihde, 2007), the significant reduction in auditory interference from digital aids makes the process of embodiment straightforward in some instances, and more complex in others, in terms of how it affects the user's perception of acoustic space. Achieving an embodiment relation between the user and their hearing aid had previously been complicated by either the physical nature of the device or the quality of sound that it produced. More often than not both of these factors hindered the development of a full embodiment relation from occurring.

The process of embodiment between the wearer and their digital aid, however, is more straightforward. This is made possible in three ways. First, the fact that digital aids are tiny devices means that the user often forgets that they are wearing them (Schaub, 2011). Second, because they are so small they can easily be worn in both ears, even if the user only suffers from unilateral hearing loss, in order to produce a balanced, binaural experience of sound and acoustic space from 360

degrees. For optimum effect, and to enhance the development of an embodiment relation between the individual and their device, Kuk and Korhonen (2014) assert “the first and most important requirement to receiving binaural cues is to wear hearing aids in both ears. In addition, the hearing aids should be very similar to avoid mismatching between devices, which can create unnecessary differences in delays” (p. 27). By wearing an aid in each ear these issues are overcome as a more balanced experience of sound for the user is achieved. Third, the quality of sound produced by the aid(s) emulates the natural experience of sound as closely as possible, eliminating auditory interference for the user and affording the user an uninterrupted access to their surrounding acoustic space.

However, when the hearing aid is used to reproduce sound from a mobile phone, for example, the establishment of an embodiment relation is more complicated. The user no longer employs the aid to provide a ‘window’ on their immediate physical world, but are instead applying the device to provide auditory access to an acoustic space that is independent and isolated from their physical surroundings. However, this is not to say that an embodiment relation can not take place, but rather the user must become accustomed to the type of sound transmitting from the device as well as their technologically reduced capacity to hear the sounds of their surrounding environment. Digital hearing aids, therefore, are no longer devices used exclusively for the purpose of connecting hearing impaired individuals to other people and the world around them, but are

paradoxical devices that have the capacity to isolate the wearer in a singular, personalised auditory world of their own design.

Summary

This chapter has traced the history of hearing aids across millennia, from rudimentary roots to providing users with an enhanced experience of sound and greater accessibility to acoustic space through digital technology. What becomes immediately evident through an examination of the evolution of hearing aids is great emphasis and value has always been placed upon the ability to hear and detect acoustic information, not only as a means of survival, but in order to communicate and for the individual to maintain a relationship with the world around them. Tracing the history of hearing aids also clearly illustrates that attempts to augment and extend the ear and the sense of hearing has resulted in a number of compromises for the user, whether it was being limited to a monaural or uni-directional sound, or a distorted experience of the world or sounds characterised by auditory interference. Yet the possibilities afforded by the amalgamation of hearing aids and digital technology reveals that function of hearing aids has evolved to become paradoxical. Acoustic prosthetic technologies for the ear developed specifically to provide the wearer with enhanced auditory acuity and the ability to perceive at least some of the characteristics of their surrounding acoustic space are now also being used to create customised and privatised experiences of sound, seemingly in contrast to the primary purpose of

hearing aids to enhance the user's access to, and awareness of, their immediate acoustic space.

This chapter has revealed the paradoxical nature of hearing aids while tracing their historical development and impact(s) upon the user's perception of acoustic space. The following chapter will discuss the development and application of the stethoscope, an acoustic prosthetic technology for the ear used to assist in the diagnosis of internal illness. It begins by tracing the history of techniques used to aurally access the interior of the body, and the impact that the monaural and binaural stethoscopes had upon the physician's experience of exterior, and interior, acoustic spaces.

CHAPTER FIVE

Anonymous history, phenomenology and the development of the stethoscope

5.1 Introduction

Applied to the chest and back of patients to assist in the diagnosis of potential internal illness and abnormalities, the stethoscope is an acoustic medical prosthetic designed to physically extend the ear and the sense of hearing in order to clearly articulate the sounds of the interior of the body. According to media ecologist Neil Postman (1992) the stethoscope was “the most significant of the early medical technologies” (p. 127) in its ability to mediate and reproduce the sounds of the body, sounds that had previously been largely inaudible to the unmediated ear, and transmit them directly into the ear of the physician. To date, the stethoscope has been understood as having contributed to several significant shifts in the practice of clinical medicine. Medical historian Stanley Reiser (2009), argues that the stethoscope was revolutionary in that it was the first instrument generally used for the purpose of diagnosis, and subsequently transformed the practice of medicine in the nineteenth century, first, by enhancing the physician’s ability to detect internal disease through sound, and second, by changing the nature of the relationship between the physician and patient. Cultural historian Jonathan Sterne (2003), meanwhile, contends that the stethoscope made a significant contribution to a shift from the theoretical to the perceptual in the field

of medicine through the development of specialised listening techniques that assisted doctors in distinguishing between normal and abnormal sounds within the body of the patient.

However, in part because extant scholarship has failed to pay sufficient attention to the role of the ear in medical practice, existing readings, such as those mentioned above, neglect the stethoscope's role in altering not just the physician's perception of the patient's body, but also their perception and experience of sound and acoustic spaces more generally. To date, that is, the wider effects of the development and application of the stethoscope, and how it complicated the physician's experience of acoustic space, have largely been overlooked. The examination of this specialised prosthetic technology for the ear has remained largely confined to the realm of medical scholarship, as existing research has predominantly focused upon the role that this medical prosthetic technology for the ear contributed to advancements in diagnostic practices and medical knowledge.

This oversight is a problem. History is incomplete until the phenomenological effects of the application of the stethoscope are examined, in particular how the mediation of sound through this device profoundly changed the physician's experience of sound and space. Furthermore, we cannot appreciate how the stethoscope contributed to considerable historical changes in the mediation of sound, and how this altered the physician's perception of the acoustic spaces that they were privy to. This chapter, therefore, argues that the stethoscope

not only modified the physician's experience of sound, but also significantly altered their perception of space, enabling the revelation of two private interiorised acoustic spaces, first, within the body of the patient, and second, within the head of the physician. It further argues that the appearance of these private acoustic spaces through the use of the stethoscope directly contributed to feelings of displacement for the physician through the creation of hybridised and interiorised forms of acoustic space.

This chapter will advance these arguments through a historical account of the development and practical application of both the monaural and binaural stethoscopes during the first half of the nineteenth century. It pays particular attention to how each of these acoustic medical prosthetic technologies augmented the ear and sense of hearing, and how this augmentation reshaped the physician's perception of acoustic space. In the process, it will draw on the work of phenomenologist Don Ihde. Through the lens of Ihde's (1979; 2007) theory of the embodiment of technological artefacts and the concept of the phenomenological construction of auditory fields, it will consider how the physician negotiated between two different sources of sound when using the stethoscope, facilitating the experience of a form of hybridised acoustic space for the user. In addition, Ihde's theory of auditory fields is foundational to the discussion of how the construction of an internalised auditory field also contributed to this sense of displacement for the physician from their surrounding environment. At the same time, the chapter will outline how these changes in models of acoustic space

mapped onto wider societal shifts in how the human body was understood and approached, drawing on Foucault's (1994) contention that the medical gaze underwent a significant transformation in the early nineteenth century. The ultimate aim of the chapter is to generate further insight into how these medical prosthetic technologies for the ear not only significantly altered the physician's perception of acoustic space, but also emplaced them within a new form of auditory environment.

5.2 Acoustic space, auscultation and the unmediated ear

Attempts made by physicians to hear sounds inside the human body prior to the development of the stethoscope in the early nineteenth century are significant in themselves, as these efforts represent older relations to acoustic space that were transformed in the wake of the stethoscope as "our capacities for listening [we]re changed by technological culture" (Ihde, 2007, p. 4). These methods, of course, were relatively remedial, since prior to the early nineteenth century physicians appear to have had a very limited understanding, or experience, of the interior acoustic space of the body. As the physician had no reliable means by which to listen to the interiorised space of the patient's body, they often depended upon what they were able to see or feel directly in order to reach a diagnosis. Consequently, most knowledge about the human body, how it functioned, and the characteristics of internal illness prior to the development of

the stethoscope was acquired visually through the post-mortem examination of cadavers.

However, in instances when it was necessary to at least attempt to listen to the insides of a live body, the physician found themselves having to rely heavily upon an acute sense of hearing in the hopes of identifying the cause of the patient's malady. From this, two key methods of unmediated auditory examination emerged within clinical medicine. The first of these practices was immediate auscultation (auscultation without mediation), which entailed the physician attempting to listen to the internal sounds of the body, in particular the heart, lungs, respiratory system and the gut, with an unmediated, or naked, ear. This method can be traced back several millennia to the Hippocratic era (460 – 370 BCE), although it was not known as auscultation until the early nineteenth century after being formally named by French physician René-Théophile-Hyacinthe Laënnec.

The practice of auscultation required the physician to place their ear directly to the chest of the patient to hear the sounds produced by the thoracic cavity. During the 16th century, French surgeon Ambroise Pare observed, “if there is matter or other humours in the thorax, one can hear a noise like that of a half-filled gurgling bottle” (Nuland, 1995, p. 224), suggesting that auditory access to the interior of the body could reveal the characteristics of the patient's illness. Yet despite the extremely close and intimate placement of the ear to the body (as

shown in Figure 5.1), immediate auscultation often proved inadequate to aurally access the inner body, particularly in attempts to detect abnormalities of the heart.

Figure 5.1: A painting by French artist Théobald Chartran which shows Rene Laënnec demonstrating the practice of immediate auscultation on a patient at the Necker Hospital in Paris in the early nineteenth century.

Reprinted from Science Source. Retrieved 14 July 2016 from <https://www.sciencesource.com/archive/Rene-Laennec--French-Physician-SS2353547.html>

The physician, according to Laënnec (1830), was frequently unable to clearly articulate the sounds from the hidden space within the body, meaning that the sonic information they were able to access was often ambiguous. These inadequacies, then, appear to have contributed to the development of a second method for the auditory examination of patients; a method which utilised the body as an acoustic receptacle to diagnose potential internal illness.

It was this second method of auditory auscultation, the practice of percussion, which hinted at the presence of an internal acoustic space within the body. Percussion essentially used the thoracic cavity as a resonator. When the surface of the chest was sharply tapped by the physician the ensuing sounds

suggested the presence of an interior acoustic space. Formally identified by Viennese physician Josef Leopold Auenbrugger in the mid-eighteenth century, percussion essentially elaborated upon immediate auscultation through the addition of touch. In his treatise *Inventum Novum* (1761), Auenbrugger explains of the practice of percussion:

I present to the reader a new sign for the detection of diseases of the chest, which I have discovered. It consists in the percussion of the human thorax and the determination of the internal condition of this cavity by the varying resonance of the sounds thus produced (p. 220).

This method Auenbrugger speaks of consisted of the physician placing their ear to the chest of the patient and lightly tapping the chest in different places, listening for the ensuing sounds in order to detect any changes or abnormalities in the thickness of bodily tissue or the presence of secretions in the lungs. It appears that Auenbrugger, whose father was a winemaker, learnt how to tap wine barrels to determine how full they were. During his medical studies he found that the human chest could resonate in much the same way when tapped (Bedford, 1971), and as French philosopher Michel Foucault (1994) explains, the “degree of dullness of the sound produced when a barrel is struck indicates the degree to which it is filled” (p. 199). Thus, by essentially tapping the chest of the patient in a similar

manner to a wine barrel, percussion revealed the likely presence of a hidden space within the thoracic cavity that, through the resonance of sound, could reveal information about the characteristics of this interior space.

This method of the aural examination of the interior of the body thus required the physician to attempt to approach the body of the patient as something to be listened to and explored acoustically in an attempt to determine the nature of the patient's malady. As such, percussion used the implied interior acoustic space of the body as a kind of echo chamber that resonated with slightly different sounds depending on whether the chest was clear and healthy, or diseased and congested. As previously discussed in Chapter Two, Schafer (2007) contends that the only place that sound can be naturally bound is within an interior space, therefore the sounds of the patient's body, namely the thoracic cavity and the gut, were confined within this implied interior acoustic space.

Through the resonance of sound the acoustic space within the thoracic cavity, which had remained elusive prior to Auenbrugger's development of this tactile-acoustic method of examination, became readily apparent for what appears to be the first time. As a result, it became easier for the physician to detect the presence of infection and disease within the chest cavity from the type of sound that was produced through the vibration of tapping on the body. The accuracy of this method was verified by testing the method on cadavers, whereby in a corpse where the sound cavity of the thorax was injected with liquid, then the sound, on

the side of the chest that has been filled, became deadened up to the height reached by the liquid (Foucault, 1994).

As the interior space within the thoracic cavity became increasingly full of liquid it became immediately evident to the listener, as the sounds produced by the chest were much deeper in tone as sound was not able to resonate through the cavity clearly. This method was revolutionary in the eighteenth century as first, it revealed the presence of a private acoustic space within the body that had previously been largely undetectable, and second, it provided a means through which the physician could 'see' the interior of the body by listening to the sounds that were produced within this acoustic space.

Yet despite the development of these clinical methods of auditory examination, there remained instances where the physician was unable to aurally access the interior of the patient's body through the practice of percussion. Although this method "cast not a little light on our knowledge of the obscure diseases of the chest" (Foucault, 1994, p. 222), Auenbrugger (1761) acknowledges that despite the relative success of his method it was by no means perfect. In his treatise he writes,

I confess with all candour that there are defects which conscientious observation will, I hope, amend with time. It is possible that there are even other important truths for the recognition of disease still hidden from this method of diagnosis.

Some of these may prove of great usefulness for the differentiation, prognosis and cure of diseases of the chest (p. 222).

Auenbrugger's observations about the shortcomings of his method appear to have been founded, as there remained facets of the human body and auditory clues as to what was occurring within this concealed space that remained hidden from the physician's ear. Several factors contributed to this hindrance, including modest patients remaining partially clothed, and the difficulty of aurally examining obese patients (Laënnec, 1830). In such cases the sounds produced through percussion were distorted by the flesh of the patient's body and/or their clothing.

A further gender-specific hindrance for both immediate auscultation and percussion was that these practices were widely considered to be socially and morally inappropriate when performed on female patients, especially in the case of young and unmarried women. This was largely due to the fact that during the nineteenth century, the breasts were predominantly considered to be the most sexualised part of the female body (Cartwright, 1995). As both immediate auscultation and percussion required the physician to position their ear directly to the chest, this placed them within a very close proximity to the female patient's breasts (Laënnec, 1830; Sterne, 2003). Writing during the early nineteenth century, physician Zimmerman (1817) explains that

Doctors should be free to make their observations in this respect by placing their hands directly on the heart...but our delicate morals prevent us from doing so, especially in the case of women...this exploration, which is carried out very precisely above the chemise, may take place with all moral decency (p. 122).

While these auditory methods of examination appear to have become more widespread during the eighteenth and early nineteenth centuries, woman's bodies were approached with greater trepidation on the part of the physician, to the point where female patients were treated differently to men. The moral prohibition of these auditory practices, and the resulting inability to hear the sounds of the interior acoustic space within the body, disadvantaged the female patient considerably, as it meant that interior illnesses and abnormalities were frequently left undetected, leaving the patient to succumb to their illness due to a lack of medical intervention and understanding of their physical predicament. However, it was this very inability to listen to the interior acoustic space of a female patient's body that directly led to the development of the first specialised acoustic prosthetic technology for the ear for medical purposes: the stethoscope. This device not only further enhanced the physician's ability to hear and examine the inside of the patient, but also enabled them to experience the interior acoustic space of the body to a far greater degree.

By providing the physician with a mediating device through which to clearly articulate the interior sounds of the body, the stethoscope contributed to a

shift towards an increasingly privatised experience of both sound and space. It appears that the first stethoscope was created by French physician René Laënnec while working at Hôpital Necker in Paris during a widespread outbreak of tuberculosis in 1816. According to Laënnec (1830), he was compelled to create his stethoscope after experiencing difficulties examining an obese female patient whom he suspected to be suffering from an undiagnosed heart disorder. Due to the patient's gender, age and size, Laënnec had to exercise great discretion during the examination process, and was consequently unable to perform either mediate auscultation or percussion. In his treatise *De l'auscultation médiate ou raité du diagnostic des mailades des pommés et du coeur* (A treatise of mediate auscultation on the diagnosis of diseases of the heart and chest), which was first published in 1819, Laënnec explains that upon recalling some basic principles regarding the transmission of sound, he was able to fashion a rudimentary listening device in an attempt to be able to clearly hear the sounds of a patient's chest and heart. He writes,

In 1816, I was consulted by a young woman labouring under general symptoms of a diseased heart, and in whose case percussion and the application of the hand were of little avail on account of the great degree of fatness. The other method... being rendered inadmissible by the age and sex of the patient, I happened to recollect a simple and well-known fact in acoustics, and fancied, at the same time, that it

might be turned to some use on the present occasion. The fact I allude to is the augmented impression of sound which conveyed through certain solid bodies, as when we hear the scratch of a pin at one end of a piece of wood, on applying our ear to the other.

Immediately, on this suggestion, I rolled a quire of paper into a kind of cylinder and applied one end of it to the region of the heart and the other to my ear, and was not a little surprised and pleased, to find that I could thereby perceive the action of the heart in a manner much more clear and distinct than I had ever been able to do by the immediate application of the ear (1830, p. 5).

From his account it appears that Laënnec was primarily motivated to develop his stethoscope in order to provide physical distance between himself and his female patient, thus avoiding the female patient having to come under the scrutiny of an unmediated aural examination (as shown in Figure 5.2).

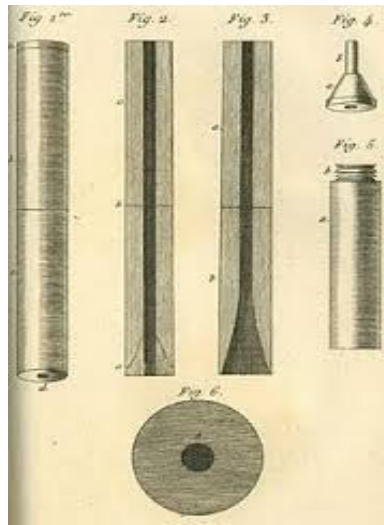


Figure 5.2: An illustration of Laënnec's monaural stethoscopes that appears in his *Treatise* (Laënnec, 1830, p. 110).

The stethoscope provided the user with a different type of private auditory experience than was possible via the unmediated ear through the amplification of sound, ushering in two distinct shifts in the physician's auditory experience. First, as the internal sounds of the patient's body travelled through the stethoscope the ensuing amplification could reveal much greater acoustic detail to the physician than was possible through the naked ear. Second, the ability of the stethoscope to mediate the sounds of the body and make them louder subsequently provided the physician with a means by which to clearly detect not only the internal sounds that had previously remained hidden, but to also clearly identify the interior acoustic space of the patient's body; a space that had only been hinted at through the practice of percussion. Dr V. Art (1820), a physician in the early nineteenth century, describes his experience of listening to the interior of the body through a stethoscope, explaining,

When this cylinder is applied to the chest of a healthy person, in the act of speaking or singing, nothing is heard but a kind of low murmuring, more distinct in some parts of the chest than in others. But when there is an ulcer in the lungs, this murmuring is changed, and the effect is altogether singular (p. 53).

