NICOLE ROBSON

HUMAN-SOUND INTERACTION: THE RELATIONAL EXPERIENCE OF (IN)AUDIBLE INSTALLATION ART

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School of Electronic Engineering and Computer Science
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ABSTRACT

This thesis is inspired by installations in the sound art tradition, which - through the simple arrangement of speakers in space - produce rich sensory experience. There are no sensors, mappings, or feedback loops, yet they may be perceived as interactive due to the close entanglement of the listener with sound. Enacted across the disciplines of sound art and human-computer interaction, this PhD research examines that phenomenon: How do sound installations *work*? How might sonic entanglement inform the *design* of an interactive artwork? How is it *experienced*? And, given that the activity of listening is perceptual, how might it be *articulated* using qualitative research methods?

To begin addressing these questions, a preliminary interview study is conducted with sound installation artists to examine site-specific design processes. A novel ultrasonic technology is then developed that harnesses listener entanglement with sound as the source of interactive effects. Two sound installation artworks are created using this technology and employed as research probes in three subsequent studies. The first of these explores the relational experience of listening to the installation *Being With The Waves* during public exhibition with a particular focus on the influence of social factors. In the second study, individual listeners are interviewed using the micro-phenomenological method to elicit detailed descriptions of lived experience. In the final study, a new artwork called *Sonographies* is developed in situ at a London gallery. The active influence of material agencies on artistic practice is explored through first-person methods.

Relational and feminist epistemology becomes increasingly pertinent to this PhD as it progresses. Rather than trace every influence and relationship between a listener, the artwork and outside forces, this research produces a patchwork of situated knowledges. Interdisciplinary insights emerge through the intersection of sound art and HCI. Notably, audience perspectives are centred in this research, where they are largely absent from sonic art discourses. Key contributions include the practical implementation of relational philosophy through art practice, interaction design and research methods, as well as provocations for HCI to recognise facets of interactive experience that become illuminated through an orientation to the sonic and challenge disciplinary conventions.

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DECLARATION

I, Nicole Robson, confirm that the research included within this thesis is my own work or that where it has been carried out in collaboration with, or supported by others, that this is duly acknowledged below and my contribution indicated. Previously published material is also acknowledged below.

I attest that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge break any UK law, infringe any third party's copyright or other Intellectual Property Right, or contain any confidential material.

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Date: August 2025

Nicole Robson

PUBLICATIONS

Some ideas and figures have appeared previously in the following publications:

1. Nicole Robson, Nick Bryan-Kinns and Andrew McPherson 2023. "On Mediating Space, Sound and Experience: Interviews with situated sound art practitioners" *Organised Sound* 28(1): 25–34.

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1

INTRODUCTION

> *Sound is intrinsically and unignorably relational: it emanates, propagates, communicates, vibrates, and agitates; it leaves a body and enters others; it binds and unhinges, harmonizes and traumatises; it sends the body moving, the mind dreaming, the air oscillating. It seemingly eludes definition, while having profound effect.*
> LaBelle [2015, p. xi]

This thesis is inspired by installations in the sound art tradition, which harness the relational qualities of sound to produce rich sensory experiences through the arrangement of multiple speakers emitting a spatial composition. There are no sensors, mappings, or feedback loops. Yet, the attentive listener might discern changing sonic phenomena with their movement and according to their particular listening position in relation to sound sources. Therefore, sound installations may be *perceived* as richly interactive from a human perspective due to the close entanglement of the listener with sonic phenomena. Enacted across the disciplines of sound art and human-computer interaction (HCI), this PhD research examines that phenomenon: how do sound installations *work*? How might sonic entanglement inform the *design* of an interactive artwork? How is it *experienced*? And, given that the activity of listening is perceptual, how might it be *articulated* using qualitative research methods?

These questions are addressed partly through the lens of artistic practice via interviews with renowned sound art practitioners along with my own creative endeavours, which span interaction design and sonic composition. A novel ultrasonic installation technology is developed during this PhD, which, grounded in a sound art paradigm, effectively sonifies and magnifies the physical interaction of a listener with a spatial sound field. Two artworks are created with the technology, and these are exhibited as part of three qualitative research studies exploring listener experience. Through observation, post-experience surveys and interviews, the studies aim to articulate physical and perceptual behaviours along with the felt quality of sonic interaction.

The 'intrinsically and unignorably relational' character of sound [LaBelle, 2015, p. xi] is a key concern. An acoustic event such as a clap doesn't exist in isolation; it bears the trace of its location, reverberations and resonances of the place in which it is heard [Voegelin, 2023]. Furthermore, the clap *sound* exists only in the listener's perception according to their physical attributes and perceptual behaviour: how it is attended to and made sense of. The experience of listening is, therefore, not wholly subjective because it is contingent on external characteristics of the environment. This thesis examines sonic experience as a relational phenomenon, mediated by specific design qualities of the artwork, social and material agencies unique to the context in which it is presented.

In a further relational move, the disciplines of sound art and HCI are set into dialogue, interfered and diffracted by this PhD. Resonances, dissonances, and more pertinently, the *effects* of difference [Haraway, 1991], are discerned as an emergent outcome of interdisciplinary perspective. Engaging the qualitative methodologies of HCI in the context of sonic experience leads to a heightened appreciation of sound as a medium: more like an event than a fixed object [O'Callaghan, 2007], a material in *flux* [Cox, 2018] with *invisible mobility* [Voegelin, 2021] that *immerses* the listener [Brewster, 1999, Ihde, 1976]. Relationality becomes an epistemological issue. Research methodologies come to be recognised as discursive *and* material apparatuses that actively shape the collection and interpretation of data. In response, efforts are taken to adopt epistemic positions that are grounded in the situated and contingent experience of listening.

Key contributions of this PhD research include provocations for HCI to recognise facets of interactive experience that become illuminated through an orientation to the sonic, to incorporate all sensory knowledge equally and consider the epistemic implications of relational philosophies, which are touted as signalling a paradigm shift in HCI [Frauenberger, 2019] and underpin posthuman sensitivities in contemporary design research [Coskun et al., 2022, Homewood et al., 2021, Yoo et al., 2023].