As such, diseases that had remained hidden within the walls of the body, which for thousands of years were largely inaudible and undetectable to the unaided ear, had now found a voice through the stethoscope. The diseased internal organ, according to Robinson (1929), “murmured its tale of woe into the ear of a great and sympathetic physician” (p. 351). The ability for the physician to identify and experience this interiorised acoustic space was fully realised for the first time through the use of the stethoscope. This was made possible by, first, the amplification of acoustic minutiae that could not be detected by the unmediated ear, and second, by the stethoscope physically closing one of the physician’s ears to ambient noise, which provided them with a privatised experience of sound (as shown in Figure 5.3).

Figure 5.3: Painting by Robert A. Thom showing Laennec using his monaural stethoscope. Reprinted from the National Library of Medicine. Retrieved 30 January 2016 from <https://collections.nlm.nih.gov/catalog/nlm:nlmuid-101651398-img>

The detection of an interior acoustic space within the body also contributed to a shift in the early nineteenth century towards a broader understanding of what was implied by the medical gaze, as the ways in which the physician approached and examined the patient began to include the aural examination of the implied acoustic space within the body. Prior to the development of Laënnec's stethoscope in the early nineteenth century the medical gaze placed a distinct emphasis upon the visual, what could be detected by the eye, as a form of surveillance of the human body. However, as argued by Foucault (1994), the stethoscope significantly changed the meaning, and indeed the practice, of the medical gaze. Instead of simply implying the use of visual methods of examination, it evolved to become a multi-sensorial approach to the examination of the body; one that included touch and hearing. He argues,

Thus armed, the medical gaze embraces more than is said by the word 'gaze' alone. It contains within a single structure different sensorial fields. The sight/touch/hearing trinity defines a conceptual configuration in which the inaccessible illness is tracked down by markers, gauged in depth, drawn to the surface, and projected virtually on the dispersed organs of the corpse (p. 202).

While seemingly validating its auditory diagnostic capabilities, Foucault argues here that the stethoscope and subsequent methods of auscultation brought about a shift in the way the body was approached, and the establishment of a sensorial triangulation in medical practice in which sound, touch and vision had to collaborate in the diagnostic process. The result was the formation of a new medical semiology whereby the acoustic-tactile practice of mediate auscultation was included in the realm of the medical gaze to decipher a "mixed web of the visible and the readable" (p. 202) signs indicating internal illness.

Furthermore, Foucault observes that through the detection of a three-dimensional space within the body, the physician had to deal with spatial information for arguably the first time. Laënnec (1830) acknowledges that in some cases it was possible for the physician to incorporate tactile and visual elements into their examination of the patient, and in such cases being able to see and feel physical symptoms in addition to mediate auscultation meant that the physician could reach a more thorough diagnosis as these signs confirmed what they had

heard. Physician John Forbes (1830) also affirms the value of auditory access to the body granted by the stethoscope, stating that

In the great majority of such instances, it will, at once, remove all obscurity and difficulty; in every case it will communicate to the mind of the practitioner a degree of certainty, and consequent satisfaction and comfort, which no combination of mere symptoms can inspire (p. xi).

However, as Laënnec's stethoscope was monaural, with each ear exposed to a different source of sound, physicians had to develop and apply special auditory practices in order to decipher the sounds of the interior acoustic space of the body clearly and accurately without being distracted by ambient noise.

In addition to opening up a new acoustic space in the body of the patient the stethoscope also facilitated a new experience of sound on the part of the physician. By simultaneously listening to two mutually exclusive sources of sound, the physician essentially entered a type of hybridised acoustic space that was neither entirely internal nor external, but rather a combination of both. To obtain enhanced acoustic detail from the body, and distinguish clinical meaning, physicians were required to develop new skills in the practice of listening, whereby listening became an active, rather than a passive, experience. However, this was not always straightforward as each ear was exposed to a different source of sound.

Therefore, the physician encountered two mutually exclusive acoustic spaces. In the unaided ear the user could hear the ambient sounds of the immediate physical environment, while through the other they heard the amplified sounds produced by the stethoscope. For those clinicians not accustomed to the techniques of using a stethoscope, this effect could lead to the physician becoming confused and not being able to hear either source of sound clearly. This is likely to have brought about an unbalanced experience of sound. However, unlike individuals with bi-lateral hearing loss who relied on a single non-electric hearing aid to enhance their experience of sound, the experience of two separate soundscapes may have somewhat puzzled the physician as their auditory attention was torn between two different acoustic sources. Physician Charles Scudamore (1826) explains “in using the stethoscope care is to be taken that it is kept perfectly flat upon the part [of the body] to which it is applied, in order the sound may not escape, nor air be admitted” (p. 8), indicating that the physician was required to limit potential auditory distractions as much as possible in order to hear the sounds of the interior acoustic space of the patient’s body.

While Laënnec (1830) suggests in his treatise that one way to counteract this potentially confusing and distracting acoustic juxtaposition was for the physician to conduct their examination in a quiet environment to limit ambient noise, this was not always possible in a busy and noisy hospital, and as a result, mediate auscultation was often conducted in less than ideal conditions, distracting the physician and compromising their ability to hear bodily sounds. In order for

the physician to become skilled at listening through a stethoscope they were expected to be able, first, to differentiate between normal and abnormal sounds within the acoustic space of the body, and second, to simultaneously metaphorically ‘close’ the unmediated ear to ambient noise. Indeed, according to Laënnec, this skill was a necessity if physicians were to realise the full potential of the stethoscope.

Similarly, in a medical journal published in 1868, physician Hewitt argues that by employing the practice of auscultation “we have a means of diagnosis...of the greatest possible value and importance. Every student of medicine should diligently prepare himself [sic] for making use of this means of diagnosis by practicing it on all occasions” (p. 298). One rudimentary method used to assist in the physician shutting out ambient noise was asking the patient to speak in order for the sounds in the chest to resonate at an increased level. Art (1820) explains that for the physician who had become skilled at this practice, “the voice of the invalid then ceases to be heard by the ear which is disengaged, and it comes to the observer entirely through the canal in the cylinder” (p. 53). This technique, which is essentially a form of selective listening, required the physician to construct an auditory field that saw them focusing upon a single source of sound and acoustic space. The stethoscope, when applied to the body of the patient correctly, compartmentalised first, the physician’s auditory attention, and second, reshaped their perception and experience of their immediate auditory field(s). As previously

discussed in Chapter Four, an auditory field, according to phenomenologist Don Ihde (2007), is a

Specific form of “opening” I have to the World and as an “opening” it is a particular perspective I have on the World. It is an existential structure in that all things that present themselves do so within the field – the field “transcends things- but the field itself is not synonymous with World (p. 74).

In order to hear and articulate the sounds of the patient’s body through the stethoscope the physician had to master the practice of shutting out ambient noise. In order for this to take place a “temporary suspension of the first existential attention towards things must occur” (p. 74). The constriction of an auditory field occurs through isolation; in the case of the physician this involves an isolation of their auditory attention. Their attention towards, and awareness of, their surrounding external acoustic environment had to cease as their auditory focus turned inwards to the sounds emanating from the stethoscope. Ihde (2007) describes how an auditory field can be constructed when listening to music. He writes “in the overwhelming presence of music that fills space and penetrates my awareness, not only am I momentarily taken out of myself in what is often described as a loss of self-awareness...but there is a distance of things” (p. 78). In the instance of the auditory field constructed by the physician, any of their

remaining attention towards their surrounding acoustic environment and the narrative of the patient ceased, as their attention was turned inwards to the interior sounds of the patient's body.

It appears that Laënnec managed to master this skill of the constriction of an acoustic space. In an article entitled *Directions for the use of the stethoscope* (1826), which was published in the peer-reviewed medical journal *The Lancet*, the writer observes that Laënnec had

Tuned his ear so nicely to the study of minute sounds, that he can distinguish at the same moment the pulsations of the heart, the noise of the respiration, of the various rattles... and that although the students move about him and sometimes talk in a half voice, he is seldom obliged to demand silence (p. 313).

However, although Laënnec and some of his peers had mastered the art of listening through the stethoscope, it appears that not all physicians were convinced of the instrument's ability to grant them auditory access to the interior of the body.

Despite the effectiveness of Laënnec's device and techniques of listening, there were also implications in the use of the monaural stethoscope. The most pronounced of these implications was the diminished relationship between the physician and their surrounding environment and a sense of displacement. As discussed in Chapter Four, sound provides the individual with information about

the nature and characteristics of their surroundings. With one ear employed by the stethoscope, the physician's attentiveness to their surrounding auditory environment was effectively halved. Through the construction of an auditory field in order to focus their attention towards the sounds of the body produced by the stethoscope, the physician's awareness of what was happening around them was reduced even further, therefore fracturing the relationship between the physician and their immediate physical environment.

Consequently, the physician's experience of acoustic space was strangely divided. As one ear remained open to the sounds of their immediate physical environment, the stethoscope and the sounds of the patient's body engaged the other ear. By forming an auditory field in order to focus their auditory attention solely towards the sounds resonating from the stethoscope, the physician had to isolate the field characteristics of their circumambient acoustic space, which resulted in a suspension of their first existential attention (Ihde, 2007). Therefore, the field in which the physician directed their auditory attention (the sounds produced by the stethoscope, transcended their field of presence (their immediate physical environment). If the physician was able to direct their attention towards the sounds of the body and mentally block out the noise from their immediate environment, the distinction between the inner acoustic space of the patient's body and the acoustic space of the outside world became more apparent.

Certainly some physicians were sceptical about the construction of an auditory field in which to operate the stethoscope in an effective manner,

considering the practice as a bane on the medical profession. In the Preface to the first English edition of Laennec's treatise, physician John Forbes (1830) argues of the stethoscope

That it will ever come into general use, notwithstanding its value, is extremely doubtful; because its beneficial application requires much time and give a good bit of trouble both to the patient and the practitioner; because its hue and character are foreign and opposed to all our habits and associations (p. 45).

One concern held by some physicians about the 'foreign' nature of the instrument was that it created both a physical and metaphorical distance between the physician and the patient (Sterne, 2003). Foucault (1994) explains that the stethoscope "solidified distance, transmits profound and invisible events along semi-tactile, semi-auditory axis. Instrumental mediation outside the body authorises a withdrawal that measures the moral distance involved; the prohibition of physical contact makes it possible to fix the virtual image of what is occurring well below the visible area" (p. 202). By distancing themselves from their patient, along with the constriction of their auditory field in order to focus solely on the sonic information produced through the stethoscope, the physician became increasingly isolated through an acoustic distancing, and a reduction in their awareness of, and engagement with, the patient or their surroundings. As

such, the physician experienced a form of displacement due to a rupturing of the continuity of sound from their immediate environment through fracturing of their acoustic surroundings. This displacement through constriction of the auditory field, albeit temporarily, significantly altered the acoustic relationship between the physician and their environment through a discontinuity of mediated and unmediated auditory experience that was the result of the physician changing between listening to interior and exterior acoustic space.

5.3 The binaural stethoscope and acoustic space

By providing sound to both ears instead of only one, the binaural stethoscope once again altered the physician's perception and experience of acoustic space. While it was not invented until nearly three decades after Laënnec's monaural stethoscope, the binaural stethoscope in the mid 19th century served to further consolidate the privatisation of acoustic space. Its delayed invention was in part due to the fact that its development was dependent upon the availability of materials that allowed the device a much greater degree of flexibility when in use by the physician (Reiser, 2009; Sterne, 2003). There is some contention regarding who invented the first binaural stethoscope, however patent records indicate that it was developed by Irish physician Arthur Leared in 1851 (as shown in Figure 5.4). Leared's binaural stethoscope consisted of a basic design that incorporated two tubes with earpieces connected to a single tube with two chest pieces. This made it possible for the physician to simultaneously listen to

two different areas of the patient's chest or gut that allowed the comparison of sounds, which assisted in pinpointing the precise location of abnormalities within the body with greater clarity. Leared's binaural stethoscope was revolutionary as the instrument "discovered many secrets in the wondrous box that holds the heart and lungs" (Robinson, 1929, p. 219).



Figure 5.4: An example of Leared's binaural stethoscope.
Reprinted from Antique Medical Instruments. Retrieved 31 October 2018 from http://www.antiquemed.com/test/binaural_stethoscope.htm

The binaural stethoscope brought about a new experience of interiorised acoustic space that appears to have been very different to that afforded by any other acoustic prosthetic technology for the ear to date. As the binaural stethoscope both physically and metaphorically closed the ears to ambient noise, an interior acoustic space seemed to appear within the head of the physician. This phenomenon, known as in-head localisation, occurs under certain acoustic conditions whereby the sound appears to originate from the centre of the head (Schafer, 2007; Sterne, 2003; Toole, 2005; Truax, 2001). Therefore, the auditory

effects and perception of sound experienced through the monaural and binaural stethoscopes was markedly different for the physician. In an article that appeared in *The Lancet* in 1856, some five years after Leared developed his binaural stethoscope, physician Dr James Pollock observes,

To those most accustomed to the investigation of chest disease, the instrument is but of slight importance, and an accurate estimate of the chest sounds can no doubt be easily made with a simple cylinder, such as Laënnec used, or by any of the ebony, cedar, deal, or mahogany tubes which abound in the shops... The increase of sound to be gained by using both ears at once, while all loud external noise is excluded, is, however, a means of obtaining new information on the exploration of the chest, which has excited the attention of several careful auscultators (p. 398).

As the earpieces effectively shut both of the ears to ambient noise, the binaural stethoscope provided the physician with a very different experience of both sound and acoustic space than had been possible through the monaural stethoscope. The binaural stethoscope consolidated the physician's access to the interior space of the patient's body, which they were now able to perceive as a clearly defined, three-dimensional space. This was achieved as the device effectively encased the physician within their own private acoustic space through the elimination of potentially distracting ambient noise from their physical

surroundings. By shutting out circumambient noise, the binaural stethoscope offered the physician the opportunity to detect the acoustic minutiae occurring within the body of the patient, as they were able to hear the sounds of the body through both ears, and their auditory attention was not at risk of being divided between two mutually exclusive acoustic spaces.

Furthermore, the ensuing effect of in-head localisation made possible through the application of the stethoscope not only provided the physician with the ability to focus on a single source of sound in the body of the patient, but also created the impression of the sound originating from the middle of the head. Sound localisation, as previously discussed in Chapter Two, is the individual's ability to identify the point of origin of a sound in direction and distance. In-head localisation, on the other hand, takes place through the use of binaural prosthetic technologies for the ear, such as the binaural stethoscope, as the same sound is delivered to each ear (Schafer, 2007; Sterne, 2003; Stankievich, 2007; Toole, 2005). This provided the physician with the impression that the sounds that they heard through the stethoscope actually originated from the middle of their head, rather than from the patient's body. This effect could only occur when both of the ears were sufficiently closed to ambient noise and a separate source of sound was transmitted through a binaural device such as Leared's stethoscope. As a result, this private, interior, acoustic space that became apparent through in-head localisation could not be perceived without the use of a binaural stethoscope.

This effect of in-head localisation experienced by the physician had a significant impact upon their sense of space. As discussed earlier in Chapters Two and Four, sound conveys spatial information to the individual about their surroundings, and the inability to hear ambient sound means that the individual is no longer acoustically aware of what is happening around them. Consequently, an acoustic distancing occurs. There has been much debate about the ability of sound to convey spatial information, most notably beginning with Strawson's (1959) claims that sound is non-spatial, and as such does not provide us with any relevant information about the physical spaces that we inhabit, as opposed to the visual and tactile experiences of space. As noted by Nudds and O'Callaghan (2009) "Strawson claims that a world of sounds would be a no-space world because sounds are not intrinsically spatial...spatial concepts here have no intrinsically auditory significance, and audition's spatial capabilities depend upon its inheriting spatial content from other modalities" (p. 9).

However, applying Strawson's assertion within the context of the auditory effects of the binaural stethoscope and the shutting out of ambient sound, suggests that his argument is flawed. This is evident in two ways. First, in the case of the physician using the stethoscope, although the sounds mediated through the device did not provide them with any acoustic information about their surrounding environment, it did enable them to perceive acoustic information pertaining to the physical characteristics of the interior acoustic space of the body, including the spatial properties of the thoracic cavity, and the location of any abnormalities.

Second, by closing the ears to the sounds of their environment, a sensory distancing, in this case an auditory distancing, between the physician and their surroundings took place, as one of the senses became shut off from their experience of their world, thus separating it from the other four senses (Howes, 2005).

As the physician's experience of private interiorised acoustic spaces became more profound, so did their sense of displacement. Whereas the skilled application of the monaural stethoscope required the physician to mentally shut out the sounds of their surrounding environment, the blocking of the ears through the use of the binaural stethoscope amplified this auditory displacement, through automatically closing out ambient sound. As discussed earlier in Chapter Four, sound affords us with information about the characteristics of our surroundings. These sounds provide us with a sense of space and belonging as we form a relationship with our immediate physical environment (Truax, 2001; Stocker, 2013).

As sound acts as an interface between the individual and their physical surroundings, by deliberately closing the ears to ambient noise, the physician was effectively displaced from their surrounding environment as their auditory focus shifted towards the sounds produced by the stethoscope. Therefore, both their auditory awareness and experience consisted almost exclusively of the sounds of the patient's body that were reproduced by the stethoscope. Leared's binaural stethoscope also featured rubber on the tips of the earpieces that would have further prevented the physician from being able to hear ambient noise.

Consequently, the physician ceased to hear the voice of the patient and turned their attention towards the sounds of the body as they entered into the private acoustic space of first, the patient's body, and second the interior acoustic space of their own mind.

The perceived interiorisation of acoustic space through the effect of in-head localisation raises the question of the subjectivity of the physician. Acoustic artist Charles Stankievich (2007) questions when listening through a binaural prosthetic technology, what constitutes the interior and the exterior, and where does the subjectivity of the individual begin and end? Merleau-Ponty (2013) offers some insight in this question in his consideration of the essence of the human body and perception. He argues that the circumference of the body forms a kind of boundary, meaning that the individual is not normally aware of spatial relationships. In relation to the auditory effects of the binaural stethoscope, the body essentially formed a definitive boundary between interior and exterior through the effects of sound localisation. Crossley (1995) elaborates that

In the first instance, Merleau-Ponty argues that perception is not an inner representation of an outer world. If one looks behind the eyes, he notes, 'one will find neither substantive mind nor perceptual experience, but rather shadows stuffed with organs' (1968, p. 138). There is no inner theatre of the mind where 'shows' from the outside are projected. Perception occurs in-the-world

rather than in the mind. It is an opening onto or rather an opening within Being (p. 46).

Yet in the case of the binaural stethoscope, this is indeed what occurred for the physician, as sounds from the patient's body were perceived in the imagined acoustic space within the head of the physician. This effect was essentially a projection, made possible through a binaural prosthetic technology for the ear, of one interior acoustic space (the inside of the patient's body) being projected into another interior acoustic space (the head of the physician). It is implied, therefore, that the physician subsequently becomes de-centred and displaced from their surroundings as their acoustic space was not in fact in-the-world, but rather within their own head. As this interior acoustic space within the head was internalised, it could not be perceived by anyone other than the physician. Therefore, they were essentially encased within their own acoustic cocoon and subsequently had very limited auditory-based spatial awareness of their surrounding environment. This auditory cocooning resulted in a sense of displacement for the physician that was more profound than that experienced through the monaural stethoscope, as the sense of hearing was essentially cut off from the other four senses. The exterior acoustic space, however, remained a shared experience as the individual with open ears was able to experience and perceive the spatial characteristics of their environment.

This sense of acoustic displacement that occurred through the use of the binaural stethoscope brings forth the question of *where* are we when we listen? Veit Erlmann (2014) contends that when we listen to music through headphones “we are with us” (p. 321), as we become entranced in the music as listening becomes more about ourselves than a collective experience. This observation can be applied to the physician whose ears were mediated by the stethoscope. As they were no longer bound to a definitive sense of space through ambient sound, this provided physicians with what Erlmann refers to as a “freedom” to create their own perception and experience of the world that is not tied to sound, space or place.

However, while the stethoscope provided a new kind of experiential and perceptual freedom, it also marked the beginning of a shift away from more social and communal experiences of sound and communication. Whereas the hearing aid had been developed specifically to extend the ear of the hearing impaired individual, thus enabling them to hear speech and the sounds of their environment, the stethoscope, despite the monaural stethoscope closely resembling early models of ear trumpets, deliberately shifted the auditory focus of the physician away from the ambient noise, and directed it inwards.

Rather than enabling acoustic access to shared social environments, the experience of sound through the stethoscope was very much a private one. This interiorisation of acoustic space marked a significant milestone in the privatisation of listening that gained momentum from the mid-nineteenth century (Sterne,

2003). In turn, this had implications for the communal and social dimensions of sound as listening became an increasingly individualised experience, a trend that began to gain traction during the Victorian era. As shown in this section, the stethoscope made a significant contribution to the transformation in the acoustic dimension in medicine. The human body was no longer simply something to look at and touch, it also became something to listen to; a sonic vessel that could be explored through the use of this prosthetic technology for the ear. The stethoscope-wielding physician “could conduct an autopsy on the patient while the patient was still alive” (Postman, 1992, p. 25). The clarity with which the physician was able to detect and hear the different internal sounds of the body meant that it was no longer necessary to wait until the patient died to identify the medical issue that led to their demise. The stethoscope essentially revealed secrets of the body that had previously remained hidden, while turning the physician’s ear inwards instead of out into the world.

Unlike acoustic hearing aids, which amplified ambient sound and directed it inwards towards the ear, the binaural stethoscope was designed to amplify the sound of one acoustic space (the body) while essentially removing the physician from another (the surrounding soundscape). The primary auditory and phenomenological effects of the use of the stethoscope for the physician was two-fold; first, the body of the patient effectively became a sonic vessel; a form that became detached from the world and evolved from something to listen *with* to a form to be listened *to*. Second, the impression of an interiorised acoustic space

within the head of the physician contributed to a significant sense of displacement from their acoustic environment and physical surroundings. Consequently, it appears that the stethoscope may very well have been the first acoustic prosthetic technology for the ear that clearly brought about the effect of in-head localisation. This in itself marked a significant milestone in the evolution of prosthetic technologies for the ear as it effectively indicated the beginning of the ability to control and manipulate acoustic space, a feat that prior to the mid-nineteenth century had been largely limited to the direction in which acoustic hearing aids were pointed by the wearer. The ability to construct not only private but internal acoustic spaces was nothing short of revolutionary at the time, and continues to be of relevance in media environments that are increasingly populated by various privatising prosthetic technologies for the ear.

Summary

This chapter has considered the role played by the stethoscope in the reshaping of the perception of both interior and exterior acoustic spaces. It has explored the use, development and application of monaural and binaural stethoscopes and their ensuing effects upon the experience of sound, acoustic space and the development of techniques for privatised listening. It has also examined how these factors contributed to the physician experiencing a sense of auditory displacement and, in the case of the monaural stethoscope, the perception of a hybridised form of acoustic space that was neither interior or

exterior, but rather the merging of two formerly mutually exclusive acoustic spaces.

Furthermore, it has discussed how the use of the stethoscope revealed not one but two different private, interiorised acoustic spaces; first within the body of the patient, and second, the perceived interior acoustic space that appeared through the effect of in-head localisation in the physician. Through the examination of the physician's construction of an auditory field in order to direct their aural focus towards the body of the patient, the integral role of the stethoscope in the shaping of the physician's perception of acoustic space is evident. This investigation into the phenomenological effects and experience of sound perception through the stethoscope is of value as their development and subsequent use marked the beginning of a movement towards the increasing privatisation of mediated listening experiences that began to build momentum in the late nineteenth century through the increasingly widespread use of prosthetic technologies for the ear such as headsets and headphones.

Whereas this chapter has focused on interiorised space, the following will trace the history and application of prosthetic technologies for the ear developed for the purpose of auditory pleasure: headphones. It begins with the development of the first headphones, which, like the binaural stethoscope, had a significant impact upon the privatisation of listening and the interiorisation of acoustic space. It explores the ways in which headphones generated privatised experiences of sound, and contributed to discontinuities in the way in which acoustic space was

perceived by the user. Finally, the following chapter explores how these acoustic prosthetic technologies for the ear have historically contributed to newly privatised experiences of acoustic pleasure, which in turn affected how both interior and exterior acoustic spaces were perceived.

CHAPTER SIX

An anonymous history of the phenomenological influence of headphones

6.1 Introduction

Worn in, over, or on the ear, headphones are personal acoustic prosthetic technologies that enable private, individualised experiences of sound. Over the last century headphones have evolved to become omnipresent audio accessories, with their daily use becoming the norm for generations of Walkman, iPod and digital media device users. Unlike other devices discussed in this thesis, specifically hearing aids, headphones have already been the subject of some critical analysis in terms of their relationship to changing regimes of acoustic space. As a number of critics have argued, headphones have served as an isolating technology that effectively distances the user from their surrounding environment and other people by facilitating private listening experiences (Attali, 1985; Bull, 2000; Bull, 2007; Hosokawa, 1985; Stankievich, 2007; Sterne, 2003; Truax, 2001). According to these critics, whereas sound was once an inherently social, shared experience, the widespread use of headphones has seen auditory experiences become increasingly atomised (Hosokawa, 1984; Truax, 2001). According to sound artist Charles Stankievich (2007), for example, headphones provide “a bracketing of the world for a precise analysis of sound” (p. 5), operating as personal audio technologies that allow the user to listen to a soundscape of their choice without interference.

Media and communications theorist Heike Weber (2010) contends that in the late twentieth century headphones enabled mobilised techniques of privatised listening, while Michael Bull (2007), argues that the ubiquitous nature of personal media devices is indicative of “a culture which universalises the privatisation of public space [and] auditory privatisation” (p. 4). Similarly, social theorist Jacques Attali (1985) contends that headphones facilitate an “acoustic cocooning technique” (p. 341), enabling users to shut out the distractions of extraneous environmental noise that dominates urban spaces.

However, while this existing literature is valuable, it does not provide a comprehensive historical picture of the process by which this privatisation took place over the past hundred and thirty years. Nor, relatedly, does it examine the full range of different forms of auditory privatisation made possible by these acoustic prosthetic technologies for the ear, or acknowledge the extent to which their affordances to privatised models of acoustic space often coexisted with affordances to older, more communal models of acoustic space. This chapter, therefore, proposes to extend this body of work by providing a thicker, historical account of the process by which headphones served to produce newly privatised experiences of remote or isolated acoustic pleasure across technologically enabled modernity, from the late nineteenth century to the present. Paying particular attention to, first, how each of these devices altered how sound was experienced by the user, and second, the implications that changes in the reproduction of sound had upon the user’s subsequent perception of acoustic space(s), it shows that

headphones do not affect the user's perception of acoustic space in a generic manner. Rather, historically various types of headphones have altered the user's experience of acoustic space in very different ways. The chapter further shows that several types of headphones presented the user with hybridised experiences of acoustic space through the merging of two formerly distinct, and separate, soundscapes, in which privatised acoustic space and more communal forms of acoustic space merged. Such hybridised experiences of acoustic space became apparent through the use of monaural and bone conduction headphones.

In advancing this argument, this chapter draws from phenomenologist Don Ihde's post-phenomenological theory of embodiment relations, in particular the sensory extension-reduction structure. It applies Ihde's extension-reduction model to illuminate how different types of headphones produced different experiences of acoustic space by reshaping the user's perception of both interior and exterior soundscapes, and how this technologically enabled modification of auditory experience altered the way in which they related to, and experienced, the world around them. Ihde's model of extension, or amplification, and reduction further elaborates on his theory of the embodiment relations that take place between humans and their technologies. As discussed in earlier chapters, when an embodiment relation takes place the human user experiences the world through the machines and devices that they use, as they effectively operate as an extension of the body. Advancing this theory, the sensory extension-reduction structure holds that as a technology becomes embodied, there is an extension of experience.

However, when an extension takes place, there is also a reduction of some facet(s) of that experience. Tracing the historical development and application of headphones, in conjunction with Ihde's extension-reduction model, provides a means by which to examine how headphones have historically generated new privatised experiences of isolated acoustic pleasure, which in turn led to new discontinuities in the user's perception of acoustic space.

6.2 Extending the telephone

The privatisation and interiorisation of acoustic space that emerged with the advent of the stethoscope during the first half of the nineteenth century within the medical profession began to spill over into the domestic setting in the late nineteenth century. This occurred through the development of acoustic prosthetics for the ear – namely headphones – that were designed specifically for the purpose of entertainment and acoustic pleasure. However, unlike the stethoscope, which reproduced the sounds of the interior of the body of the patient directly in front of the physician, the earliest known headphones were essentially an extension of the telephone. Thus, these headphones provided the listener with auditory access to remote acoustic spaces. Developed in 1876, Alexander Grahame Bell's telephone was groundbreaking as it was the first technology that was capable of transmitting sound across vast distances. Interestingly, the potential of the telephone to be used as a medium to broadcast

audio to multiple locations simultaneously was seemingly realised shortly after the telephone's arrival into the home.

Within five years of the telephone's debut, services offering aural entertainment that utilised telephone networks to provide members of the public with private listening experiences began to materialise in parts of Europe and the United States. Fondly dubbed the *pleasure telephone* (Mee, 1898), these services were "in [their] simplest form... an application of that familiar and wonderful invention the telephone" (Wright, 1897, p. 343). The pleasure telephone services, which operated from the 1880s until the early 1920s, effectively foreshadowed broadcast radio programming that emerged in the early twentieth century. As the first radio broadcast did not take place until 1920 (Sterne, 2003; Weber, 2010) these telephone services appear to have been the only means that members of the public had for listening to live audio broadcasts. Yet, instead of using a generic telephone receiver, these entertainment services used headphones attached to a unit connected to existing telephone wires. Therefore, these services appear to have afforded many individuals with their first opportunity to aurally enter a new form of privatised, remote acoustic space through being the user of an acoustic prosthetic device for the purpose of auditory pleasure.

As users of the pleasure telephone services had no option but to use headphones in order to access and listen to broadcasts of news, sermons, music, and theatrical performances, they were effectively manoeuvred towards more private experiences of sound and acoustic space. Consequently, the user's

perception of acoustic space became, to varying degrees, internalised, as their auditory attention was turned inwards rather than out towards the sounds of the world around them. Furthermore, as the various pleasure telephone services operating in parts of Europe and the United States in the late nineteenth and early twentieth centuries used different models of headphones, the listener's ensuing perception of acoustic space varied, depending on the type of headphones utilised by the service available in their particular location. For example, one of the earliest pleasure telephone services, the Telefon Hirmondó (the Telephone Herald) that operated in Budapest from 1893 until the 1920s, used headphones in the form of earpieces that were held to the ear in a similar fashion as early telephone receivers (Mee, 1898), as illustrated in Figure 6.1 below.



Figure 6.1: A print advertisement for the Telefon Hirmondó telephone service, c.1900. Reprinted from The Radio Museum. Retrieved 22 January, 2015, from https://www.radiomuseum.org/cy/only_hungary.html

These headphones were representative of the headphones used by several pleasure telephone services in the United States and parts of Europe, thus the claims made

here regarding the Telefon Hirmondó are more broadly applicable to similar services. In order to aurally access this “speaking, singing, lecturing and concert giving ‘newspaper’” (Mee, 1898, p. 1), two monaural earpieces were attached to the pleasure-telephone unit that was connected in the home or public listening room. These earpieces, as shown in Figure 6.2 below, offered the listener the opportunity to enter and perceive a form of privatised acoustic space that was remote from their immediate physical location.



Figure 6.2: An illustration of the Telefon Hirmondó telephone service earpieces, c. 1895. Reprinted from The Radio Museum. Retrieved 4 October, 2018, from https://www.radiomuseum.org/cy/only_hungary.html

These headphones, such as those used in conjunction with the Telefon Hirmondó service, generated a new kind of technologically-enabled discontinuity in the listener’s resulting perception of acoustic space. Sterne (2003) argues that as there was an ‘enlightenment’, there was also an ‘ensoniment’ that occurred during the nineteenth century. He explains that this took the form of “a series of conjectures among ideas, institutions, and practices that rendered the world audible in new ways and valorised new constructs of hearing and listening” (p. 2).

Whereas the stethoscope had enabled physicians to perceive hybridised and interiorised acoustic spaces, it was a specialised medical device used exclusively by medical professionals. The pleasure telephone services, on the other hand, brought privatised and isolated experiences of listening pleasure to the wider public. Therefore, it can be argued that the pleasure telephone and the accompanying headphones in part contributed to this 'ensoniment' as they made possible new mediated practices of listening, and experiences of sound and acoustic space that had not previously been possible through the naked ear.

As each connection to the Telefon Hirmondó service provided two separate monaural earpieces, these acoustic prosthetic devices had the propensity to generate markedly different forms of detached acoustic enjoyment for the user, depending on whether the listener utilised one or two earpieces. The user could either listen binaurally, or two people could listen to the service at once monaurally. By using a single earpiece, the user's perception of acoustic space would have been similar to that experienced by the physician through the monaural stethoscope, or a generic telephone receiver. Through the mediated ear, the listener was afforded auditory access to the remote acoustic space of the performance at the other end of the pleasure telephone wires, while the other remained open to the sounds of their immediate physical surroundings (as shown in Figure 6.3 below).

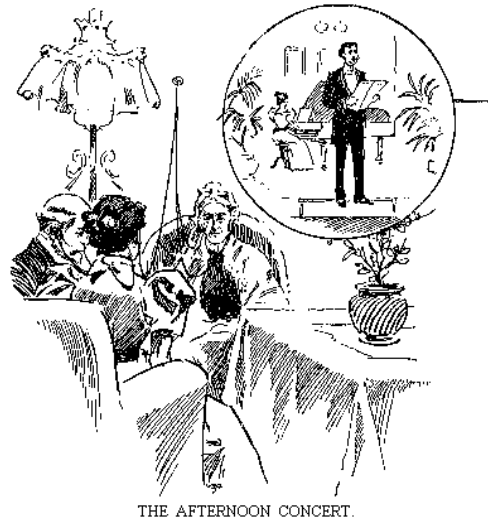


Figure 6.3: The Afternoon Concert: an illustration of individuals utilising the Telefon Hirmondó to listen to a concert in the home that was taking place at a different location. Reprinted from Early Radio History. Retrieved 13 October, 2018, from <https://earlyradiohistory.us/1898pls.htm>

In such instances whereby the user listened monaurally, there was a risk that their auditory attention could be compromised as it was effectively drawn in two different directions; outwards to the sounds of their surrounding environment, and inwards towards the sounds produced by the earpiece. Consequently, this produced an alteration in the user's experience of the spatiality of both of the acoustic environments that the listener was privy to, as they could give neither their full attention.

As discussed in previous chapters, when experience is mediated by a machine or technological device, the user's experience of their surrounding environment through that device is transformed. For example, Marshall McLuhan (2013) argues that the telephone requires that the user give it all of their attention, implying that the telephone user must consciously focus their auditory awareness

towards the sounds produced by the receiver rather than the ambient sounds around them. Although here McLuhan is referring to a standard telephone, this observation is also applicable to the use of the pleasure telephone earpieces, as they essentially operated as a version of a one-way telephone. Ihde (1979) elaborates that in instances where a shift in perception takes place, such as that between the telephone and its human user, “a co-implied extension-reduction structure operates, whereby there is both a certain extension and amplification of experience and a reduction and transformation of experience” (p. 9). This sensory extension-reduction model can be applied to acoustic prosthetic devices, in this case different types of headphones, in order to reveal how they contributed to the reshaping of auditory experience and the listener’s resultant perception of acoustic space.

When applying the extension-reduction structure to the listener’s experience of sound through the Telefon Hirmondó earpieces or headphones, it becomes apparent that there were several implications for the listener’s experience of acoustic space. This occurred through the simultaneous experience of two independent soundscapes when listening to the pleasure telephone through a single earpiece. First, the listener’s auditory perception was extended into a remote acoustic space that was independent of their surrounding environment. This was made possible as the earpiece provided access to the isolated acoustic space of the performance that was taking place at the other end of the telephone line. Second, as they aurally entered this mediated acoustic space, the user’s

awareness of, and attentiveness to, their surrounding acoustic space was significantly reduced. With their auditory focus turned towards the sounds produced through the earpiece of the pleasure telephone, the listener's perception of their immediate acoustic setting faded, as the sounds around them became little more than 'background' noise.

By using just one earpiece, the listener's ability to detect the directionality of sounds in both their surrounding acoustic setting and the acoustic space of the pleasure telephone was compromised, meaning that they would have had difficulty deciphering the location of different sounds. By placing a single headphone earpiece to the ear, through the mediated ear the listener could hear music or performance taking place. Through the other 'open' ear, they could hear the sounds of their immediate surroundings, such as people talking. However, they would not have been able to clearly detect which direction those sounds were coming from. While they would have likely been able to determine the approximate location of the voices, they would not have been able to distinguish the exact location of the people talking if they were out of sight. The listener would have also been aware that the performance they were listening to was coming from the earpiece. Yet, as they were simultaneously listening to a different source of sound through each ear their experience of both of these acoustic spaces would likely have been confusing and disorienting.

Furthermore, the listener would not have been able to detect any depth of sound in either acoustic space. This would have occurred as the sounds produced

by the earpiece were perceived as being very flat and originating from a single point. Additionally, the listener's awareness of their exterior soundscape was effectively halved, with the ambient sounds of the surrounding environment also appearing to resonate from a single position. Therefore, the listener's experience of these two acoustic spaces, one external, and one internalised, remained one-dimensional. While they could detect two different acoustic spaces, they remained entirely separate, creating a distinct discontinuity in the listener's experience of both spaces. For example, if the listener focused on the sounds reproduced through the earpiece, their awareness of the exterior acoustic space dissipated, and they were no longer consciously aware of the sounds taking place around them. Consequently, the listener experienced a discontinuity in their experience of acoustic space, whether they were consciously aware of it or not. In turn, this contributed to a sense of displacement or alienation on the part of the listener, becoming aurally disengaged from the world around them, as they became preoccupied with the isolated world of sounds accessible through the pleasure telephone.