1.1 RESEARCH CONTEXT

I identify as a sound artist and researcher whose work explores site-specific performance, installations and community-focused, public art projects[1]. My professional and academic background is in music and the arts. This PhD research is

1 https://nicolerobson.com/

conducted within the Centre for Digital Music in the School of Electronic Engineering & Computer Science at Queen Mary University of London between 2019 and 2024. It is made possible by a fully-funded PhD scholarship awarded by the Media and Arts Technology (MAT) Centre for Doctoral Training (CDT)[2], itself funded by the Engineering and Physical Sciences Research Council (EPSRC)[3]. The MAT CDT (active 2008-2024) promoted interdisciplinary research at the intersection of technology development and the arts, with taught components centred on programming skills and maker cultures. Therefore, while this PhD is inspired by art practice and involves the creation of artworks, it is examined from a STEM perspective, and issues of technology design and human interaction with technology are the primary focus.

This research also relates to the work of my two supervisors, their research labs and associated projects. It is conducted within the Augmented Instruments Laboratory (AIL), which, led by Prof. Andrew McPherson, is a music technology research group that creates new digital musical instruments (DMIs), examines performer-instrument interactions, and develops hardware and software tools for interactive audio systems[4]. While my work focuses on sound installations rather than musical instruments, it is nonetheless influenced by (and contributes to) the field of DMI design, a community that centres on the New Interfaces for Musical Expression conference[5]. This research is also conducted within the Sonic Interaction Design Lab, which, led by Prof. Nick Bryan-Kinns, explores the design and evaluation of interactive systems that prioritise sound over vision, including interactive soundscapes, tangible interfaces, and real-time collaborative music systems[6].

This thesis doesn't neatly fit within the usual boundaries set by programmes such as the MAT CDT and Electronic Engineering & Computer Science departments. It might be described as arts-led HCI research in the sense that HCI methods are employed to study and design interactions in the context of sound installations, and art practice is engaged as a form of interdisciplinary knowledge generation [Sullivan et al., 2023]. However, unlike much interactive art research and arts-based HCI inquiry, this is not research about sensor and mapping-based interactive technologies and their implementation in a particular artistic or musical context. Instead, sound installation practices, associated values, traditions, critical perspectives and philosophies are explored in the context of interaction design.

2 https://mat.qmul.ac.uk/
3 https://www.ukri.org/councils/epsrc/
4 https://instrumentslab.org
5 https://nime.org
6 https://sid.eecs.qmul.ac.uk

By considering the work of artists, musicians, and engineers usually held separate from HCI and STEM scholarship, the aim is to challenge and critique conventional practice. This particular approach has little precedent beyond Bowers and Haas [2014], who explore the installation work of David Tudor and Nicolas Collins as an alternative to more familiar ideas of instruments and interfaces. Similarly, Kang et al. [2022] study artist-engineers Billy Klüver, Nam June Paik, and Robert Moog and propose 'techno-aesthetic encounters' as a means to support nonlinear (situated, materially-driven, multi-sensory) and art-based modes of inquiry in HCI.

1.2 MOTIVATION

This research is motivated by the observation that although technologically simple, installations in the sound art tradition yield rich sensory experiences that have an inherently interactive quality. While other scholars have noted the interactive quality of sound installation listening [Davis, 2010, Harries, 2013, Matthews, 2019], I arrived at these observations as a result of my own experiences. The relevance and design potential of sound art paradigms to engineering and interactional perspectives was sensed during a visit to the Ars Electronica Festival in 2019. Note that further details are included in Appendix A.1.

In the vaulted attic spaces of the Ursulinenkirche at the OÖ Kulturquartier in Linz, I encountered *Stay* (2005-) by Sine Wave Orchestra [Jo et al., 2005], a participatory sound installation in which visitors were invited to take a small sine tone generator, set its frequency, and clip it to one of many metal rods suspended throughout the gallery space. Over the course of the exhibition, the gallery space became filled with what, from a distance, sounded like a cloud of white noise hanging in the air. Stepping among the wires, I became aware of shifting harmonic clusters and an even closer listening afforded the perception of individual tones, micro-compositions and the interplay of different pitches as they combined in the air. The soundscape was so complex and fixed in the exhibition space that as I moved, I could perceive my changing spatial relationship to the installation via the shifting balance and orientation of tones. I recall my attentive disposition as a kind of listening, feeling and thinking in movement [Buttingsrud, 2021, Sheets-Johnstone, 1981b], discerning in every moment the cumulative effect of the installation as a microcosm of local detail specific to my bodily position and activity.

In acoustic sound installations, such as *Stay*, auditory feedback is closely and directly coupled to bodily movement, and just tiny movements of the head lead to discernible sonic variation. By harnessing the acoustic entanglement of a listener with sound and augmenting the sound art paradigm of installation with new technology design, artworks might be created that afford detailed interaction on a micro-scale. It is my experience that sound installations are richly *meaningful*, though producing understanding and depth of experience that addresses the body more than conscious thought patterns, a kind of non-representational, body-sound meaning. This meaning is not produced from a distance, as in the case of an audience member at a performance. The installation is performed in the act of listening; it manifests as a personal experience, unique to the listener's embodied perspective in its midst.

The perspectives of ordinary listeners in their encounters with sonic artworks are largely absent from sound art discourses, which means that little is known about how visitors listen to sounding artworks, a lack that is lamented by theorists and curators [Kannenberg, 2016, Keylin, 2020, Semmerling, 2018]. This might partly be explained by the 'impenetrability of listening', the difficulty of recalling and articulating sonic experience, which Schulz [2002] suggests is a barrier to the broad engagement of audiences with sound art. The field of HCI is replete with methodological approaches for articulating user experiences, but eliciting data that is truly reflective of a listener's experience requires careful consideration of research methods and protocols. These shortcomings motivate the desire to explore qualitative methods used in interactive art and experience-centred HCI research to elicit sonic experience.

1.3 HOW THIS RESEARCH IS CONDUCTED

This research is conducted through creative practice with art and technology, and four qualitative research studies. Inspired by installations in the sound art tradition, a novel ultrasonic technology is developed. Two artworks are produced with the technology and deployed as research probes in participant studies exploring the experience of listening to sound art. Four participant studies are conducted as part of this thesis, and each explores the relational design and/ or experience of sound installation art.