However, by employing both earpieces and listening to the pleasure telephone services binaurally, the listener was presented with a very different experience of acoustic space. This occurred as the user was able to 'close' their ears to ambient sound. Schwartz (1998) observes that,

Human hearing is constant, involuntary, and nearly impossible to shut off. That is, the ordinary unassisted ear takes in all of the sounds within its individual range, whether we are awake, drowsing, or ‘sound’ asleep, and whether we want to hear them, are indifferent to them, or make every effort to ignore them” (p. 487).

However, in the case of the Telefon Hirmondó, the earpieces essentially operated as prosthetic ‘earlids’, blocking out the sounds of the user’s immediate exteriorised soundscape. Simultaneously, these prosthetic earlids granted the listener with a richer and more sonically detailed experience of the remote acoustic space facilitated by the earpieces. In turn, this created an increasingly immersive aural experience, as the listener’s attention was no longer split between two independent acoustic spaces. As discussed previously discussed in Chapter Five, binaural acoustic prosthetics for the ear, such as the stethoscope or headphones, enable the user to perceive an interiorised acoustic space as the sounds produced by the device appear to originate from the centre of the head, rather than the external world. This effect of in-head localisation, which Schafer (1994) refers to as ‘headspace’, was made possible through the Telefon Hirmondó earpieces as the user became encased within their own isolated acoustic space as the earpieces prevented ambient noise from entering the ear. Schafer explains that head-space, a popular expression with adolescents, refers to “the geography of the mind, which can be reached by no telescope...in the head-space of [headphone] listening...the

sounds literally seem to emanate from points within the cranium itself" (p. 124). Therefore, Schafer continues, through the creation of this interiorised space perceived within the cranium, headphones produce the ultimate form of private acoustic space as the head-space facilitated through the use of binaural headphones cannot be perceived by anyone other than the headphone user themselves.

It appears that listening to the pleasure telephone services through binaural headphones was the first time that members of the general public were enabled to perceive a form of interiorised acoustic space through the effect of in-head localisation. The extension-reduction model indicates that by shutting the ears to the sounds of the surrounding environment, the listener's auditory perception was extended into a private, interiorised acoustic space. This acoustic space not only enabled auditory isolation from the surrounding exterior acoustic space, but also by blocking out ambient noise the headphones also afforded the listener the ability to focus all of their auditory attention towards the sounds of this interiorised acoustic headspace. Conversely, the listener's awareness of their surrounding physical environment was significantly reduced to the point that it was almost entirely eliminated as they became cocooned within their own auditory space. The implications of this reduction in awareness of their immediate physical environment meant that the sense of auditory displacement that had been experienced through the use of a single pleasure telephone earpiece became amplified, which ultimately severed the relationship between the listener and their

surrounding acoustic environment as they were no longer aware of the sounds occurring around them.

Yet as the earpieces that were used in conjunction with the Telefon Hirmondó service were only capable of producing monophonic (mono) sound, the acoustic information that appeared to resonate from the head through the effect of in-head localisation was still perceived as emanating from a single position. The implications of this effect were that the private and isolated acoustic space experienced through the earpieces was not perceived as being spherical with sound coming from every direction, as experienced naturally through the unmediated ear. Rather, it was a flat, one-dimensional acoustic space with very distinct horizons, in direct contrast to McLuhan and Carpenter's (1960) explanation of the characteristics of acoustic space being horizonless and boundless, with sound coming from every direction. Consequently, it seems that while the earpieces used in conjunction with the Telefon Hirmondó service provided a means through which to create an interiorised headspace, they did not have the capacity to provide the listener with the impression of a fully realised three-dimensional acoustic space that was perceived as being spherical.

However, the headphones used in conjunction with another of the pleasure telephone services, the Théâtrephone, generated a markedly different kind of immersive acoustic space for the listener. This was made possible as the service endeavoured to present the user with a listening experience that more closely resembled that of the unmediated ear. This was attempted by, first, providing

earpieces that were intended to be used binaurally (as shown in Figure 6.4), and second, enabling a multi-directional experience of sound through the use of new sound reproduction technologies. Launched at the World Expo in Paris in 1881, the Théâtrophone was developed by French engineer and inventor Clément Ader, who had played an integral role in the establishment of France's first telephone network. In a similar fashion to the Telefon Hirmondó service, the Théâtrophone also transmitted news, sermons, musical and theatrical performances to public listening rooms and the homes of subscribers in Paris and selected parts of France broadcast directly from the Paris Opera.



FIG. 4.—GENERAL VIEW OF A THEATROPHONE.

Figure 6.4: An illustration of the Théâtrophone pleasure telephone unit. Note the two earpieces hanging from each side of the box.

Reprinted from Early Radio History. Retrieved 14 February 2017, from <https://earlyradiohistory.us/1892the.htm>

Yet, unlike the Telefon Hirmondó, the Théâtrophone was specifically designed to provide the listener with the impression of being present at the performance by enabling them to perceive a greater depth of sound, and therefore

a more comprehensive impression of the remote acoustic space they experienced through the headphones. In order to afford listeners with the ability to detect the acoustic minutiae of the performance taking place, approximately 80 transmitters were positioned at the front of the stage of the Paris Opera to capture different sounds from multiple positions across the stage. These transmitters converted sound to electrical signals, which were then fed to the local telephone exchange through the telephone wires (Wright, 1897). This seemingly excessive number of transmitters enabled the Théâtrephone listener to detect an additional auditory dimension as changes in sound levels provided an indication of where the performers were positioned on the stage. This effect, to some degree, provided the listener with a richer sense of the remote acoustic space they were able to aurally access through the headphones, as they were able to identify the directionality of sounds as well as, to some degree, perceive the spatiality of the performance venue.

Second, as the Théâtrephone headphones were effectively two supra-aural earpieces that had to be physically held over each ear (as illustrated in Figure 6.5), sound travelled to each of the earpieces through a separate line or channel. This meant that the listener was able to experience sound in what was essentially an early, albeit basic, form of stereo by creating a simple multi-directional auditory perspective.



Figure 6.5: An advertisement for the Théâtrophone service within the home. Date unknown. Reprinted from Association de la Régie Théâtrale. Retrieved 16 February, 2017, from <http://www.regietheatrale.com/index/index/thematiques/Severine-Mabille-theatre/Severine-Mabille-le-theatrophone.html>

When applying the extension-reduction structure to this scenario, the listener's perception of the remote acoustic space accessed through the Théâtrophone headphones was extended. This was possible as the sound broadcast from the multiple transmitters on the stage were able to convey the directionality of sounds within the Paris Opera, an effect which had not been possible through the Telefon Hirmondó headphones. In turn, through the effect of in-head localisation that occurred through the use of binaural headphones, the illusion of an interiorised two-dimensional, acoustic space became apparent. Whereas the Telefon Hirmondó headphones only had the capacity to provide the user with the impression of a one-dimensional space, the Théâtrophone service and headphones enabled the listener to detect the origin of different sounds, thus broadening their perception of the remote acoustic space at the end of the telephone wires.

In a similar fashion to the Telefon Hirmondó earpieces, there was a reduction in the Théâtrophone headphone user's awareness of their immediate acoustic environment. As their ears were physically closed to ambient noise, this again resulted in the listener experiencing a form of sensory distancing from their physical setting, whether in the home or a public listening room, as shown in Figure 6.6 below.



Figure 6.6: An illustration of people gathered in a public listening room to enjoy programmes transmitted by the Théâtrophone service. Reprinted from Early Radio History. Retrieved 14 July, 2017, from <https://earlyradiohistory.us/sec003.htm>

The implications of this new privatised auditory experience was that the listener sensed, either consciously or unconsciously, a discontinuity in their perception of acoustic space, as they entered the isolated and remote world of the Théâtrophone. Second, the listener's ensuing experience of an interiorised acoustic space, made possible through the effect of in-head localisation, was that of a two-dimensional space as they were able to perceive the directionality of sounds to some degree. As such, the characteristics of the imagined interiorised

acoustic space more closely resembled the natural experience of detecting sound coming from multiple directions, as perceived by the naked, the unmediated ear, rather than the one-dimensional soundscape offered through the Telefon Hirmondó headphones.

However, despite the Telefon Hirmondó and the Théâtrephone services offering the listener with the opportunity to experience binaural sound, it appears that the Electrophone was the first pleasure telephone service that offered the user with all-in-one, dedicated binaural headphones for privatised acoustic gratification, as opposed to separate earpieces. A further distinguishing feature of the Electrophone headphones was that they were designed to provide the user with an additional degree of auditory isolation. The Electrophone, which operated in London and selected parts of the United Kingdom from 1895 to 1925, utilised circumambient headphones that cupped the ears (as shown in Figure 6.7), thus providing additional auditory insulation for the user by providing a larger physical barrier that prevented ambient noise from reaching the inner ear.

Figure 6.7: Advertising image showing the Electrophone headphones in use (c. 1894). Reprinted from The Telegraph. Retrieved 20 October, 2018, from <https://www.telegraph.co.uk/technology/connecting-britain/electrophone-invention/>

Consequently, the shape and size of the Electrophone headphones affected the listener's ensuing impression of acoustic space. According to the extension-reduction model, the user's ability to construct, and perceive, an internalised acoustic space was extended through the use of these binaural circumambient headphones. This was possible as the physicality of the headphones themselves provided favourable acoustic conditions for the effect of in-head localisation to take place, possibly to a greater extent than was possible through the Telefon Hirmondó and the Théâtrephone earpieces that had to be held to the ear when in use. Yet, as the Electrophone headphones surrounded the entire ear, they further reduced the listener's capacity to detect the sounds of their surrounding soundscape.

However, the Electrophone headphones did not have the capacity to reproduce the effect of sound directionality and localisation afforded by Théâtrephone headphones, as they were only capable of reproducing mono sound. In turn, this had implications for the listener's resulting perception of acoustic space. Thus, according to the extension-reduction structure, the listener's ability to construct, and metaphorically 'enter' an isolated and privatised acoustic space was extended as the physicality of the headphones provided the user with a greater degree of auditory insulation from ambient noise. As the earpieces were larger and cupped the ear, they effectively provided a form of passive noise cancellation. Effective passive noise cancellation is dependent upon the physical design of the headphones, specifically the earpieces, and the way in which they cover the ear

and block out extraneous noise, and the materials used to make the outer casing of the earpieces (Hansen, 2001; Molesworth, Burgess & Kwon, 2013). In the case of the Electrophone headphones, as the earpieces cupped the ear, and the earpieces had a solid backing, they were more effective at enclosing and insulating the ear against the distractions of ambient noise. The implications of the user's perception of acoustic space, according to the extension-reduction structure, were that these headphones extended the user's auditory isolation by providing a more robust barrier against extraneous ambient noise than had previously been possible in other models of headphones.

Yet in extending the listener's auditory isolation, the Electrophone headphones in turn further reduced their awareness of their immediate location, leading to a greater auditory distancing between the user and their immediate environment. It appears possible that the degree of sensory displacement may have been experienced more acutely due to the passive noise cancelling capacity of the headphones, as the earpieces of the headphones afforded the wearer with a greater degree of auditory isolation from unwanted ambient noise. In turn, this resulted in the user experiencing a sense of displacement and a further fracturing of the relationship between the listener and their immediate environment.

In spite of the various pleasure telephone headphones that provided users with new mediated experiences of private acoustic space, paradoxically they also facilitated a means of shared listening. The ability to take part in a private, yet collective, experience of sound brings to the fore long-held notions of headphones

operating as devices that isolated people not only from their surrounding environment, but also from one another. As discussed earlier in section 6.2, both the Théâtrephone and Electrophone pleasure telephone services provided a pair of binaural headphones, or earpieces, with each connection, thus enabling an individualised, yet shared, listening experience. Alternatively, if the pleasure telephone user accessed the service in a public listening room, a number of people could be found ensconced within their own isolated acoustic space, while sharing the experience of the auditory entertainment of the pleasure telephone with others, as shown in Figure 6.8 below.



Figure 6.8: People gathered in an Electrophone public listening room in London (Thompson, 1903, p. 15).

While these binaural headphones bracketed the user off from their immediate acoustic environment, users were able to access a common soundscape for the purpose of entertainment and auditory amusement. In so doing, the pleasure telephone can also be considered an acoustic technology that facilitated a new form of social interaction. In an article that appeared in *The Strand*

newspaper in 1898, Mee asserts that one of the most appealing features of the pleasure telephone was not the quality of sound that the headphones were capable of reproducing, or the auditory isolation that they provided, but rather that people did not have to leave their homes in order to be entertained by theatrical and musical performances. Mee argues that at the end of the nineteenth century the pleasure telephone would instigate social gatherings, as people could gather in the home or public listening rooms in order to enjoy various programmes together. He writes “the telephone will be a quite indispensable element in English social life...and it will be so entertaining and useful that it will make life happier all round, and bring the pleasures of society to the doors of the artisan’s cottage” (p. 339). In so doing, the pleasure telephone not only mobilised the experience of sound, but also facilitated a form of social event.

Prior to the development of the telephone, and the pleasure telephone services, sound had been tied to place. A key implication of the mediated experience of sound and acoustic space made possible through the pleasure telephone headphones was that the listener no longer had to be physically present in order to experience music, theatre, sermons, and the like. Therefore, the pleasure telephone and its accompanying headphones afforded people the opportunity to metaphorically extend the ear in order to access such events while remaining in the domestic setting, as their auditory attention and imagination were transported to the remote acoustic space of the performance venue.

Interestingly, however, it appears that it was not the intention of the pleasure telephone services to provide isolated experiences of sound. As public radio broadcasts did not commence until the 1920s, at approximately the same time that the electro-dynamic speaker was produced, the only means of broadcasting live audio was via the telephone. Furthermore, due to the limited advances and capabilities of acoustic technologies in the late nineteenth and early twentieth centuries, the only means available of accessing the sounds transmitted by the telephone was by a standard generic receiver or the earpieces and headphones of the pleasure telephone services. Consequently, it appears that these headphones were developed and used out of necessity, rather than for the specific purpose of generating privatised experiences of acoustic enjoyment. Therefore, it seems probable that the creation of the isolated acoustic spaces experienced by pleasure telephone users were not deliberate, but rather a by-product of the lack of sound reproduction technologies available at the time.

Yet despite enabling newly privatised, and shared, experiences of isolated and remote acoustic entertainment, access to the pleasure telephone services and their headphones was often limited to the middle and upper classes due the cost associated with their use. The Electrophone, for example, cost approximately sixpence for five minutes, with an annual home subscription costing approximately £5 pounds a year (Wright, 1897), which equates to approximately £550 (or NZ\$1100) in today's terms. Consequently, access to isolated acoustic spaces for auditory recreation was largely restricted to the wealthy. It appears that

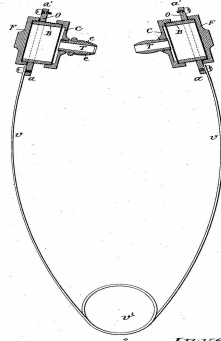
the pleasure telephone provided the only means for members of the public to experience private acoustic spaces specifically for the purpose of auditory pleasure until the mid-twentieth century. Despite the fact that the first half of the twentieth century saw a number of advances in headphone technology, these acoustic prosthetic devices for the ear were intended for, and predominantly used, for specialised purposes. With the advent of wireless radio in the early 1920s, the pleasure telephone services were quickly discontinued as radio began to broadcast news and entertainment to the masses.

The late nineteenth century also saw the development of a different type of headphone fashioned for specialised, professional purposes that made creation of a private, isolated space for concentrated listening possible. It seems that the earliest recorded patent issued specifically for a pair of headphones was the patent for a pair of in-ear receivers submitted by French engineer Ernest Mercadier on 16 June 1891 (U.S. patent number 454138) (Stamp, 2013). Named the 'bi-telephone', these headphones, as the name suggests, were designed to be used in conjunction with the telephone by telephonists. Although these headphones were not used for entertainment purposes, they remain worthy of consideration within the context of this study as they effectively foreshadowed the earbud style of headphones that became commonplace in the late twentieth century. According to Mercadier's patent, the bi-telephone was intended to provide telephone operators with "improvements in telephone receivers...which shall be light enough to be carried while in use on the head of the operator" (Stamp, 2013, para. 4). The function of

the bi-telephone was threefold; first, they were invented to provide greater amplification of sound than was possible through the telephone handset; second, they allowed the telephone operator to keep their hands free; and finally, they enabled construction of a private, isolated acoustic space, whereby the user could clearly hear the sounds and signals transmitted by the telephone without interference from ambient noise.

The bi-telephone afforded the construction of a privatised acoustic space for listening in a different way than the various headphones of the pleasure telephone services. Whereas the pleasure telephone headphones had either been supra-aural (covering the ear) or circum-aural (cupping the ear) in design, the bi-telephone was a type of in-ear receiver. This meant that the two miniature receivers, or speakers, of the headphones were placed in the opening of the ear. This placement of the speakers physically blocked the ear, meaning that ambient noise was not able to enter the ear canal, thus presenting the user with a private acoustic space in which to listen without interference from potentially distracting noise from the surrounding environment. A rubber cover placed over each of the receivers further reinforced this auditory isolation. These covers not only served to “lessen the friction against the orifice of the ear [which] serves to effectually close the ear to external sounds” (Stamp, 2013), but also provided an additional barrier against extraneous noise as the covers ensured that the receivers sat snugly in the ear (as shown in Figure 6.9 below).

(No Model.)
E. J. F. MERCADIER.
BI-TELEPHONE.
No. 454,138. Patented June 16, 1891.



INVENTOR:
E. J. F. Mercadier
BY
S. H. Abbot
his attorney

Figure 6.9: The illustration of the Bi-Telephone submitted with Mercadier's patent application for the device.

Reprinted from Google Patents. Retrieved 30 July, 2016, from <https://patents.google.com/patent/US454138A/en?q=mercadier+bi-telephone&dq=mercadier+bi-telephone>

In establishing a private space for the telephone operator to be able to listen to the sounds through the headphones without being disturbed, it appears that the bi-telephone contributed to a new form of what Sterne (2003) refers to as 'audile technique'. Such auditory techniques evolved through the use of acoustic prosthetic technologies for the ear when the sense of hearing was isolated from the other senses in order to intensify, and to some extent simplify, the act of conscious listening. As discussed earlier in Chapter Five, it appears that one of the earliest forms of audile technique was developed by René Laënnec so that physicians could operate the monaural stethoscope efficiently and effectively. Although there is no specific historical evidence to draw from, it is possible that the binaural stethoscope may have provided the basis for the design of the bi-telephone, as they were both very similar in style and shape. Furthermore, due to their physicality,

the binaural stethoscope and the bi-telephone operated in a similar fashion, because they were both positioned in the opening of the ear canal to shut out potentially distracting noise, thus affording the user the ability to focus their auditory attention solely on the sounds emanating from the device (see Figure 6.10).