Study 1: Interviews with Situated Sound Art Practitioners explores the relationship of artists to space, sound and experience. It is described in Chapter 4.

Study 2: Experiencing *Being With The Waves* at a Public Art Festival explores listening behaviours and their mediation by social factors. It is reported in Chapter 6.

Study 3: Exploring the Felt Quality of Sonic Interaction explores interactive experience in relation to theories of sounding and listening. It is reported in Chapter 7.

Study 4: Examining the Situated Design and Gallery Curation of *Sonographies* primarily examines the influence of material agencies on creative practice and is described in Chapter 8.

The studies do not follow a linear path, nor are they methodologically consistent. Rather than attempt to trace every influence and relationship between design activities, human listeners and outside forces, the studies presented here seek merely to map pathways through the 'complex and multi-layered world that art and our experience of it offers' [Candy and Ferguson, 2014]. Each is a unique assemblage of artwork, research methods and socio-material context, making very particular *agential cuts*. That is, momentary acts of delimiting that produce the boundaries of what is considered inside or outside the phenomena under study [Barad, 2007]. I characterise the outcome of these studies as a patchwork of partial and situated knowledges that nonetheless overlap and relate in ways that enable me to make connections between them.

Chapter 3 introduces the epistemological and methodological approaches taken in this thesis. It articulates epistemic positions and individual perspectives that impact the research, before describing the various qualitative methodologies employed in this thesis for data collection and analysis.

1.4 MAIN RESEARCH QUESTIONS

This PhD research is guided by two main research questions (MQs). These are over-arching and high-level questions in their most general form, to which all studies relate. While it is conventional to present only one overarching question, I believe that the dual focus on aspects of design and experience in this thesis, while inevitably interrelated, is best served by separate questions, promoting clarity and detail in the discussion.

MQ1: How does the design of a sound installation artwork, its material situation and social context relate to lived experience?
MQ2: How can qualitative research methods be employed to effectively articulate the experiential detail of listening-based interactions?

The final chapter, Chapter 9, addresses these questions via a comparison of findings across the research studies and an evaluation of qualitative research methods for articulating the experience of sonic interaction.

1.5 CHAPTER-SPECIFIC RESEARCH QUESTIONS

A series of lower-level research questions (RQs) are addressed specifically by individual Chapters 4, 5, 6, 7 and 8. These are discussed within each chapter, and key findings are summarised in Section 9.4 of the final chapter.

To begin examining the phenomenon of sound art installation, an interview study is conducted with experienced practitioners to learn about their practice, process, understandings of and attitudes to audience experience. The following research questions are addressed by Chapter 4:
RQ1: What can be learned from experienced sound artists about the relationship of practice to the site of an installation and subsequent reception of the work by a listening audience?

(a) How is site addressed in their process via methods, tools, and technologies?

(b) What do artists understand about the audience's behaviour and experience?

Chapter 5 describes the design and technical implementation of a novel ultrasonic technology inspired by installations in the sound art tradition. Through the practice of composing music and sound design with the technology, it addresses the question:
RQ2: How might the entanglement of a listener with the physical phenomena of sound be harnessed in the design of an interactive sound installation to promote rich sensory experience?

In Chapter 6, the first artwork created with the ultrasonic technology, called *Being With The Waves*, is exhibited publicly at Ramsgate Festival of Sound. Through visitor surveys and video observations, it addresses the questions:
RQ3: How do listeners experience a sound installation in the context of a public art festival?

(a) What do listeners do? In terms of:

  (i) Physical behaviour (e.g. movement, bodily dispositions)

  (ii) Perceptual activity (e.g. directing attention, intention setting)

(b) How do the material and social context mediate behaviour?

The focus of Chapter 7 is a lab-based study in which individual participants interact freely with *Being With The Waves* before an hour-long interview. The micro-phenomenological interview method (see Section 3.5.3) is employed to help the listener articulate moments of sonic interaction in rich detail. Informed by relational ontologies, interview data is read with theories of sounding and listening to explore the question:
RQ4: How is sonic entanglement *experienced* as embodied sensations and felt qualities?

Chapter 8 describes the practice of creating a second artwork using the ultrasonic installation technology, called *Sonograhies*, while working in situ at *no format Gallery* in South London. RQ5 is addressed through my practice:
RQ5: How do nonhuman, material influences shape *my* artistic practice and process with the ultrasonic installation?
Visitors to the installation during its public exhibition are invited to complete short

post-experience surveys to elicit insights into the reception and understanding of the work as a secondary focus. Following the methodological trajectory of Chapter 7, I engage in a relational analysis of survey data, attuning to (dis)connections with my artistic intentions and own embodied understanding of the work along with the relationship of survey responses to the sociomaterial context.

1.6 STATEMENT OF CONTRIBUTION

This thesis makes five core contributions to knowledge, primarily in the space of HCI and interaction design, but with relevance to sound art and sound studies discourse.

(a) The design of a novel installation technology, which, grounded in a sound art paradigm, effectively sonifies and magnifies the physical interaction of a listener with a spatial sound field, producing interactivity without sensors.

(b) The adoption of qualitative research methods from the social sciences and HCI to the domain of sound art and an evaluation of their effectiveness for eliciting the detail of listening-centred interactive experience.

(c) Insights into the physical and perceptual behaviours of listeners and felt qualities associated with movement-sound interaction. Analyses that examine the dependence of experience on social and material factors.

(d) The practical implementation of relational philosophy and two examples of diffractive analysis, a relational method for interpreting data (introduced in section 3.6.2).

(e) A series of provocations for HCI to recognise facets of interactive experience that are foregrounded by an orientation to the sonic and to incorporate all sensory knowledge equally.

In the next chapter, Chapter 2, I position the research in relation to disciplinary perspectives, comparing the lineage and value systems of installations in the sound art tradition and interactive sound installations. I introduce key theoretical frameworks and survey existing literature related to this research, casting a wide net over sound and HCI-related fields. In so doing, I demonstrate the need for this investigation and identify gaps in the literature that are addressed by this research.

2

BACKGROUND

This PhD is inspired by installation practices in the sound art tradition. Typically, such sound art installations are technologically simple and might be described as *static* rather than *interactive* because emitted sounds do not change as a result of listener movement via computational processes. There are no movement sensors, programmed interactivity, mappings or feedback loops. Any dynamic qualities of interaction emerge solely through the listening faculties of the visitor as a result of their bodily presence and entanglement with sound and space.

This chapter begins by tracing the roots of sound art and articulating key characteristics of installations in that tradition: the spatial arrangement of sound and its relationship to the site of exhibition. Intersections of the sound installation format with HCI research are then explored in Section 2.2, charting connections with art, music and design-related sub-fields. Predominantly, sound installations in the HCI literature employ interactive systems, with sensor data mapped to sound-producing outputs, which is a paradigm based on symbolic representation, metaphors of dialogue and control. By contrast, a rich vein of HCI literature explores the physical entanglement of humans and materiality as an alternate paradigm of interaction, one that resonates with the relational practices of sound art. This is discussed under the heading of 'human-matter interaction' in Section 2.2.3.

Throughout this thesis, the foci of individual chapters oscillate between matters of design (the making of installations) and matters of experience (how they are felt and interacted with). This thesis takes a relational view of experience as co-produced by human subjectivity and external factors. This accords with the pragmatic aesthetics of John Dewey (Section 2.3) and, later in the thesis, with the more radically relational and posthuman ontology of agential realism developed by Karen Barad. Section 2.4 defines a relational space for human experience that, more than Dewey, emphasises our entanglement with the material world.

Audience perspectives and experiences of listening are notably lacking within sound art and sound studies discourse. Section 2.5 explores the specific challenges of eliciting sonic experience and Section 2.5.2 reviews approaches to the study of experience in interactive art and ethnomethodological domains, both of which em-

phasise the sensitivity of human interaction to the social and cultural context. The chapter concludes with a summary, emphasising the core pillars of this research: human experience, site-specificity and more-than-human perspectives.

2.1 SOUND ART INSTALLATIONS

From the outset of this thesis, I have pointed to sound's relational condition, which LaBelle [2015, p. xi] argues can be 'traced through modes of spatiality, for sound and space, in particular, have a dynamic relationship.' As an art material, sound is uniquely immersive, collapsing the distance between the art object and its audience. The spaces of acoustic sound wrap the experience around the listener [Brewster, 1999, p. 103] who is immersed in sound but also complicit with its production since their footsteps and bodily sounds contribute to the auditory environment [Voegelin, 2010, p. 5]. The inherent interactivity of sound, space, and listener [Matthews, 2019, p. 297] is central to installation practices in the sound art tradition. These are described across the following subsections, tracing their genesis in relation to parallel art movements and describing key characteristics.

2.1.1 *Historical Context*

Sound art is a form of artistic expression that utilises sound as its primary medium and material, encompassing a wide range of practices from field recordings and sound walks to sound installations and performances. The writing of Brandon LaBelle offers a comprehensive introduction to sound art, which they characterise as a practice that 'harnesses, describes, analyzes, performs, and interrogates the condition of sound and the process by which it operates' [LaBelle, 2015, p. xi]. Further surveys and documentation of sound art exhibitions may be found in Licht [2007], Roden and LaBelle [1999], Seiffarth and Steffens [2010] and Weibel [2012].

The development of sound art in the mid to late 1960s coincided with the development of site-specific methods in the visual arts, along with performance and installation art. LaBelle [2015, p. xiv] proposes that these correspondences are not by chance, 'for the very move away from objects towards environments, from a single object of attention and toward a multiplicity of viewpoints, from the body toward others, describes the very relational, spatial, and temporal nature of sound itself.' Krauss [1979] articulates a movement within the visual arts toward an expanded

field of sculpture, encompassing architectural and landscape interventions far beyond the walls of the gallery. Marking and constructing site, sculptural works were no longer isolated objects but integrated components of their surroundings, with meaning shaped by context: site-specificity, therefore, became a critical concept in fine art.

In the domain of experimental music, John Cage - its key progenitor - positioned non-musical sound and its situated production as key ingredients. Consider the 'silent' work *4'33"* [Cage, 1952/1960], in which the pianist David Tudor walked onstage, sat down at the piano and did nothing except to mark subsequent movements of the piece by closing and re-opening the lid of the piano [Ross, 2007, p. 369]. Cox [2021, p. 70] notes that *4'33"* 'functions like a sort of window or door that opens the space of musical performance... to the extra-musical world from which the concert hall separates itself, and the extra-musical sounds music traditionally excludes.' Those that occur, do so according to the spatial and temporal frame of the performance. Arguably, *4'33"* epitomised Cage's belief that everyday sounds and actions could constitute art, a concept embraced by artists like Allan Kaprow and Claes Oldenburg, for whom the performativity of the body and the larger contextual frame of audience and space are made the focus of art in Happenings and Environments [LaBelle, 2015, pp. 57-63].

The term 'installation' was first used by the artist Dan Flavin in 1967. Working with light, space and colour, Flavin arranged neon strip lights to illuminate and effectively stage the room itself as an artwork [Seiffarth, 2012, para. 3]. In 1971, Max Neuhaus coined the term 'sound installation'. He was inspired by the possibility of arranging sound in space, rather than over time, and in doing so, to allow the listener to place sound in their own time [Seiffarth, 2012, para. 7]. The site-specific and spatial organisation of sound, which defines installation practice in the sound art tradition, has proved fertile territory for artistic exploration and continues to inspire new practices and research.

2.1.2 *Spatial Sonic Arrangement*

Sound installations usually form a sonic arrangement or environment that surrounds the listener [Seiffarth, 2012, para. 6]. Conventionally, this is achieved via a multi-channel arrangement of loudspeakers emitting a pre-composed or generative sonic composition distributed spatially around or throughout the exhibition space. Take, for example, Janet Cardiff's installation *The Forty Part Motet*,

an oft-cited example of multi-channel sound installation. Here, the Renaissance composer Thomas Tallis's work *Spem in Alium* is played through forty individual speakers in an oval arrangement, each playing one voice of the larger choral arrangement [Harries, 2013, p. 7]. The spatial arrangement allows the audience to experience the music from different perspectives and choose their path through the physical space of the exhibition layered with the virtual space of sound[1].