Figure 6.10: An illustration of Mercadier's bi-telephone headphones in use. Reprinted from *The Smithsonian* by J. Stamp, 2013. Retrieved 30 January, 2016, from <https://www.smithsonianmag.com/arts-culture/a-partial-history-of-headphones-4693742/>

The intent and functionality of the bi-telephone facilitated a new version of discontinuity in the user's experience of sound and acoustic space. Applying the extension-reduction structure, the miniature speakers inserted into each ear effectively extended the user's ability to ensconce themselves within their own private acoustic space. In so doing, this in turn significantly reduced the user's awareness of the sounds of their surrounding environment by physically closing the ear. In so doing, the user's auditory attention was turned inwards to the sounds reproduced through the device from the telephone as opposed to outwards towards the surrounding soundscape. Additionally, the rubber-covered receivers

which blocked the opening of the ear canal reduced the user's awareness of the surrounding environment by enabling a greater degree of acoustic isolation than appears to have been achievable through circum-aural and circum-ambient headphones.

Consequently, several implications arose from the use of this device. First, while the bi-telephone would have produced the effect of a head-space, whereby the user perceived the sounds produced by the headphones as appearing from the centre of the head, this would also have been experienced as a one-dimensional flat acoustic space, as opposed to the spherical acoustic space as described by Carpenter and McLuhan (1960) and Schafer (1994). Instead, sound would have been perceived by the listener as coming from a single point within the head, as opposed to being experienced as multi-directional. This effect came about as the sound produced by the headphones was mono, and therefore did not provide the user with any auditory cues to indicate acoustic spatiality within their 'head-space'. A similar effect can be produced by using a pair of earbuds when having a conversation via mobile phone. Furthermore, unlike the binaural earpieces that accompanied the *Théatrephone*, which could provide the user with an impression of the directionality of different sounds, within the context of telephony, the telephone was used to send either the voice or signals across distance, predominantly monotonous sounds that provided little opportunity for the user to detect any depth within the isolated, private acoustic space. Yet this transformation in the experience of auditory space remains significant as the user

shifted from being able to hear the sounds of a three-dimensional acoustic space through their naked ears, to a one-dimensional, mediated perception of acoustic space that was characterised by the tinny, dull mono sound produced by the bi-telephone headphones. Unfortunately, it is not clear whether Mercadier's device was widely produced or used, as it appears that only the record of the original patent remains. What this acoustic prosthetic is indicative of, however, was the desire for an auditory device that was capable of blocking out ambient sound in order to afford a private, uninterrupted listening experience, thus enabling the user to focus upon a single source of sound as they became enclosed within their own isolated acoustic space. In addition, the bi-telephone is indicative of the development and application of acoustic prosthetic technologies for the ear spreading to specialised fields other than medicine, namely the fields of telephony and communication.

6.3 Headphones and customised auditory isolation

The desire to create a private acoustic space in which to listen to a customised and personalised listening was the catalyst for the development of the first set of headphones designed to be used independently of the telephone. Utah-based electrical engineer Nathaniel Baldwin sought to develop a personal acoustic device that could both amplify sound and facilitate a private listening experience by minimising auditory interference from the surrounding environment, therefore allowing him to clearly detect only the sounds that he wished to hear. However,

unlike Mercadier, Baldwin set out to develop a device that would amplify sound from his immediate physical setting, as opposed to sound from a remote location. Interestingly, despite Mercadier's development of the bi-telephone taking place over a decade earlier, popular culture widely credits the invention of the first pair of headphones to Baldwin in 1912 (Howeth, 1963; White, 2003). This oversight may in part be attributed to popular culture's preoccupation with the quirky fact that Baldwin crafted his first pair of headphones at his kitchen table, and the event that led to their invention. It appears that after experiencing difficulty hearing the preacher at a Latter Day Saints conference at his tabernacle, Baldwin set out to craft a personal acoustic device that would allow him to clearly hear what the preacher was saying while abolishing extraneous ambient noise. Baldwin had a keen interest in sound amplification and reproduction, and by applying his existing knowledge he was able to develop a compressed air amplifier and a pair of sensitive receivers attached to a headband to form a pair of headphones, as shown in Figure 6.11 below.

Figure 6.11: An early pair of Baldwin's radio headphones, produced c. 1918. Reprinted from The Guardian, by S. Gibbs, 2017. Retrieved 16 June, 2018, from www.theguardian.com/technology/gallery/2017/mar/17/most-influential-headphones-in-pictures

Dubbed the 'Baldyphones', Baldwin's headphones generated a new form of isolated acoustic space by enabling a focused auditory experience of a select part of the wider surrounding acoustic environment. Whereas the bi-telephone had reproduced the sounds transmitted by the telephone from a remote location, the Baldyphones were fashioned to provide the user with an insulated listening experience comprised of specific sounds occurring within the immediate, surrounding environment (Howeth, 1963). Therefore, Baldwin's ensuing perception of an interiorised acoustic space that occurred through the effect of in-head localisation was not independent of his immediate acoustic environment. Rather, the headphones provided Baldwin with a narrowed and clarified representation of one particular area within his surrounding acoustic space, thus allowing him to hear the sounds that he wanted to hear with minimal acoustic interference. In this sense, Baldwin's headphones operated in a similar manner to a hearing aid, in that his headphones allowed him to hear a particular source of auditory information through the amplification of sound.

When applying the sensory extension-reduction structure to this scenario, Baldwin's auditory attention was extended into one part of the immediate acoustic environment, in this case towards the spoken words of the preacher, while his awareness of other ambient noises occurring within the exterior acoustic space were reduced. Therefore, through the way in which he used his headphones, Baldwin established a personalised, private acoustic space populated by the sounds of one small part of his wider, enveloping soundscape. The implications of the use

of these headphones was that while Baldwin was able to shut himself off from superfluous noise, he was also effectively able to exercise a form of control over his auditory experience, as the headphones enabled them to hear only what they wanted to hear. Yet like the bi-telephone, the Baldyphones were only capable of producing mono sound, the user did not experience their privatised, interiorised acoustic space as being a spherical 360 degrees. Instead, sounds were perceived as coming from a single direction, which did not afford the user with any impression of the directionality of sounds required to create the effect of sounds resonating from multiple directions simultaneously. Nevertheless, despite the deficit of acoustic spatial information that these headphones had the capacity to provide, the development of the Baldyphones marked an important milestone in the evolution of headphones. This was because they enabled the user to build their own exclusive, private acoustic space populated by the sounds of the surrounding acoustic environment they deemed to be desirable, while extraneous noise was effectively eliminated. Yet in doing so, the user also largely displaced themselves from their wider soundscape, thus creating a discontinuity in their experience of their encompassing acoustic environment.

Given the current widespread use of headphones to create privatised experiences of acoustic gratification, it is hard to fathom that it was not until several years after Baldwin developed his headphones that there were any external parties interested in his personal auditory device. Baldwin finally secured his first client, the US Navy, who placed an order for 100 pairs during World War I to

improve the ability to receive and decipher wartime communications both clearly and privately (Howeth, 1963). Although it took some time for Baldwin's headphones to catch on, they became the industry standard for radio operators for a number of years. Interestingly, it was another two decades before the next significant technological breakthrough in the sound reproduction capacity of headphones that had the potential to provide listeners with a new experience of isolated soundscapes.

Advances in sound reproduction technology in the 1930s saw the release of dynamic headphones that had the capacity to provide users with an immersive form of acoustic space. Produced by German audio manufacturers Beyerdynamic in 1937, the Dynamic Telephone 48 headphones (DT48s) were initially developed to monitor radio signals as opposed to being used for acoustic pleasure. Although the DT48 headphones, like the Baldyphones, were predominantly used for communication purposes, they remain worthy of consideration here due to their capacity to reproduce a higher quality of sound and the effect of sound localisation than had been previously achieved through earlier models of headphones.

This shift towards higher fidelity sound had a significant bearing upon the user's experience of sound and the way in which the listener perceived the head-space facilitated by these headphones. Initially released less than two years before the outbreak of World War II, the DT48 headphones featured dynamic transducers, a type of microphone that detects sound waves and converts them into electrical signals. The microphone also included a voice coil surrounded by a

magnetic field, which generated an electrical signal that corresponded with the sound detected by the microphone. This advance in sound reproduction technology meant that the headphones had the capacity to reproduce sounds of both higher and lower frequencies, a spectrum of sounds that had not previously been attainable through headphones. In so doing, the user was presented with an auditory experience that more closely resembled the range of sounds heard naturally through the naked ear by able-hearing individuals. A further point of differentiation, albeit small, between the DT48s and Baldwin's headphones was that the DT48s included pads on the earpieces (as shown in Figure 6.12). Not only did this make the headphones more comfortable to wear for prolonged periods of time, but also provided an additional acoustic barrier against the potential distraction of ambient noise.



Figure 6.12: An early pair of the Beyerdynamic 'Berlin' DT48 headphones, c. 1940. Reprinted from Beyerdynamic. Retrieved 31 January, 2018, from https://europe.beyerdynamic.com/company/press/experience-audio-history#&gid=news_gal_group&pid=2

There were several implications for the user's experience of acoustic space through the use of the DT48 headphones. As the headphones were capable of producing a wider range of sounds, the user's perception of their private acoustic space began to resemble a spherical space. The extension-reduction structure shows that the auditory insulation facilitated by the design of the earpieces of the device, in conjunction with their capacity to reproduce a wider spectrum of high and low frequencies, the user's perception of an interiorised acoustic space through the effect of in-head localisation was extended. Whereas earlier models of binaural headphones such as the bi-telephone and the 'Baldyphones' had produced the effect of one-dimensional sound coming from a single point in space, the DT48s had the potential to present the user with the illusion of sound coming from a number of different directions at once. In turn, this enabled the user to perceive themselves as being at the centre of their private acoustic space, rather than on the periphery, which was the effect produced through previous types of headphones which produced the effect of uni-directional sound.

Yet despite providing a broader spectrum of sounds within the privatised acoustic space afforded by the headphones, the user would have continued to experience a sense of auditory displacement from their immediate environment. As the headphones surrounded the ear and enabled a greater degree of auditory isolation, the user was no longer consciously aware of the sounds around them as their auditory attention was directed towards the sounds produced by the headphones rather than outwards into their surrounding soundscape.

Furthermore, despite the capacity of the DT48s to provide a wider range of sounds, which more closely emulated the experience of listening through the naked, unmediated ear, these headphones were initially used for professional and specialised purposes, such as radio communications during World War II (Beyerdynamic, 2016), meaning that a majority of the sounds that the user heard were either signals or the voice at the other end of the line. In such cases this provided very little scope for the user to experience an immersive, privatised acoustic space characterised by the impression of sounds coming from multiple directions at once.

However, had these headphones been used to listen to music, for example, the user's ensuing experience of acoustic space would have been very different in that the multi-layered characteristics of a musical composition would have likely presented the user with the impression of a three-dimensional interiorised head-space. Somewhat oddly, it appears that the potential for the DT48 headphones to produce a high-fidelity experience of sound and acoustic space for the listener was not immediately realised. This is because it was not until the mid 1950s, some five years after World War II ended, that the DT48 headphones were demonstrated to the public as the world's first high-fidelity headphone. Even then, it was the late 1950s before these headphones were made available for purchase by members of the general public. Interestingly, the DT48s eventually proved to be so popular that they continued to evolve and remained in production until 2012. The DT48 headphones were representative of significant advances in headphone technology

made towards the middle of the twentieth century, and indicative of a growing interest in the ability to create private spaces for the purpose of auditory pleasure.

Although headphones slowly became available for purchase by the general public in the early 1950s, private experiences of acoustic space afforded through the use of headphones were not widespread. The principal reason for this was that the home audio systems that headphones plugged into were costly. Furthermore, as argued by Weber (2010), during this period headphones were predominantly used so as not to disturb others, rather than as a device that afforded the user a kind of privatised auditory enjoyment pleasure. However, in the mid 1950s Beyerdynamic produced a line of monaural headphones, named the DT49, or 'stick' headphones, that were designed specifically to be used in Plattenbars, the German name for record bars, which were places where people could go and privately listen to vinyl records of their choice (as shown in Figure 6.13). The DT49 headphones were used in order to provide both a discreet sonic experience, in addition to enabling a personalised form of listening pleasure.



Figure 6.13: The Beyerdynamic DT49 stick headphones in use at a Plattenbar. Reprinted from the Analogue Audio Association of Switzerland. Retrieved 2 October, 2018, from <http://www.aaa-switzerland.ch/1-o-Home.html>

These ‘stick’ headphones were hard-wired to record players, and used in place of listening booths in order to provide the user with a customised and discreet acoustic experience that did not disturb others within close proximity who were privately listening to a privatised soundscape of their own. Similar in appearance to a handheld telephone receiver without a mouthpiece (as shown in Figure 6.14), the DT49 headphones were reminiscent of the earpieces used in conjunction with the Telefon Himondó and Théâtrephone pleasure telephone services.



Figure 6.14: A pair of the Beyerdynamic DT49 ‘stick’ headphones in a stand and in use. Reprinted from Beyerdynamic. Retrieved 19 March, 2018, from <https://europe.beyerdynamic.com/company/press/experience-audio-history>

Little information remains about the DT49 headphones, however, it appears that they had similar effects upon the user’s perception of acoustic space that had been experienced through the monaural earpieces of the pleasure telephone. As one ear was engaged by the sound produced by the headphones, the user’s other ear remained open to the sounds of the surrounding physical environment. A comparable effect is experienced by using a telephone handset

today. Ultimately, as one ear remained open to ambient noise, this resulted in the perception of a hybridised acoustic space, as there was a discontinuity, or overlapping, of their experience of both the surrounding external soundscape, and the private acoustic space presented through the headphones. Consequently, the user's resultant perception of acoustic space was neither interior nor exterior, but rather an amalgamation of both. Thus, this hybridised acoustic space was not 'boundless' and 'horizonless' as asserted by McLuhan and Carpenter (1960), but was instead a potentially confusing and disorienting merging of two mutually exclusive soundscapes. As Blesser and Salter (2007) explain, in order for an individual to recognise the horizons of their immediate acoustic environment, they must be conscious of the sounds occurring within that space. However, the implications of the use of the DT49 'stick' headphones was that the user was no longer as conscious of the acoustic information around them as their auditory attention was directed towards the sounds produced by the headphones.

When applying the extension-reduction structure to this situation, part of the user's auditory perception was extended into the private acoustic space enabled by the stick headphones, a space that was populated and characterised by the music that they chose to listen to. Conversely, however, their awareness of the exterior acoustic space was significantly diminished. The user's attentiveness to the sounds of their surrounding soundscape could also have been reduced further if the user constructed an imaginary auditory field, whereby they 'tuned out' the sounds around them in order to turn their auditory focus towards the sounds

produced by the headphones. In such cases, the user became oblivious to ambient noise, as they found themselves absorbed in the private acoustic space of the headphones to such a degree that the usual distinction between the interior and exterior acoustic spaces disappeared. Ultimately, by constructing this imaginary auditory field, the listener was no longer aware of the sonic events taking place in the soundscape around them as it faded into the background of their consciousness. Through this discontinuity in their perception of acoustic space, the listener also experienced a sense of displacement from their immediate physical environment as they became immersed in a privatised acoustic space generated for the purpose of auditory entertainment. This is a key factor in the history and evolution of headphone technology as the DT49 headphones foreshadowed a significant shift towards customised experiences of sound and acoustic space solely for acoustic desire. This move towards customised acoustic space for the purpose of entertainment continued to build significant momentum from towards the end of the 1950s.

6.4 Expanding interior acoustic space

The first model of stereo headphones, developed specifically for the purpose of auditory entertainment brought about a deep transformation in the mediated experience of acoustic spatiality. This effect was made possible as stereo sound generates the illusion of omni-directional sound by feeding a slightly different, but complimentary, audio channel to each earpiece (Gefland, 2011). Prior to the

integration of stereo sound technology into these acoustic prosthetic technologies for the ear, the sound produced by headphones, both monaural and binaural, had effectively only gestured towards the spatiality and localisation of sound. As advances in audio technology enabled acoustic information to be reproduced in stereo, these headphones facilitated a new kind of immersive auditory pleasure for the user, one that significantly altered how the listener perceived their personalised, interiorised acoustic space.

In 1958 jazz musician John C. Koss introduced the Koss SP₃ Stereophones, headphones that were designed specifically to provide an immersive, isolated audio experience when listening to music. With the significant advances in audio reproduction made during the 1950s, there was an increasing demand for “deeply private, acoustically intensified, almost entirely non-resonant fidelity sound” (Bull, 2007, p. 32). While stereo recordings were made available by EMI records in the mid 1950s, there remained few headphones that were capable of revealing the sonic intricacies of these recordings. It was Koss’s aim to produce a pair of headphones that enabled the user to experience the rich, multi-dimensional layers of high-fidelity sound within their own, private acoustic space, possibly for the first time. The founder of Koss electronics, and creator of the first pair of stereo headphones, John Koss, explains

Back in 1958, some friend of mine told me that they had a new tape that was a binaural tape, and you listened to it with a headphone, and it was

absolutely thrilling. This was the first step towards stereo...we started to make a private listening unit, and we put jacks in the front so people could listen with headphones. But we couldn't find any headphones that would do the job; they were all made for warplanes and communications. I was talking to my engineer about it one day...he tore some cushions off another phone, and he took these two speakers with two wires coming out, into our little machine, and it was just bouncing on my ears. It was just a great sound. Now the whole thing was there. Anyone that listened to it, was like the first time you rode in a car, or the first time you did anything; it was that much of a difference. I couldn't think of a world without music in it; you can't go through the day without some kind of music. It gives you a lift, and it gives you company, and when you talk about now enclosing yourself into just the music, it gets to be even more thrilling (Koss, 2015, [video file]).

A key factor in this 'thrilling' listening experience was that this appears to be the first time that the perception of a spherical degree interiorised acoustic space within the head of the listener was fully realised through the use of an acoustic prosthetic technology for the ear. This imagined interior acoustic space was afforded, first, as the stereo sound produced by the headphones presented the listener with an extensive impression of three-dimensional sound, and second, through the design of the headphones themselves. The Koss Stereophones were circumambient in style, meaning that they surrounded and cupped the ear, thus

eliminating interference from ambient noise. Furthermore, the Stereophones featured soft foam pads on the earpieces, providing extra auditory insulation from unwanted sounds (as shown in Figure 6.15).