Besides loudspeakers, other sound producers include transducers that turn materials into speakers, sound sculptures and self-playing musical devices. For example, the Swiss artist Zimoun[2] creates installations that fill an exhibition space with kinetic, percussive sculptures, generating complex sound environments by acoustic means: motors animate hundreds of metal washers to bounce against a concrete floor or move cotton wool balls so that they strike the sides of cardboard boxes, which cover the walls of the exhibition space.

Sound art installations emphasise the spatial arrangement of sounds over temporal organisation, allowing the listener to place sound in their own time. For artists explicitly exploring the materiality of sound, this often means replacing the horizontal organisation of sounds (melody, temporal gestures) with an exploration of timbre and resonance. Typically, these installations have no beginning or end and are sonically consistent, apparently drone-like, with complex, fluctuating sound phenomena uncovered through interaction. However, many contemporary installations tend not to take such a purist approach and deal with the interplay of stasis and variation, sound and music, balancing temporal pacing with spatial interest. Consider, for example, John Wynne's *Installation for 300 speakers, player piano and vacuum cleaner* (2009), which is described as 'monumental, minimal and immersive' all at once:

> The piece has three interwoven sonic elements: the ambient sound of the space in which it is installed, the notes played by the piano, and a computer-controlled soundtrack consisting of synthetic sounds and gently manipulated notes from the piano itself. Because none of these elements are synchronised with each other, the composition will never repeat. The music punched into the paper roll is Franz Léhar's 1909 operetta Gypsy Love, but the mechanism has been altered to play at a very slow tempo and the Pianola modified to play only the notes which most excite the resonant frequencies of the gallery space in which it is

1 https://cardiffmiller.com/installations/the-forty-part-motet/
2 https://zimoun.net/

> installed. Sound moves through the space on trajectories programmed using a 32-channel sound controller, creating a kind of epic, abstract 3-D opera in slow motion.
> [Wynne, para. 1]

Listeners are encouraged to discover sound installations by moving through the space. The listener determines their own pathway and how each part of the work is audited: 'coming or going, staying or stopping is a free choice at any given moment' [Bandt, 2006, pp. 355-356]. Sound installations, therefore, differ from multichannel electroacoustic composition and spatial music created with formats such as ambisonics or Dolby Atmos, as there is no sweet spot, no ideal listening position. For the spatial aspect to be appreciated requires the active engagement of listeners to explore *by ear*. The artwork unfolds in the audience's listening and is determined by their bodily and attentional behaviour as they orient their ears to the environment, focusing on some aspects and overlooking others [Gibson, 1966, Lahlou, 2011]. The extent to which the audience participates in constructing the listening experience has led authors to describe interaction with this kind of work in musical terms, such as performing [Harries, 2013, p. 7], composing or soundmaking [Keylin, 2020, p. 106] within one's listening. However, Bandt [2006, pp. 353-354] notes that while sound is primary in these installations, the spatial presence of sound, which 'inhabits space, filling height, width and depth with its presence' means that there are also haptic, proprioceptive and visual concerns in the perception of artworks.

2.1.3 *Site-Specificity*

As a set of oscillations, sound expands outwards from its source, reflecting and absorbing into physical surfaces and bodies. LaBelle [2012, p. 1] suggests that 'sound is always already a trace of location' and 'a rich platform for understanding place and emplacement'. Sound is inseparable from the acoustic properties of the site; according to Bulley [2018, p. 16], it 'has reality'. Artists working in a sound art tradition are attentive to the relationship between sound and the place in which it sounds, and installations are inherently site-specific.

For Seiffarth [2012, para. 2], 'the term sound art primarily covers sound installations and sound sculptures that can be experienced in a unique physical space that cannot simply be replaced'. Similarly, de la Motte-Haber [1999] emphasises that sound installations are dependent on the site. Sound sculptures, on the other hand,

could be placed in different rooms, meaning that they are not. Sound art installations are found in public spaces such as art galleries and also in more unusual, liminal spaces of architectural or historical interest. Working site-specifically, some artists focus on the associative qualities of a place, such as its social and historical context and its purpose or use [Klein, 2009, Spinks, 2013]. Others enter into a dialogue with its materiality via site-responsive improvisation or analysis of acoustic properties [Fløe, 2018, Hayes, 2017].

Key figures in the history of sound art installations include the artists Maryanne Amacher, Christina Kubisch, Max Neuhaus, Alvin Lucier, and Francisco López. All are artists who explore the materiality of sound, 'its texture and temporal flow, its palpable effect on and affection by the materials through and against which it is transmitted' [Cox, 2011, pp. 148-149]. The site of installation is, therefore, an active determinant in the installation's composition, and artists often work to include its acoustic response and material properties in the work. For example, installations might take advantage of physical and acoustic phenomena and place speakers to fill the space with sound. By choosing frequencies with wavelengths that fit the room, a composer can create standing waves and effectively *shape* sound waves so that their reflections and interferences create a series of nodes and antinodes. As audience members move through the installation, they encounter different pockets of sound, which leads to the impression that they are 'playing' the space with their own body position and movement. La Monte Young used this technique in his *Dream House* installation (1969) of sound and light in a New York townhouse [Kotz, 2009, p. 103].

2.1.4 *Aesthetics of Listening*

Writing from the perspective of science and technology studies, Akrich [1992] posits that the design of a technology inscribes users and behaviours. Arguably, the materialist design of sound installations by, for example, Amacher, Lucier and Neuhaus inscribe a mode of listening to *sound in itself*, as vibrational phenomena. This listening mode or *aesthetic* foregrounds a primarily perceptual engagement with sound, which is explored and promoted by Salomé Voegelin; most notably in 'Listening to Noise and Silence: Towards a Philosophy of Sound Art' [Voegelin, 2010]. Voegelin seeks to establish a phenomenological framework for engaging with sound art, focusing on subjective and embodied listenings as critical and creative acts that reconfigure our relationship to the world beyond the visual and

representational. Voegelin aims for 'a sonic epoché... a stripping away from the sonic anything that ties it to visuality... not to reduce the heard but to get to the wealth of the heard through bracketed listening' [Voegelin, 2010, p. 35].

While not directed at sound art listening specifically, the American composer and accordionist Pauline Oliveros developed deep listening (from 1970) as a practice and philosophy. Deep listening cultivates a heightened state of awareness and a tuning in to all sounds - the external, internal, and imagined - with full attention and openness, often through meditative exercises and sound-making improvisation [Oliveros, 2005, 2022]. Deep listening is fundamentally active. While hearing may be involuntary, 'listening actively directs one's attention to what is heard, to the interaction of the relationships of sounds and modes of attention' [Oliveros, 2022, pp. 37-38]. For Oliveros, there are two essential listening modes: *global* listening that expands to the entire environment as a field of sonic possibilities, and *focal* listening with narrowed attention to the detail of sounds [Oliveros, 2022, pp. 30, 38]. Deep listening involves balancing both modes as a means to connect with all that there is: 'expanding to the whole field of sound while finding focus' [Oliveros, 2022, p. 36].

For LaBelle, this inclusive quality of deep listening underscores 'a relation to sound and its inherent situatedness through the lens of time'. For if we listen deeply and actively, then we are attuned not only to the whole field of sound but also to our perceptual behaviour as we do so, a 'listening to my listening' [LaBelle, 2015, p. 159]:

> What one, then, listens to is not so much the space of listening, the ambient noise and the performative sound one is making, but the time of one's own listening: to attend to sound is to temporally live the passing of its sonorous flow, its repetition over the course of time, the unfurling of cycles of audibility, daily, seasonally, and other.'

LaBelle explicitly connects this 'listening to listening' with the work of Max Neuhaus and sound installations that - via their spatial design, emphasise the participatory role of the listener to place sounds in their own time [LaBelle, 2015, p. 158].

The 'phenomenological aesthetics of listening' [Kane, 2013, p. 81] that I associate with the work of Voegelin and Oliveros may be contrasted with the conceptual aesthetics propounded by Kim-Cohen [2009], who advocates for a 'non-cochlear' sound art, as utterly distinct from music and aligned instead with conceptual art.

For Kim-Cohen, sound art should inhabit the 'extramusical', investigating context, sociality, history, institutions and cultural relationships [Kane, 2013, p. 84]. I highlight this disagreement to demonstrate that different modes or aesthetics of listening may be inscribed in sonic artworks. I work to foreground a phenomenological aesthetic of listening in the installations created in this PhD research. However, departing from Voegelin, I do not seek to bracket out the associative qualities of sound. Instead, I acknowledge the role of all sensory stimuli, conceptual and symbolic qualities, in shaping our understanding and perception of sound.

2.1.5 *Absence of Listener Perspectives*

> 'Ever since sonic artworks have incorporated sound in contemporary art museums, scholars have either looked at the materiality of these sounds, or sought to read them conceptually. Consequently, little is known about the ways in which museum visitors actually listen to sounding artworks.'
> Semmerling [2018, para. 1].

The perspectives of ordinary listeners in their encounters with sonic artworks are largely absent from sound art discourses. The experience of listening to sonic artworks is documented by artists and academics [Davis, 2010, Ouzounian, 2006, Voegelin, 2010], but audience perspectives are missing. In recent years, authors have noted the absence of empirical, qualitative study of sound art experience. Semmerling [2018, para. 27] states that 'a lot remains to be learned through empirical investigations of visitors' actual listening experiences.' Keylin [2020, p. 113] notes that ethnographic observations and interviews with audiences could address the question of how listeners act upon the affordances of participatory sonic artworks.

It would surely be beneficial for both curators and artists to understand how visitors experience the sounding content of artworks and how that experience is shaped by curatorial aspects. However, research that addresses the practical question of what artists *do* and how that might impact the experience of audiences is largely absent from sonic arts discourse. For example, the perspectives of artists engaged in situated sonic practices are well documented in collections such as the *Site of Sound* series [LaBelle and Martinho, 2011, LaBelle and Roden, 1999], but these writings tend to focus on artists' conceptual concerns and descriptions of completed work rather than the practicalities of method, tools and reception. For

example, Christina Kubisch introduces *Uber die Stille* by contemplating the notion of silence before describing the material elements that comprise the installation, the choice of sound materials and its site of installation [Kubisch, 1999, pp. 31-35]. By contrast, Barrett and Sevaldson [2011, p. 235] make a clear link between method and reception in their account of the *Barely* installation. The use of quiet sound materials pitched on the cusp of audibility at the 'experienced threshold' are designed to sensitise and engage the hearing of audience members. Their article reports on the creative processes that led to the final installation and the observed impact of different sound materials on audience attention. Attentive listening of audiences correlated with the level of complexity and change in the sound materials, noting that 'a sine tone did little to change the state of the listener whereas a soundscape of tiny details resulted in an attentive, lengthy stay'.

The relationship between method and reception is more thoroughly explored in the technology-oriented fields of interactive art and sonic interaction design, where user studies are conducted to understand how aspects of design impact reception. Researchers have explored audience interaction with sound installations via observation, video recordings and interviews with participants [Franinovic and Visell, 2007, Fritsch et al., 2014]. Studies in these fields seek to articulate aspects of design that support active engagement with an artwork; for example, to understand how an 'unwitting' bystander might become a 'witting' participant [Sheridan and Bryan-Kinns, 2008]. Section 2.5 introduces the study of interactive art experience in greater detail.

2.2 THE SOUND INSTALLATION IN HCI

Where sound installations are described in HCI literature, usually it is not in the context of sound art practice, though notable exceptions are described in Bowers and Haas [2014], Franinovic and Salter [2013] and Ryding et al. [2023]. Installations described in HCI contexts tend to be interactive in the sense that an internal mechanism or system enables the sonic composition to be modified by either an environmental factor (dynamic-passive interaction) or human behaviour (dynamic-interactive interaction) [Cornock and Edmonds, 1973, p. 13].