Figure 6.15: An original pair of the Koss SP3 Stereophones, c. 1958.
Reprinted from Koss. Retrieved 2 October, 2018, from <https://www.koss.com/history>

Applying the extension-reduction structure, the effect of in-head localisation extended the listener's perception of acoustic spatiality and the ability to detect the impression of directional sound. As discussed earlier, in-head localisation produced the effect of the sounds heard through headphones appearing to originate from an imagined space in the centre of the listener's head. When listening to sound or music through a pair of binaural stereo headphones, when the listener pauses to consider what they can hear, the sounds do not appear to originate from the exterior environment around them. For example, when listening to music through a pair of stereo headphones, the listener can detect multiple layers of sound coming from multiple directions, rather than from a single point in space. In one ear, the listener may be able to hear the sounds of a

guitar playing, a piano, drumbeats, and a vocalist singing. In the other ear, they can perceive closely related, yet slightly different sounds, such as a rhythm guitar, a saxophone and different types of percussion. If the listener concentrates on the source of these sounds, they seem to originate in the centre of the head, as opposed to coming from the surrounding exterior soundscape. Furthermore, as the listener becomes engaged with the sounds produced by the headphones, their auditory attention is turned inwards towards the perceived acoustic space in their head, and away from the sounds of their surrounding environment, which have been blocked out as the headphones cupped their ears. Consequently, the user is largely oblivious to the sounds of the world around them. Therefore, whereas the user's perception of this imagined, interiorised acoustic space is extended, their awareness of the ambient noise around them is reduced, to the point where it is almost non-existent as they become cocooned within a privatised and isolated acoustic space of auditory enjoyment.

Additionally, the listener's ability to detect the spatiality of sound as simultaneously coming from multiple directions places them at the centre of their customised private acoustic space. This restructuring of the perception of acoustic space, therefore, echoes Schafer's (2007) description of acoustic space as being

A sphere without fixed boundaries, space made by the thing itself, not space containing the thing. It is not pictorial space, boxed-in, but dynamic,

always in flux, creating its own dimensions moment by moment. It has no fixed boundaries; it is indifferent to background (p. 1).

This effect of a private, spherical acoustic space made possible through the Koss Stereophones enabled the listener with much deeper auditory depth than previously attainable, as the binaural stereo sound enabled them to distinguish between sounds that appeared to be close and those further away. Furthermore, as Schafer's explanation of the spherical characteristics of acoustic space implies, there were indeed no fixed boundaries to this interior acoustic space. In fact, it appeared to be the acoustic space of all centre and no margins as described by Carpenter and McLuhan (1963).

As this was the first time that such an auditory experience had been possible through an acoustic prosthetic device for the ear, Koss placed great emphasis on the power of their Stereophones to enable an immersive listening experience that not only emulated the naked ear's ability to detect sound from 360 degrees, but in some cases surpassed this because of the clarity of sound reproduced by the headphones. For example, in a 1960 print advertisement (as shown in Figure 6.16), the reader is invited to "add dramatic new realism to your recorded music". Featuring an image of a woman who appears to be positioned in the middle of the stage, the advertisement continues "with dramatic Koss Stereophones, you'll thrill to new worlds of stereo and sound reproduction. Your records or tapes sound just as if you had an orchestra seat in Carnegie Hall". This

is not to say that the headphones could exactly replicate the experience of being physically present at the performance, but rather they offered an alternative that meant that the listener *did not* have to be there in order to experience a multi-dimensional, engrossing musical performance. Rather, the user was able to experience the acoustic minutiae of the performance from the comfort of their own home.

Figure 6.16: A 1970 print advertisement for the Koss SP/3 Stereophones.
Reprinted from Koss. Retrieved 30 November, 2016, from <https://www.koss.com/history/>

Furthermore, the Stereophones presented the listener with a different perspective of sound than if they were physically present at, for example, Carnegie Hall, as the headphones created the impression of the listener being in the centre of the acoustic space of the performance itself. In so doing, not only could they detect the directionality and localisation of the different instruments of the orchestra, but also potentially with greater clarity than if they had been physically present at the performance and listened through the naked ear. For example, by listening through a pair of Stereophones, the listener may have been able to hear the sounds of violins to the left, and a harp to the right, just as if they were indeed

seated in the middle of the orchestra. Therefore, the Stereophones enabled a form of aural mobility, whereby the listener could experience sound from a new perspective from within their private, isolated acoustic space at home. This aural mobility was further underscored in a 1976 print advertisement for the Stereophones (as shown in Figure 6.17), which emphasises the aural experience made possible through these acoustic prosthetics. The advertisement reads:

The album was recorded live at an outdoor concert, and now its all coming back to you...The air cracking with energy as the musicians tune up...suddenly you're part of the interplay between rhythm, bass, lead and harmony as every note flowers...each unfolding in your head. You're wrapped in the sound...hearing all ten octaves. It's a power you can hear and feel as though you were in the spotlight with the musicians. And yet you're at home, free to explore this private realm of listening pleasure.

Figure 6.17: A 1976 print advertisement for the Koss Stereophones Reprinted from Koss. Retrieved 30 November 2016, from <https://www.koss.com/history/>

By imploring the reader to use Koss headphones to ‘wrap the sounds around them’, this advertisement describes the immersive quality of the sound, and ensuing acoustic space, made possible through stereo headphones. While almost all headphones produced today deliver stereo sound, with varying degrees of success, at the time of their release in 1958 the experience of stereo sound through headphones was groundbreaking. Not only had this type of sound reproduction not been experienced before, but the user’s ability to listen to their own customised soundtrack in stereo sound while creating their own private space for listening pleasure was revolutionary. Additionally, advertising material promoting the Koss Stereophones following their release continued to place a strong emphasis on the ability of these headphones to construct a space in which to listen and not disturb others, while providing the user with a private and uninterrupted experience of isolated acoustic pleasure, as shown in Figure 6.18 below.

Figure 6.18: A 1970 print advertisement for the Koss Stereophones that emphasised the auditory isolation and privatisation of listening through headphones. Reprinted from Koss. Retrieved 30 November, 2016, from <https://www.koss.com/history/>

From the image it is evident that the gentleman on the left, who is wearing a pair of Koss Stereophones, is enjoying his solitary and undisturbed listening experience, while the woman next to him is watching television, indicating that neither of them are disturbing the other's personal acoustic space.

However, there was a key implication to the use of these headphones and the creation of the acoustic spaces they facilitated. While the Stereophones enabled users to construct their own isolated acoustic space for auditory pleasure, these experiences could only take place in the home. This was because the headphones were designed to be plugged into home stereo systems, which were typically large and bulky. Therefore, while these stereo headphones enabled a degree of auditory mobility as the user did not have to be physically present at a performance to enjoy it in high-fidelity sound, these experiences remained stationary and bound to the domestic setting, and would largely continue to do so for another twenty years.

6.5 The end of noise

Silence improves the ability to listen. Ihde (2007) argues that “to hear best one calls for relative silence...[headphones] do not so much as make the music better as they shut out extraneous noise – this device enhances the sound of music by securing an accompanying silence” (p. 222). The integration of noise cancelling technology into headphones used for specialised purposes in the 1960s was indicative of the desire to create robust isolated acoustic spaces. Koss headphones

had used a form of noise cancellation by designing their headphones to cup the ear in order to minimise auditory interference from the outside world. However, in noisy environments, purpose-built noise cancelling headphones provided a form of technologically enabled ‘silencing’ of ambient noise for the headphone user. This afforded the ability to establish a private space wherein to focus their auditory attention without any auditory disturbance. Also known as active noise reduction (ANR), or Active Noise Control (ANC), noise cancelling headphones were developed to eliminate the user’s ability to detect all ambient noise, thus not merely reducing the potential for distraction of sounds from the surrounding environment, but to cancel them out altogether through the use of electrical signals.

Noise cancellation can take two forms. The first, passive noise control, as mentioned earlier in section 6.3, refers to the use of insulating materials such as foam and the use of solid materials on the back of earpieces to assist in the prevention of ambient sounds from reaching the ear. As discussed throughout this chapter, the ability for headphones to ‘block out’ sounds from the surrounding environment was largely dependant upon the design of the headphones themselves. For example, Mercadier’s Bi-telephone had been effective at providing a private acoustic space for listening as the speakers effectively closed off the ear canal, meaning that ambient sounds could not reach the inner ear mechanism. The Koss Stereophones, on the other hand, cupped the ear, forming a seal around

the ear in an attempt to shut out ambient noise in order to provide a private listening experience.

Yet whereas these headphones used the physicality of the device itself to provide a form of soundproofing from the surrounding soundscape, the second form of noise-cancellation, also referred to as Active Noise Control (ANC), is achieved by emitting an undetectable electrical sound wave from the headphones. This signal effectively cancels out the sound waves of the surrounding acoustic environment so that the headphone user can no longer detect them. The ‘cancelling’ sound waves have the same amplitude as the ambient sound waves, but instead they are inverted, so that when the two groups of sound waves meet they cancel each other out, thus controlling the user’s detection of environmental noise. The number of cancelling waves produced by the headphones can vary depending on, first, the noise cancelling capacity of the device, and second, the environment wherein the device is used. Noise-cancelling devices that are one dimensional include one or two microphones and speakers to detect external sound levels and produce noise cancelling waves, whereas three-dimensional ANC uses multiple microphones and speakers to enable more comprehensive noise cancellation in wider and noisier environments (Hansen, 2001).

There appears to have been attempts to integrate noise control functions into headphones as early as 1957, when American audio engineer Willard Meeker applied ANC to a pair of circum-aural ear protectors (Google patents, 2018). Yet it seems that the first successful merging of headphones and noise cancelling

technology occurred in 1960, when two pilots founded Plantronics to produce sets of noise cancelling headphones, named the MS50, specifically for pilots (as shown in Figure 6.19). These headphones were specifically fashioned to eliminate high levels of aircraft engine noise that compromised the pilot's ability to clearly hear communications through generic headphones while in the cockpit. Yet unlike standard headphones, these noise-cancelling headphones also included a microphone for two-way communication between crew members and air-traffic control.



Figure 6.19: Astronaut Neil Armstrong wearing a pair of the Plantronics MS50 noise-cancelling headphones.
Retrieved 10 September, 2016 from: <https://headsetplus.com/blog/plantronics-headset-history-got-started/neil-armstrong.com>

Applying the extension-reduction structure to noise-cancelling headphones, it is evident that these acoustic prosthetic devices for the ear extended the user's ability to construct a private, uninterrupted acoustic space. Noise cancelling headphones were capable of achieving a greater level of auditory isolation than was possible through headphones that employed some means of passive noise control through their physicality. Furthermore, these headphones

also extended the user's perception of a three-dimensional interior acoustic space within the head through the effect of in-head localisation as the isolation of auditory experience amplified the ability to hear the acoustic minutiae of the sounds reproduced through the device. Conversely, noise-cancelling headphones significantly again reduced the user's awareness of their surrounding acoustic environment, as they were no longer able to detect the sounds around them. This is not to say that the user's perception of their exterior acoustic space completely disappeared, rather it was transformed, experienced as a space of silence rather than one of noise. Consequently, the user was essentially placed within an acoustic vacuum, whereby the only sounds they could detect were those coming from the headphones.

This is a key factor because not only did this enable a more profound discontinuity in the user's experience of acoustic space, but also solidified the boundaries between interior and exterior acoustic spaces and auditory experience. Thus, the user was further displaced from their surrounding acoustic environment by securing a technologically-enabled silence to facilitate optimum conditions for privatised listening. However, it was not until the early 1990s that noise-cancelling technology began to be integrated into headphones that could be purchased by the general public.

6.6 Acoustic space on the move

An ambitious attempt to integrate bone conduction into a portable listening device in the 1970s offered an experience of portable and private acoustic space for what appears to be the first time. Released in 1979, the Bone Fone was not a typical pair of headphones, but rather a device that sought to provide an opportunity to listen to music anywhere, at any time, by tapping into the body's ability to detect and transmit sound in the form of vibrations. As discussed earlier in Chapter Four, the human body is capable of receiving acoustic information in two ways, via air conduction and bone conduction. While air conduction takes place when sound waves enter the ear and are then sent to the brain and interpreted as different sounds, bone conduction is the conduction of sound in the form of vibrations that travel through the skull to the inner ear, and then to the brain. The most effective part on the body for sound conduction is the skull, although studies have found that sound can also be conducted from the hands and feet, with varying degrees of success (Henry & Letowski, 2007). The Bone Fone, however, used a slightly unconventional method of transmitting sound in that it was an elongated radio device that was worn around the neck like a scarf (as shown in Figures 6.20 and 6.21).

Figure 6.20: An advertisement for Bone Fones, c. 1979. The device can be seen hanging around the neck of the woman in the picture.

Reprinted from Hamblin, J. (2013, September 9). Bone Fone, the terror! *The Atlantic*. Retrieved from <https://www.theatlantic.com/health/archive/2013/09/bone-fone-the-terror/279474/>

Figure 6.21: The Bone Fones.

Reprinted from The Radio Museum. Retrieved from https://www.radiomuseum.org/r/unknown_bone_fone.html

Weighing only 15 ounces, the Bone Fone featured two seven centimetre speakers, one on each side, with one positioned close to each ear. The device was covered in a protective water and crush resistant casing. According to Radio Shack, the producers of the Bone Fone, it could be worn under the clothing while walking or jogging. It was claimed that the device could provide the same quality stereo experience as headphones but without the inconvenience of having to wear a

headset (The Radio Museum, n.d.). Furthermore, the Bone Fone was fully portable, meaning that they could potentially offer a solution for people wanting to create a private acoustic space for auditory pleasure while on the move. For example, an advertisement for the Bone Fone, as shown in Figure 6.22, reads

You're standing in an open field. Suddenly there's music in all directions. Your bones resonate as if you're listening to beautiful music in front of a powerful home stereo system. But there's no radio in sight, and nobody else hears what you do (Bone Fone, 2018).



Figure 6.22: An advertisement for Bone Fones, c. 1979. Reprinted from The Radio Museum. Retrieved from https://www.radiomuseum.org/r/stereo_bone_fone.html

The passage above implies that while in an open acoustic space the Bone Fone would enable the wearer to hear the sounds produced by device through their bones, creating a high-fidelity experience of sound. If this claim were indeed

correct, the user's perception of acoustic space would have shifted. Applying the extension-reduction structure, first, their ability to create a portable private acoustic space through the use of a form of acoustic prosthetic for the ear was extended. Furthermore, as the ears remained unobstructed by earpieces, their awareness of their immediate auditory environment was also extended. In so doing, this produced a hybridised experience of acoustic space because they could still hear the sounds of the world around them while listening to the sounds of their own private acoustic space. However, this device also complicated, or reduced, the user's auditory acuity as they were simultaneously listening to two formerly independent soundscapes. While they could still hear and detect the directionality of sounds of the surrounding exterior acoustic space, another set of sounds produced by the Bone Fone potentially appeared to be resonating within their head. Consequently, the user's perception of acoustic space became complicated, and it seems possible that this created a muddled auditory experience for the listener as these two soundscapes merged in the mind of the user.

There were several implications in the wearer's perception of acoustic space that arose through the use of this personal auditory device. As the ears remained open, the wearer was still able to detect the three-dimensional spatiality of their surrounding acoustic space, but it is unlikely that the Bone Fone provided the ability to perceive the audio transmitted via bone conduction as three dimensional, as the device did not directly conduct sound through the most

receptive part of the body – the skull. As Henry and Letowski (2007) assert, the further away the point of entry is to the cranial bones, the less likely the vibrations are to reach the auditory nerve of the inner ear. Therefore, it appears that the Bone Fone would not have been particularly successful at transmitting sound through the bones, despite this being marketed as the primary feature of the device. Yet in spite of the potential of this auditory technology to provide a private and portable acoustic space and auditory experience, it appears that they were little more than a gimmick. However, the Bone Fone did reveal the potential for bone conduction to provide an alternative method of private listening, as well as being indicative of a growing desire for a device that enabled the portable private transmission of sound.

The release of the Sony Walkman in 1979 marked a significant milestone in the capabilities and functionality of headphones by changing the how, and where, private acoustic spaces could be created and experienced. The Walkman, according to Weber (2010) “transplanted the domestic stereo headphone listening experience into public settings and situations of mobility” (p. 352). This iconic personal music device and its accompanying headphones ignited a global trend towards portable and private listening experiences, as the construction of private spaces through the use of acoustic prosthetics was no longer confined to the home (Bull, 2000). The Walkman was developed after Masaru Ibuka, the co-founder of Sony Electronics, found himself carrying a heavy cassette recorder with him when he travelled in order to listen to music. He requested that Norio Ohga, then

Executive Deputy President of Sony, to design a playback-only stereo version, that was specifically to be used with headphones. The result was a compact, high-quality music player that was accompanied by a pair of lightweight stereo headphones that enabled fully mobile auditory experiences for acoustic gratification, as shown in Figure 6.23 below.



Figure 6.23: The Sony Walkman and accompanying supra-aural headphones
Reprinted from Sony. Retrieved from <https://www.sony.com/electronics/walkman-revolutionized-listen-to-music-on-the-go>

The Walkman, according to science-fiction writer William Gibson (1993), did “more to change human perception than any other virtual reality gadget. I can’t remember any technological experience since that was quite so wonderful as being able to take music and move it through landscapes and architecture” (p. 49). Here, Gibson underscores the potential of everyday devices to transform perception through the modification of one or more of the human senses. In the case of the Walkman, it was the ability for the user to create their own personalised, isolated soundscape and take it with them wherever they went,

creating a private musical experience for one. Musician David Byrne (2012) observes that with the release of the Walkman

[A] new venue had arrived...private listening really took off in 1979, with the popularity of the Walkman portable cassette player. Listening to music on a Walkman is a variation of the “sitting very still in a concert hall” experience (there are no acoustic distractions), combined with the virtual space (achieved by adding reverb and echo to the vocals and instruments) that studio recording allows. With headphones on, you can hear and appreciate extreme detail and subtlety, and the lack of uncontrollable reverb inherent in hearing music in a live room means that rhythmic material survives beautifully and completely intact: it doesn’t get blurred or turned into sonic mush as it often does in a concert hall. You, and only you, the audience of one, can hear a million tiny details (p. 27).

The Walkman and its accompanying headphones provided a form of mobile auditory escapism for the purpose of acoustic pleasure, creating their own virtual world of sound. Hosokawa (1984) coined the term the ‘Walkman effect’, referring to the ability of the user to assert some control over their auditory experience by creating their own individualised sonic environment through headphones used in conjunction with portable music players. Additionally, as these headphones produced stereo sound, they could also create, to some degree, the effect of in-head localisation, where the wearer perceived the sounds mediated by the

headphones as originating from an imagined acoustic space within the centre of their head.

The type of headphones that were sold in conjunction with the Walkman also marked the beginning of a new era in the design of headphones that were designed specifically to be portable. Officially named the MPR-3L2 headphones, these were a lightweight supra-aural style of headphone that sat on top of the ears, rather than the heavier circum-aural models, such as the Koss Stereophones, that cupped the ear. The supra-aural headphones were essentially two small speakers worn over the ears that were connected by lightweight metal headband. The speakers were covered in thin foam, to provide some relief from the discomfort of wearing the earpieces for long periods of time. Yet this change in design had the propensity to alter how the user perceived the private acoustic space made possible through the use of headphones. Despite the fact that the Walkman was undeniably revolutionary in its ability to enable to mobility of auditory experiences, the acoustic spaces enabled by the Walkman and its headphones were not always entirely private.