Broadly, sound installations are found in arts-led corners of the HCI literature. Through the following section (2.2.1), I describe HCI's 'turn to the arts' [Jacobs et al., 2015] and introduce a series of research sub-fields where examples of installation artwork may be found: interactive art, performance-led research, digital

musical instrument design and sonic interaction design. My intention here is not to review the work of these communities in detail, but to precisely situate the work of this PhD, which draws on and contributes to these subsets of arts-led HCI research approaches.

2.2.1 *Arts-Led HCI Research*

> Rather than defining a discipline independent of established critical perspectives, with its own theoretical cores and concerns... the alternative is that technology becomes a lens through which to understand being human in a changing world. These more universal aspirations point to the centrality of HCI, not as another discipline (or sub-discipline of computer science), but rather as a context in which to realise our identity through creativity and experience, our social relations in the modern cultural setting, and our embodiment as a fragile component of technosystems. HCI is not about static knowledge, but ways of deploying and engaging with knowledge in a technological setting.
> Blackwell [2015, p. 511]

As the above quotation sets out, HCI might be defined not so much as a coherent subject in and of itself but as an inter-discipline [Blackwell, 2015, p. 511]. For the arts, HCI provides a lens on technology and its role within interaction, illuminating possibilities for creating 'new and meaningful blended experiences' [Sturdee et al., 2021, p. 1]. HCI's 'turn to the arts' [Jacobs et al., 2015] in the early 2000s might be viewed within a wider shift to designing and studying the impact of systems in public contexts of use (see Section 2.5.1). Specifically, it has entailed an examination of artworks and their technologies, strategies that artists use to engage audiences and the experiences of interacting with the artwork. Broadly, these approaches might be subsumed under the heading of 'arts-led HCI' [Sullivan et al., 2023, pp. 1385-1386], and it is in this context that sound installations are found in HCI (and HCI-adjacent) literature.

The specific areas of research that intersect with sound installation matters are articulated below as separate and distinct subfields to highlight particular research foci relevant to this PhD research; note, however, that in practice, there is much cross-pollination.

2.2.1.1 *Interactive Art*

Interactive art is a field of practice-based research exploring emerging technologies, new forms of interaction, media art and evaluation strategies. Arguably, it is defined in (and by) the work of Ernest Edmonds, Lisa Candy (e.g. [Candy and Edmonds, 2002] and their research groups. Some of the most influential artworks in this paradigm are interactive installations outputting sound and image concurrently, such as Sidney Fels' *Iamascope* [Fels, 2000] and David Rokeby's *Very Nervous System*[3] [Muller, 2016]. There are numerous synergies between interactive art research (IAR) and HCI. Notably in terms of the interactive technologies employed and the objectives guiding evaluation [Bengler, 2015, pp. 74-77]. Interactive art research prioritises both art practice and evaluation in public exhibition contexts. Audience perspectives are considered key to understanding and negotiating the complexities of working with interactive technologies [Candy, 2014, p. 27]. The methodologies of interactive art research have inspired the design of studies presented in this PhD and are reviewed in more detail in Section 2.5.2.

2.2.1.2 *Performance-Led Research*

Performance-led research explores the development of interactive technologies in live performative contexts. Major research themes include mixed-reality games and theatre experiences in public spaces [Benford et al., 2006, 2013] and matters of movement-based and whole-body interaction, such as in dance performance [Fdili Alaoui, 2019, Sullivan et al., 2023] and installation art [Loke et al., 2012, Nam and Nitsche, 2014]. Performance-led research explores how artistry and interaction design unfold in real-life production contexts (theatres, galleries, public space) and within teams of collaborators [Tholander et al., 2021], highlighting points of messiness, tension and negotiation. In this light, Fdili Alaoui [2019, p. 1204] suggests that HCI should 'make space for alternative discourses, with a different nature of insights, outside of typical problem-solving approaches and where knowledge comes authentically from the practice.' The emphasis on practice, exploring the messiness of making and experiencing work, is pertinent to my research. These aspects are put into practice throughout this PhD and defined in Chapter 3, where I articulate my methodological orientations to practice research (Section 3.3) and research in context (Section 3.3).

3 http://www.davidrokeby.com/vns.html

2.2.1.3 *New Interfaces for Musical Expression*

HCI methods are applied to the design and study of musical interaction [Holland et al., 2013, 2019] and digital musical instruments (DMIs) in the field of New Interfaces for Musical Expression (NIME) and its annual conference[4]. This field centres on the design of new musical interfaces, primarily DMIs and, to a lesser extent, interactive sound installations. Technical reports, demonstrations, and user evaluations presented in the scientific tradition are ubiquitous, but artistic practice-based methods also feature strongly [Bowers and Green, 2018, Green, 2014].

DMIs are conventionally defined as instruments consisting of conceptually separate control surfaces and sound generation units that are related to each other via mapping strategies [Miranda and Wanderley, 2006] (explored further in Section 2.2.2.1, below). Broadly, the sound installations presented at NIME follow this paradigm of system, which is discussed in Section 2.2.2.1. Increasingly, NIME also showcases musical systems that entwine materiality and computation, such as feedback instruments that harness the nonlinear acoustic properties [Eldridge et al., 2021, Magnusson et al., 2022, Mudd, 2019, 2023], designs that explicitly explore the theme of entanglement [Butt et al., 2025] and emphasise the social constitution of musical instruments [Waters, 2021]. While user studies are commonly employed to evaluate DMI designs or explore musical affordances, Morreale and De Angeli [2015, p. 51] note that studies of installations in a NIME context are often characterised by very little, if any, evaluation of the visitor's experience. This PhD research contributes to NIME research through the development of the installation technology described in Chapter 5, methodologies for articulating sonic experience in user studies and its focus on the material and social entanglements of design.

2.2.1.4 *Sonic Interaction Design*

Researchers in the HCI sub-field of Sonic Interaction Design (SID) have argued that an overemphasis on visual displays in computing constrains the development of interactive systems that could make more appropriate use of the auditory modality [Franinovic and Serafin, 2013, pp. vii-ix]. Consider 'auditory icons' [Gaver, 1993], for example, whereby sounds simply step in for visual signifiers to convey symbolic information. Like many sound artists and sound studies theorists, SID researchers are concerned with sound as an active acoustic medium, the

4 https://www.nime.org/

specific characteristics of which may be harnessed to 'enable novel phenomenological and social experiences with and through interactive technology' [Franinovic and Serafin, 2013, p. vii]. It is this emphasis on the particular material qualities of sound as a resource for design that is taken up in this PhD. SID is primarily concerned with design, not art, however. The sound installation as a spatial format is explored in this context, but often as a means to produce design insights into, for example, the effects of public and urban settings on sonic interaction design [Adhitya and Scott, 2018, Franinovic and Visell, 2007, Mushiba, 2018].