The Walkman's MPR-3L2 headphones could complicate the user's experience of sound and acoustic space, as because of their size they provided very little insulation from the sounds of the surrounding soundscape. The user could be listening to music, and yet still be able to hear almost all of the ambient noise around them. The only means of counteracting this unwanted auditory interference was to increase the volume of the Walkman. In turn, this could cause

physical discomfort for the ears, not to mention contributing to long-term hearing loss. Furthermore, as they did not provide any form of passive noise cancellation due to their small size, these headphones were also prone to sound leakage. This meant that the sound produced by the headphones would leak out into the surrounding environment, and could be heard by people within close proximity. Consequently, the privatised experience of sound offered by the Walkman and its headphones was not entirely private or isolated. Furthermore, although the Walkman headphones were stereo, and were capable of producing the effect of in-head localisation, if the wearer was in a noisy environment, their experience of acoustic space would become problematic, and in some cases indecipherable, as the sounds of the headphones and the exterior soundscape merged to produce a cacophony of noise.

Applying the amplification and reduction model to the Walkman and its accompanying headphones, the user's ability to mobilise their auditory experience was extended. Whereas private experiences of sound made possible through the use of headphones had been confined to the home, users were now able to take their music with them anywhere. However, in many cases the isolation and privatisation that had traditionally been afforded through the use of headphones was reduced, due to the complications of sound leakage. Consequently, the user's awareness of both their interiorised and exterior acoustic spaces was reduced, as the two became merged.

As portable music players continued to evolve, so did the headphones that accompanied them, once again altering the user's perception and experience of acoustic space. Earphones, also known as in-ear headphones and earbuds, were released in the early 1990s as the popularity of personal music players continued to grow. Whereas the supra-aural headphones of the Walkman had been lightweight and portable, it appears that headphones users wanted a smaller device that could be worn in the ear, eliminating the potential discomfort of wearing supra-aural headphones for extended periods of time. In addition, the use of earphones was more discreet as they could not be seen as easily. Like Mercadier's bi-telephone, which had been developed a century earlier, earphones are small speakers that sit in the ear with the speaker pointed directly towards the ear canal and the inner ear mechanism.

Applying the extension-reduction structure, earphones extended the user's sense of auditory isolation and privatisation as they blocked the ear to external noise. Therefore, the user's awareness of their surrounding exterior acoustic space was reduced, as the listener was no longer aware of the sounds around them. As the earphones physically blocked the opening of the ear, they were more effective at shutting out surrounding ambient noise than supra-aural headphones. The potential for auditory distractions from surrounding environment was reduced further, as the earphones physically closed the opening to the ear. The addition of foam or rubber covering over the earphones also added further auditory insulation

by making sure that ambient noise was not able to enter the ear (as shown in Figure 6.24 below).



Figure 6.24: A pair of Apple earbuds
Reprinted from Apple. Retrieved from <https://www.apple.com/nz/search/EarPods-with-3.5mm-Headphone-Plug?src=serp>

Supra-aural headphones were quickly superseded with the arrival of earphones, with many preferring the greater degree of auditory isolation afforded by these miniaturised headphones. With the release of the iPod in 2001, and then the first generation iPhone in 2007, the iconic white earphones that were sold in conjunction with these digital devices made this kind of headphone even more desirable as it signified that the user belonged to an exclusive group of iPod and iPhone owners.

6.7 The future of headphones

In recent years there have been significant developments in headphone technology that are poised to reshape how isolated acoustic spaces mediated by headphones are perceived. The first of these new types of headphone technology are bone conduction headphones. Over the last decade there appears to have been

a resurgence in interest in the capabilities of bone conduction to provide private, yet open, listening experiences through the integration of bone conduction technology into headphones. Commonly referred to as ‘bonephones’, these acoustic prosthetic technologies for the ear should not be confused with the wearable Bone Fone scarf device of the late 1970s. Rather, these are headphones that are positioned around, as opposed to over or on, the ear (Hansen, 2001; Henry and Letowski, 2007). Bone conduction headphones feature two transducers that are placed directly in front of the ear, as this area is the most effective area of the body for the transmission of sound signals in the form of vibrations that travel through the cranial bones to reach the inner ear, as shown in Figure 6.25 below.



6.25 A pair of Aftershokz bone conduction headphones.
Reprinted from Aftershokz. Retrieved from <https://aftershokz.com/pages/technology>

As discussed throughout this chapter, headphones have historically been designed and applied to eliminate the distractions of extraneous ambient noise and provide a private space for acoustic pleasure, creating “head cocoons that enable listeners to actively carve out sonic privacy” (Weber, 2010, p. 340). Paradoxically, however, bone conduction headphones are designed specifically to leave the user’s ears

unobstructed and open to ambient noise, while affording them the opportunity to privately listen to a personalised soundscape of their own choosing. Yet, unlike the physician using a monaural stethoscope, who was required to construct an auditory field in order to focus and isolate their auditory intention in order to hear the sounds of the patient's body transmitted through the stethoscope, the user is simultaneously able to detect both the interior and exterior acoustic spaces at the same time. Consequently, the user experiences a merging of two formerly distinct and mutually exclusive acoustic spaces: the interior acoustic space perceptible through the effect of in-head localisation, and the exterior auditory environment surrounding them. Therefore, the user perceives a new form of hybridised acoustic space; one that is neither entirely internal nor external, but rather a combination of both. Whereas the experience of hybridised acoustic spaces that were experienced through headphones such as the monaural earpieces of some pleasure telephone services (which were a side effect of the physicality of the auditory prosthetic), the hybridised acoustic space afforded through bonephones is a deliberate effect created for specific purposes.

Bone conduction headphones, according to Henry and Letowski (2007), were initially developed specifically to be used by the armed forces so that military personnel were able to discreetly receive communications while remaining aware of the ambient sounds of their surrounding environment. The capacity of these headphones to afford auditory acuity is of utmost importance during military operations as the user is able to remain acutely aware of the sounds of impending

danger. In recent years, however, bone conduction headphones have begun to enter the mainstream headphone market, with the general public now being able to purchase these headphones for the dual purpose of acoustic pleasure and maintaining auditory awareness of the surrounding soundscape. Describing the experience of using bone conduction headphones, and being able to listen to two different acoustic environments, Vincent (2016) writes

With bone conduction your experience of just being outside is changed...you get a blend of outside and inside noise, and the result is you are more aware of whats going on...With nothing plugged into your ear canals, you can hear the rest of the world just like you would normally. Birds tweeting [and] cars honking” (para. 10).

In applying the extension-reduction model, it becomes apparent that the user’s auditory awareness of their immediate surrounding acoustic space is extended considerably, as they are afforded the ability to hear what is happening around them, which is the primary purpose of these acoustic prosthetic devices. Yet while the user’s awareness of their immediate soundscape is extended, it appears likely that there is consequently a reduction in their ability to clearly perceive the interiorised acoustic space that occurs through the effect of in-head localisation. As the ears remain open to ambient noise, there is no longer a clear boundary between the interior acoustic space that the user perceives within their head, and

the outside world. Consequently, the user perceives a hybridised acoustic space.

Lyric (2017) explains

I can be outside and walking, while listening to GPS directions from my phone through the headset. I am still able to hear traffic both moving and stationary, people walking near me from all directions, and still hear the directions I need to get to my destination. I can sit on a bus or train, listen to my book or music and still hear the people, stop announcements and other noises nearby. I can take my dogs on a long walk while still receiving information about the world around me...I feel more connected to the world around me while still being focused on the task at hand (para. 3).

To date, bone conduction headphones have predominantly been targeted towards athletes and the sporting community. Bone conduction headphones are marketed as a safer option as the user is able to remain aware of the sounds of oncoming traffic and potentially dangerous situations. In light of a number of fatalities both in New Zealand and globally as a result of headphone wearers being killed by vehicles as they were unable to hear the sound of oncoming traffic, it appears likely that the popularity of bone conduction headphones will continue to grow in the future.

The second type of headphones that are poised to be released in the near future are three-dimensional (3D) virtual reality headphones which have are being

designed to provide users with a mediated experience unlike any achieved before through an acoustic prosthetic technology for the ear. Virtual reality has been understood as a form of communication medium (Biocca and Levy, 2013; Steuer, 1992). It has been defined in terms of a collection of technological hardware and software, including computers, gaming machines, head-mounted visual display units and headphones (Steuer, 1992). The purpose of virtual reality acoustic devices is to present the listener with three-dimensional sound. It is important to note that 3D sound should not be confused with surround sound, whereby sound is produced from six different channels from five speakers, creating the impression of sound coming from 360 degrees on a horizontal plane around the listener. One of the most common places to experience surround sound is in movie theatres which use 5.1 surround sound, or 7.1 surround sound, which uses an additional two speakers to create greater depth of sound localisation.

When listening through 3D headphones, it appears that the user will perceive the sound produced by the device as coming from an external, rather than an internal acoustic space. While a number of modern circum-ambient headphones boast surround sound, 3D headphones will be able to offer the user a new kind of immersive auditory experience. To date, several companies have used crowd-funding platforms such as Kickstarter to fund the development of 3D headphones, with Ossic arguably being the most widely recognised. Ossic set out to include integrated head-tracking and advanced anatomy calibration sensors in order to provide a listening experience that is customised to the shape of the

individual's own body and head, meaning that the effect of sound localisation presented by the headphones is unique (as shown in Figure 6.26). In so doing, the headphones are intended to provide an experience of sound that emulates the user's capacity to hear sounds naturally as they would through the unmediated ear.



Figure 6.26: A prototype pair of the Ossic X 3D virtual reality headphones

Reprinted from Ossic.

Retrieved from <https://www.kickstarter.com/projects/248983394/ossic-x-the-first-3d-audio-headphones-calibrated-t/comments>

The prototype of the Ossic X 3D headphones are circum-aural in design, meaning that they surround the ear to minimise extraneous ambient noise from reaching the ear. Furthermore, these headphones also integrate active noise cancelling technology, to provide the user with the experience of a 'silent' exterior acoustic space in order to optimise their private, uninterrupted experience of sound.

Therefore, when applying the extension-reduction structure, the Ossic X headphones extend the privatisation of acoustic space. Furthermore, whereas standard headphones only have a single speaker in each earpiece, the Ossic X headphones include six on each side in order to enhance the effect of sound

directionality. In so doing, the user's perception of characteristics of this private acoustic space are also extended, as they are able to experience sounds coming not only from 360 degrees around them, but also from above and below. Consequently, as the user is able to hear sound from every direction imaginable, the interiorised acoustic space that appears through the effect of in-head localisation is significantly altered, as illustrated in Figure 6.27 below.

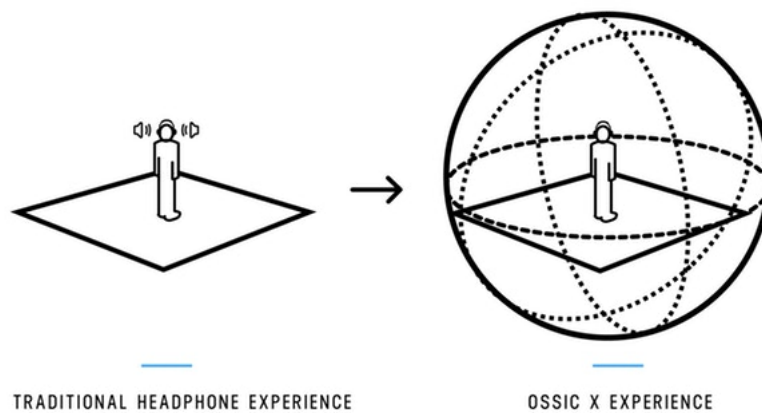


Figure 6.27: An illustration of how the Ossic X #D headphone user's perception of acoustic space. Reprinted from Ossic. Retrieved from <https://www.kickstarter.com/projects/248983394/ossic-x-the-first-3d-audio-headphones-calibrated-t/comments>

The figure on the left shows the typical experience of sound through a pair of binaural headphones, whereby the headphones deliver sound directly to the ears of the wearer, thus creating an interiorised headspace. The illustration on the right, however, shows the Ossic X user's experience of acoustic space, whereby it is claimed that they are surrounded by sound that appears to be originating from the exterior acoustic space, thus creating a fully immersive, virtual acoustic space. Therefore, the experience of in-head localisation is altered as sounds appear to be

coming from the outside world. A further complication of this reduction is that through both noise cancelling technology and the effect of omni-directional sound the user's awareness of their surrounding acoustic environment ceases while the headphones are in use. Rather, the 'natural' soundscape that surrounds the user is effectively replaced by a virtual exterior acoustic space that can only be perceived by the headphone wearer. It appears possible that this effect will lead to a new form of discontinuity in the experience of both interiorised and exteriorised acoustic spaces for the listener, as the boundaries between interior and exterior acoustic spaces, which to varying extents were distinguished by standard stereo headphones, will become increasingly blurred for the 3D headphone user.

It appeared that 3D headphones were on the cusp of being released to the general public. However, in May 2018 Ossic announced that they would not be shipping any more of its 3D headphones to their financial supporters due to a lack of funds. While there are several other companies also currently using crowd-funding to fund research into, and production of, 3D headphones, it seems that it will still be some time before audiophiles will have the opportunity to experience an immersive virtual 3D acoustic space first-hand. Consequently, it seems likely that new technologically enabled experiences of sound and acoustic space for the purpose of auditory pleasure are just over the horizon.

Summary

It has been nearly one hundred and thirty years since the first pair of headphones appeared. During this time, especially since the 1980s, headphones have evolved to become ubiquitous personal audio accessories. Extant research has predominantly framed headphones as devices of isolation and privatisation. Yet such studies have failed to consider the nuances of the differing experiences of sound and acoustic space facilitated by headphones throughout their evolution. This chapter, therefore, argued that across technologically enabled modernity, these acoustic prosthetic technologies for the ear generated different forms of privatised experiences of remote and isolated acoustic pleasure, which led to discontinuities in how acoustic space was perceived through headphones.

This chapter has traced the history of acoustic space as experience through headphones, from their initial debut as an extension of the telephone, to the present, and beyond. It has considered the ways in which headphones have been used, and how this in turn influenced the listener's perception of not only sound but also acoustic space. In so doing, it has revealed the paradoxical nature of several types of headphones, in particular the pleasure telephone and bone conduction headphones, thus identifying shifts in the use of these acoustic prosthetic technologies for the ear as solely isolating technologies, to devices that enable private, yet shared experiences of sound and acoustic space.

The evolution of headphones has not been linear or straightforward. Through the application of Ihde's extension-reduction structure, this exploration

of the effects of acoustic prosthetic technologies on the perception of acoustic space has shed light upon historical shifts in how mediated acoustic spaces are perceived. The history of headphones illustrates the phenomenological effects that various types of headphones have had upon how acoustic space is perceived. Headphones do not reproduce or mediate sound in a 'one size fits all' manner. Rather, the implications of their use upon how acoustic space is perceived are diverse, and often complex, particularly in the case of headphones that produce hybridised experiences of acoustic space that had previously not been attainable. Therefore, to compartmentalise headphones solely as isolating devices of auditory privatisation fails to take into account the vast range of auditory experiences generated by these acoustic prosthetic technologies for the ear.

CHAPTER SEVEN

Conclusion

7.1 Introduction

The focus of this study was to present an anonymous history of acoustic space through the lens of acoustic prosthetic technologies for the ear. A form of historical phenomenology used to explore the ways in which these devices altered users' perception of acoustic space across time, and how this in turn affected their experience of, and relationship to, the world around them. As discussed in Chapter Two, there is a paucity of scholarly research across the fields of media ecology, sound studies, audiology and phenomenology pertaining to the phenomenological effects of acoustic prosthetic technologies upon the experience of acoustic space. This thesis addressed this deficit in the research by developing a phenomenological history of acoustic prosthetics in three key areas of innovation and influence: namely hearing aids, the stethoscope and headphones, and examined the different ways in which these instruments altered the user's experience of sound, and in turn, influenced the perception of acoustic space. Consideration was also given to how changes in the experience of acoustic space impacted the relationship between the user and their surrounding environment. These three different types of acoustic prosthetic devices were chosen specifically for the purposes of this study as, first, they were identified as being key sites of innovation and influence in the evolution of acoustic prosthetic technologies, and

second, they are indicative of the omnipresence of acoustic prosthetic devices across Western society. As shown in this thesis, the pervasiveness of these instruments is evident through their widespread influence over the modification of the experience of sound, as well as providing a synopsis of human experience of auditory deficiency, health, and the privatisation of acoustic space(s) for the purposes of auditory acuity and acoustic pleasure.

As outlined in Chapter One, this research has been guided by three questions: “what effect(s) have acoustic prosthetic technologies for the ear had upon the user’s perception of acoustic space?”, “how have these devices influenced a shift in the mediated perception of acoustic space over time?”, and “how have changes in the experience of acoustic space altered the relationship between the individual and their environment(s)?” In order to address these questions, this research applied a novel, hybridised interdisciplinary method guided by Sigfried Giedion’s anonymous history and Don Ihde’s post-phenomenology of embodiment relations. Using anonymous history combined with a phenomenology of sound made it possible to demonstrate the effects of acoustic prosthetics from a historical phenomenological perspective. This contributed to an understanding of the effects of three groups of devices that were influential in reshaping the ways that acoustic space was perceived by the user. This approach highlights the lived experience of the auditory effects as mediated by various acoustic prosthetic technologies for the ear from antiquity to the present, while drawing attention to how the ways in which we listen and perceive sound have deep historical

characteristics. The purpose of this chapter is to summarise the key findings of this thesis. It discusses the contribution of these findings to how acoustic space is understood, and the wider implications of the use of auditory devices upon the user's perception of sound and relationship with their surrounding environment. However, first, the limitations of this research must be acknowledged.

7.2 Limitations

The limitations of this study are acknowledged in Chapter Three. As discussed at some length in Chapter Two, initial research conducted for this dissertation revealed a paucity of existing scholarly material that considered the effects of various acoustic prosthetic technologies for the ear on the user's experience of sound and acoustic space. Furthermore, it became apparent that there are also few primary historical resources that document the development of these devices, especially prior to the mid-twentieth century. In the case of hearing aids, it is possible that this lack of information stems from the fact that many hearing-impaired individuals were reluctant to discuss or document their (socially defined) disability, as pointed out by Berger (1970) and Esmail (2013). As previously noted, this reluctance was closely linked to the stigmatised association of physical and social deficits equated with the use of hearing aids. In turn, there remains a scarcity of available recorded material that describes the experience of acoustic space mediated by various hearing aids prior to the second half of the twentieth century. In delivering this discussion of the devices and their effects, the

phenomenological observations, based on Ihde's post-phenomenology, could not always be supported through references to historical testimony.

A second limitation of this research was that it was not possible to track the effects on acoustic space of all acoustic prosthetic technologies for the ear across the ages. Given the multitude of different makes and models of instruments that have been developed over the last two hundred years, considering the implications of every type exceeded the scope of this thesis. Instead, the focus was on three specific groups of acoustic prosthetics identified as key sites of changes in the mediation of sound, and alteration in the user's perception of acoustic space. This included hearing aids, the stethoscope and headphones used for the purpose of auditory pleasure, all of which remain highly relevant today.

7.3 Key findings

This thesis first considered how various acoustic prosthetic technologies for the ear from the early nineteenth century to the present afforded individuals the opportunity to reshape their perception of acoustic space. Second, it examined how in turn this could contribute to a disengagement of attention to wider surrounding acoustic environments. As shown in this thesis, such auditory disengagement, and therefore a discontinuity in the user's experience of acoustic space, were most prominent in the use of programmable digital hearing aids, the binaural stethoscope, and headphones.

The development and application of a hybridised interdisciplinary methodological strategy grounded in Giedion's (1948) anonymous history and Merleau-Ponty (2013) and Ihde's (2007) theory of embodiment relations afforded this study a means to illuminate the ways in which the mediated experience of acoustic spaces evolved and shifted over time. Furthermore, by applying this approach this thesis was methodologically aligned to, first, trace the historical evolution of acoustic prosthetic devices in significant sites of innovation, and second, offer insight into how these devices mediated sound and altered the perception of acoustic space from a phenomenological viewpoint. Combining these two methodological strategies enabled the study to illustrate the effects these devices had on the perception of sound and acoustic space for the user.

In addition to the consideration of the physicality and phenomenological effects of these devices, accounts of historical records were integrated into the discussion where possible to highlight the lived experience of the auditory influence that came about through their use. Therefore, the findings of this study not only draw attention to the historical influence and effects of acoustic prosthetics technologies upon the mediation of sound, but also how this in turn affected the user's perception of acoustic space and their surrounding environment. Four major findings are worthy of note in this study.

7.3.1 The importance of the shaping of acoustic space

The first key finding of this research is that historically acoustic prosthetic technologies for the ear have modified the user's experience of sound, and therefore acoustic space, in a number of different ways. This, in turn, had a substantial bearing upon the listener's understanding of, and relationship to, their surrounding environment(s). These changes in the perception of acoustic space became increasingly apparent in the tracing of the historical development of acoustic prosthetic technologies for the ear, and by comparing and contrasting shifts in the mediated experience of sound and acoustic space between different periods of modernity. The site where these changes are most evident is in the use of aids for hearing from the early nineteenth century to the present.

To cite an example from this research, as discussed in Chapter Four, early models of non-electric hearing aids such as the ear trumpet provided users with a monaural and directional experience of sound as the device was uni-directional and had to be pointed towards a particular source of sound. While an ear trumpet amplified sound to some degree, it collected sound only from a small part of the user's surrounding acoustic space. This meant that the listener was merely able to detect and experience a small portion of the soundscape. In comparison, modern digital hearing aids have the potential to offer the user the impression of multi-directional sound due to the integration of omni-directional microphones into the device. This, in turn, enables the listener to simultaneously hear sounds from multiple directions, affording a much more detailed experience of the surrounding

acoustic environment. Such changes in the experience of sound and acoustic space can be seen as evidence of how the acoustic prosthetic technologies for the ear of Western modernity have redefined users' perception of acoustic space. These shifts in auditory perception illuminate the contribution of acoustic prosthetic devices to a reshaping of the modernisation of human auditory subjectivity.

This finding matters because modern hearing aids change the nature of the relationship between the user and their immediate physical environment. As discussed in Chapter Four, a deficit in hearing could contribute to a sense of displacement for the individual and a disengagement from their surrounding environment, as they were unable to hear what was occurring around them. While non-electric and early electric aids offered some relief from impaired hearing, they only provided a directional experience of sound and acoustic space. Consequently, the user's awareness of their physical environment remained limited, and a sense of auditory displacement remained.

In comparison, modern digital aids have the capacity to enable the user to hear sounds from multiple directions simultaneously, therefore broadening their awareness and perceptions of the surrounding acoustic environment. As a result, this provides a very different experience of acoustic space, including retrieving a sense of emplacement for the user within their physical environment through enhancing auditory awareness. Comparing these two experiences of sound through hearing aids draws attention to differing perceptions of acoustic space

facilitated through acoustic prosthetic technologies for the ear from the early nineteenth century to the present. This underscores the fact that the acoustic prosthetics of modernity have generated an ongoing transformation of sensory experience by revolutionising our modes of auditory perception. Consequently, such changes in the way that acoustic prosthetic technologies for the ear have historically mediated sound, and therefore how acoustic space has been perceived by users of these devices, have contributed to a re-tuning of the mind's ear through shifts in the phenomenological perspective of 'being in the world'.

A further key outcome from this thesis is that the different experiences of acoustic space offered through the use of acoustic prosthetic technologies for the ear challenge Carpenter and McLuhan's definition of acoustic space. As discussed in Chapters One and Two, Carpenter and McLuhan (1960) defined acoustic space as being horizonless and boundless, a spherical space of all centre and no margins. However, in light of the findings of this research it appears that this is not always the case when acoustic space is perceived through an acoustic mediating device. By looking at how acoustic prosthetics for the ear alter the user's perception of acoustic space it becomes apparent that the characteristics and qualities of acoustic space proffered by Carpenter and McLuhan refer to the unmediated characteristics of acoustic space by individuals with able-hearing, a noteworthy shortcoming as illustrated in this thesis.

As discussed at some length in Chapter Four, the experience of acoustic space for hearing impaired individuals was very different than that of those with

‘normal’ hearing abilities. For example, the way in which acoustic space was mediated through the ear trumpet had very distinct horizons and boundaries for the user, as they were only able to detect sound from one particular direction. This was also the case with early electric hearing aids that used directional microphones to detect and collect sound. Furthermore, as discussed in Chapter Five, the perception of acoustic space for the physician using a binaural stethoscope was not boundless, but rather bound by the confines of the interior acoustic space of the patient’s body that were transmitted by the stethoscope. This finding suggests that it is not sufficient for a single definition or explanation of what defines acoustic space. Rather, when approaching the study of soundscapes, consideration should be given to the characteristics of the ways in which acoustic space is mediated and perceived within given contexts.

7.3.2 The paradoxical nature of acoustic prosthetics

The second key finding of this research is that in some cases the use of acoustic prosthetic technologies for the ear is paradoxical. In tracing the history of these devices, this paradox became apparent in two areas; first, in the functionality and capabilities of digital hearing aids, and second, through the implications of bone conduction headphones. The same aids which were ostensibly designed to connect hearing impaired individuals to the world paradoxically became devices that isolate the user in a customised, singular auditory world of their own design. As discussed in Chapter Four, to date hearing aids have predominantly been

understood as devices that enhance the ability of individuals with a deficit in hearing to detect sounds that cannot be clearly perceived through the unaided, impaired ear(s). Yet over the last century knowledge about how the ear operates, in conjunction with steady advances in acoustic technology, has contributed to extensive changes in the functionality and capabilities of hearing aids in the processing and mediation of sound. For example, this became increasingly evident in the second part of the twentieth century with the advent of the transistor hearing aid in the 1950s as electric hearing aids enabled the user to make minor adjustments to the sound that was reproduced by the aid, such as altering the volume and gain, which in turn enabled the user to modify their auditory experience, albeit in a small way.

The digital hearing aids of today, however, afford the user with a much greater degree of control over their acoustic experience by changing the options on their aid(s). Modern digital aids can be programmed to eliminate certain sound frequencies, and even eliminate potentially distracting ambient noise. By changing the setting the user is presented with different experiences of sound, and therefore acoustic space, allowing them to manage their auditory experience as the functions of digital aids allow the user to switch between various settings to suit their immediate acoustic environment. While eliminating many of the annoyances of extraneous ambient noise, the user also tapers their perception and awareness of acoustic space.

The implications are that the user returns to a directional experience of sound and acoustic space, reminiscent of that offered by early non-electric hearing aids such as the ear trumpet. This effect of auditory displacement through digital hearing aids is further complicated by the capacity of these acoustic prosthetics to be paired with other digital devices such as mobile phones, portable music players and televisions through Bluetooth technology. Paradoxically, therefore, hearing aids are no longer solely used to enhance the user's ability to hear the surrounding ambient sounds. Rather, they can now also be used to provide the user with a customised and privatised listening experience that is completely independent of their surrounding environment. Consequently, this has a significant bearing upon the user's perception of acoustic space as their auditory attention was turned inwards towards the non-ambient sounds produced by the digital device rather than outwards into the wider exterior soundscape. Moreover, this example provides evidence of the paradoxical nature of the modernisation of acoustic subjectivity through a contemporary experience of sound whereby the user potentially excludes much of the surrounding acoustic environment from their consciousness, thus re-tuning their mind's ear.

The second site where the purpose of an acoustic prosthetic technology for the ear has become paradoxical is through bone conduction headphones. This has occurred as these headphones leave the ear open to ambient sound rather than eliminating it from the user's auditory experience. As discussed in Chapter Six, headphones were initially developed to provide the user with a private listening

experience by, first, covering and protecting the ears from extraneous ambient noise, and second, providing amplified sound from a chosen source. However, as bone conduction sends acoustic signals to the ear in the form of vibrations these headphones leave the ears open and unobstructed, enabling the user to experience the sounds of their immediate surrounding sonic environment. Thus, the user's perception of acoustic space is significantly altered. The effects of the use of bone conduction headphones is that the listener again retrieves a degree of awareness of their surrounding environment, which in turn re-connects the user to, and re-replaces them within, their physical auditory environment.

Furthermore, one of the key functions of headphones, to shut out sound, is altered, in that the bone conduction headphones are rather utilised to raise the user's awareness of the presence of the exterior soundscape. Therefore, bone conduction headphones are fundamentally paradoxical in nature, in that while still providing the user with the private experience of sound through the acoustic prosthetic device, the ears remain open to ambient noise rather than blocking it out. As in the case of personally programmable digital hearing aids, the use of bone conduction headphones reinstates the fractured relationship between the user and their surrounding acoustic environment, while shifting the traditional notion of headphones being an isolating acoustic device.

7.3.3 Hybridised experiences of acoustic space

The third key finding of this research is that several acoustic prosthetic technologies for the ear facilitate the experience of a hybridised acoustic space. In such instances, the user experiences a form of acoustic space that is neither entirely interior nor exterior, but rather a combination of both. In part, this has come about as the nature of select acoustic prosthetic technologies for the ear has become paradoxical. Existing explanations of the concept of acoustic space have clearly differentiated between interior and exterior acoustic spaces. However, bone conduction headphones users are given the ability to perceive a hybridised form of acoustic space.

For example, this study has found that by changing the purpose and capacity of these devices to reproduce and mediate personalised and private acoustic experiences, bone conduction headphones have had a significant bearing not only on the user's perception of their acoustic space(s), but also the nature of the relationship between the user and their surroundings, and therefore the ensuing sense of displacement from their immediate environment. This occurs as the listener is able to experience two separate acoustic spaces at the same time. This can be beneficial in terms of raising the user's awareness of their surrounding environment, particularly in relation to promoting personal safety through auditory acuity. Furthermore, despite the potential to split the acoustic prosthetic user's auditory attention, the ability to hear both the ambient soundscape while listening to private and personalised sound reduces the user's sense of

displacement from their surrounding environment. This hybridised experience of acoustic space was also evident for the physician when using the monaural stethoscope. While one ear was open to the sounds of their immediate environment, the other was engaged by the stethoscope in order to hear the sounds from the interior of the patient's body. Ultimately, as discussed in Chapters Five and Six, the implications of this merging of interior and exterior acoustic spaces is, first, to provide a new experience of acoustic space, and second, to redefine how acoustic space is understood within the context of technologically mediated experiences of sound facilitated by new forms of acoustic devices that are continuing to emerge.

7.3.4 Contribution to method

A fourth contribution of this study is the development and application of an innovative historical phenomenological method. As discussed in Chapter Three, neither media ecology nor media archaeology offered an approach that afforded the specific aims of this study. This hybridised methodological approach was necessary in order to respond to the questions that drove this study, and to provide greater insight through examining the historical phenomenological effects of acoustic prosthetic technologies for the ear. First, the method applied in this thesis provided a means to trace the historical evolution of acoustic prosthetics in key sites of innovation and application, and second, to consider the phenomenological effects of these devices upon the perception of acoustic space

for the user. The novel interdisciplinary method was realised through joining together the strands of Sigfried Giedion's (1948) approach to the compiling of anonymous history, and a post-phenomenology of sound and embodiment relations informed by Maurice Merleau-Ponty (2013) and Don Ihde (2007).

The findings from this research effectively extended the scope of Giedion's (2013) anonymous history by considering how acoustic prosthetics altered the lived experience of sound across history. Through the integration of these two approaches to form an interdisciplinary approach it was possible to achieve three key outcomes. First, it provided a methodological framework with which to not only guide the development of a non-linear history of acoustic prosthetics within the dearth of available historical records, but also to shed further light on how these devices mediated sound and altered the perception of acoustic space from a phenomenological viewpoint.

Second, the use of historical phenomenology provided a means of contrasting and comparing changes in the mediated perception of acoustic space that occurred over time. In so doing, it enabled the development of a more detailed and robust understanding of acoustic space and the phenomenological effects of certain devices within the fields of media ecology, sound studies and phenomenology. Third, by tracing the evolution of acoustic prosthetic technologies for the ear this study offers a relatively extensive history of acoustic prosthetic technologies for the ear to date. Thus, by making a contribution to the fields of media ecology, sound studies and phenomenology through an historical

phenomenological examination of acoustic prosthetic technologies for the ear, this thesis has extended extant research pertaining to, first, the development and ensuing effects of these devices across history, and second, the consideration of their effects upon the user's perception of sound and acoustic space. It is hoped that through the development of this approach to the study of the history of the effects of acoustic prosthetic technologies for the ear and the experience of media environments brought about by their use, that this method will provide a means by which to consider and explore the wider phenomenological effects of other forms of media artefacts.

7.4 Implications

Two key implications have emerged from this study's examination of the effects of acoustic prosthetic technologies for the ear upon the experience of acoustic space. First, this study brings into question long-held notions regarding the fundamental nature and form of acoustic space. When Edmund Carpenter and Marshall McLuhan (1960) first established the term 'acoustic space' in the 1950s, they applied the concept in order to compare and contrast the differences between orality (the spoken word) and literacy (the written word). The initial coining of this term occurred prior to the release of the first pair of stereo headphones, and the development of portable music players such as the Sony Walkman and the Apple iPod. As this study has illustrated, acoustic prosthetic technologies play a defining role in the shaping of the experience of acoustic space. This raises the

question of whether or not existing definitions and understandings of the characteristics of acoustic space, namely Carpenter and McLuhan's (1960), Ong (1982) and Schafer's (1994) explanations of the term, take into account the complexities of the perception of acoustic space mediated by prosthetics for the ear.

Second, this study compels us to revisit long-held notions of the function of acoustic prosthetics, namely hearing aids and headphones. Whereas hearing aids were developed to assist the user's ability to hear ambient sound, the function can no longer be defined as clearly, as these same hearing aids offer increasingly private and personalised experiences of sound. In a similar manner, bone conduction headphones also afford the user with the ability to hear two mutually exclusive soundscapes simultaneously. Rather than shutting out the ambient sounds of the user's surrounding environment, bone conduction headphones are designed specifically to allow those sounds to reach the ear. Such developments challenge the widespread understanding of headphones as devices that isolate the user from other people and the world around them, as argued by the likes of Attali (1985), Bull (2000; 2007), Hosokawa (1984), Ihde (2007), Stankievich (2007), Stocker (2013), Truax (2001) and Weber (2010).

These two factors indicate the value of further consideration about, first, implications surrounding shifts in the perceived form and experience of acoustic space in light of the current technological climate. Second, long-maintained notions regarding the purpose and capacity of acoustic prosthetic technologies for

the ear would benefit from additional reflection, as these devices can no longer be identified and differentiated on the basis of being of prosthetics that solely extend the ear, or alternatively, provide auditory isolation.

7.5 Opportunities for further research

In providing a historical phenomenology of acoustic prosthetic technologies for the ear upon the experience of acoustic space, this thesis has not only revealed a paucity of research that considers the effects of certain devices, but also identifies areas worthy of further study. Having considered different types of acoustic prosthetics developed and used for medical and entertainment purposes, knowledge would be augmented by future consideration of factors such as the patterns of use of individual devices, or who predominantly uses them. This study has clearly identified that benefit would be gained from increased attention to the historical phenomenology of sound as experienced through various acoustic devices, as opposed to exploration of sound as a form of energy transfer, which dominates current research, as discussed in Chapter Two. Therefore, it is recommended that future research be conducted into the wider phenomenological effects of specific groups or individual models of acoustic prosthetic technologies for the ear, thus shedding further light upon the complexities of their effects on the perception of soundscapes. Furthermore, as digital acoustic prosthetic technologies for the ear continue to evolve and connect users and their environments in different ways, it is probable that these devices will continue to

facilitate new auditory experiences that will continue to alter how sound and acoustic space is perceived.

With the imminent release of three-dimensional surround sound headphones it is also possible that these devices may enhance, and potentially surpass, the natural hearing threshold of the unmediated ear by enabling the experience of 720-degree omni-directional immersive sound. The existing body of literature would benefit from further research into the experiences of sound and acoustic space mediated by emerging acoustic prosthetic devices in order to draw further attention to the ever-changing shape of mediated auditory experiences.

Finally, as indicated earlier in this chapter, the findings in this thesis suggest that further research be conducted into the diverse characteristics of mediated experience of acoustic space in different contexts. Up until now researchers have predominantly been reliant upon definitions of acoustic space, that is Carpenter and McLuhan's (1960) and Schafer's (1994) descriptions of acoustic space being spherical and boundless and horizonless, a definition that may not be entirely relevant to rapidly changing media environments. For this reason, this study poses two key questions to be contemplated in future research: "What does constitute acoustic space in our current fluid, media saturated environments?" and "Will the definition of acoustic space laid down by Carpenter and McLuhan in the 1950s still remain relevant in an epoch when the experience of hybridised acoustic spaces is becoming increasingly common"?, as this has implications for how acoustic space has been understood and approached in

scholarly discourse to date. At present, this field is ripe for research, and the opportunities for future investigation are plentiful. This thesis, therefore, invites convergent research from a wide variety of disciplines, including media ecology, sound studies, media archaeology, media studies, cultural studies, sensory studies, sociology and history to pursue further research into the complexities and hidden facets of acoustic prosthetic technologies for the ear.

In conclusion, the findings from the analysis conducted in this thesis provide evidence of significant shifts in the purpose, and phenomenological effects, of acoustic prosthetic technologies for the ear. These insights into changes in the ways that aural devices mediate sound can also carry with them significant implications, not only in terms of *how* acoustic information is processed and received, but also ultimately the individual's sense of space and belonging in the world, as they re-tune the mind's ear. It could be argued that in our current media saturated environment(s) that the next technological revolution is set to take place in the ear. This new generation of acoustic prosthetic devices that is continuing to emerge is enabling experiences of sound - and therefore acoustic space - that differ from anything previously possible through either the naked or mediated ear. As such, there is benefit to furthering research which examines the role of acoustic prosthetic technologies for the ear in order to develop a more robust understanding of the integral role that acoustic space has upon the relationship between the individual and their environment(s) and how this affects a sense of space, and ultimately the ways in which the world is experienced through sound.

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