2.2.2 *Interactive Sound Installations*

To reiterate, it is predominantly interactive sound installations that are described within arts-led HCI discourse. The fields of interactive art and NIME research inherit from many traditions. Without wishing to make a simplistic distinction, it is worth highlighting key influences on their development from early computing, audio engineering, and HCI of the late twentieth century. These influences have led to widespread conceptions of interactivity as produced via mappings, which helps to explain the differences between sound installations described within HCI and sound art paradigms.

Like sound art, the development of interactive art was influenced by the emergence of participatory art forms throughout the twentieth century, such as Kaprow's 'Happenings' that invited the spectator to engage with the artwork as a co-creator (see Almenberg [2010]) for a comprehensive review). As the modern era of computing was dawning, Norbert [1954] theorised control in terms of communicative messages (acts of control) and the feedback gained in response (the effect of control). Cybernetic thought was a key influence on the genesis of interactive art. In 1968, Jack Burnham declared 'systems esthetics' to be the preeminent mode of contemporary artmaking [Burnham, 1968] and Roy Ascott that 'the art of our time tends towards the development of a cybernetic vision, in which feedback, dialogue and involvement in some creative interplay at deep levels of experience are paramount' [Ascott, 1968, p. 106].

Writing from a NIME perspective, McPherson et al. [2025] trace the contemporary prominence of mappings-based DMI design from Claude Shannon's information theory [Shannon, 1948], which was influential on early digital synthesis [Chowning, 2014, p. 7], through HCI research of the 1990s-early 2000s (HCI's 'second-wave') that coalesced around 'a central metaphor of the mind and com-

puter as coupled information processes' (p. 114). McPherson et al. [2025] also call attention to unidirectionally in mapping-based systems and trace the assumption of mapping as a 'directed flow of control data' (p. 112) to key engineering principles in modular audio synthesis, such as impedance bridging (pp. 113-114), which allows electrical circuits to be conceived as separate but connectable and freely reconfigurable modules [Teboul, 2024, p. 26].

2.2.2.1 *Mapping Sonic Interaction*

Conventionally, interactive sound installations utilise sensing technologies to detect various aspects of human activity and translate them into data. The system is programmed to interpret that data and generate an output via speakers or actuators [Bongers, 2002]. Interactive systems may be expressed in formulaic terms as *input (sensing) > mapping > output (sound synthesis) = sonic expression* [Franinovic and Salter, 2013, p. 41] or, diagrammatically, as a feedback loop whereby the sonic output is evaluated by human perception, forming intentions and actions that again produce input to the system [Wanderley and Depalle, 2004, p. 633].

In interactive sound installations, sensor data acquires symbolic meaning in the computer program, and a system of mappings determines the relationship between human action and auditory feedback. Magnusson [2009, p. 168] describes such tools as having 'such a high degree of symbolic pertinence that it becomes a system of knowledge and thinking in its own terms'. Indeed, interactive art tends to be conceptualised as a conversational exchange between human and artwork [Edmonds et al., 2009, Polaine, 2005, Schraffenberger and Heide, 2015, Stern, 2001].

Fraisse et al. [2021] present a comprehensive review of 195 installations that afford real-time interaction, and where sound is either the input or output modality. Reviewing interaction types, they find that 'embodied interaction is the most common (N = 94), followed by visitors' motion (N = 74) and visitors' sounds (N = 35)'. As is often the case in HCI literature, the meaning of 'embodied interaction' is unclear here and not defined by the paper. However, exploring installations included in the corpus, it seems that it refers to what Duarte et al. [2022, p. 7] articulates as *body tangibility*, 'the material aspect of our bodies in its physical interaction with tangible things available to us in the environment'.

The Fraisse et al. [2021] review shows that tangible interfaces are the most prevalent means of input to interactive sound installations before body movement. Where sound art installations may be quite narrowly defined as spatial sound fields explored through listening and body movement, interactive sound instal-

lations include room-sized, interactive musical systems (e.g. Frid et al. [2019]), sound-producing objects and sculptures. Arguably, they also foreground a digital perspective of sound as primarily manipulable 'in the box' by a computer system rather than coupled with the acoustic space in which it is output.

A key advantage of mapping is the possibility to re-imagine, toy with and subvert movement-space-sound relationships in ways that are usually not possible using just a speaker array (i.e. deploying the methods of sound art installation). For example, tracking the body at a macro scale, the installation *SonoFluo* explores indirection between bodily input and movements of swarming sound [Fehr and Erkut, 2015]. *Post-Truth and Beauty* by Tim Murray-Browne (2017) is a light and ambisonic installation that uses a camera to track head movement. As the listener changes their body position, they hear different parts of a spatial composition but never the whole thing. Conceptually, the piece is designed so that participants can never quite grasp what is going on and 'aims to create a sensory experience analogous to the ungraspable nature of 'truth' by presenting partial glimpses into an abstract world of light and sound' [Murray-Browne, 2012, para. 1].

In the ultrasonic installation developed through this PhD (described in Chapter 5), listeners explore auditory space with their movement. My installation affords exploration of sound distributed through the physical space of the gallery. In Yu Zhang's interactive installation, *A Heard Space*, the listener explores a virtual auditory space with their movement. Real-time data produced by a gyroscope mounted on headphones controls the individual's path through the virtual sonic environment. Interestingly, auditory space is not mapped onto the physical space of the installation but is generated in relation to the visitor's starting point [Zhang and Funk, 2024].

2.2.2.2 *Microinteraction*

Jensenius [2015, p. 16] notes that although there are some examples of 'intimate' control [Wessel and Wright, 2002] in DMI design, there is a strong focus on gesture-based controllers, which has emphasised the *macro* and large-scale potentials of sonic interaction. The availability of technologies, such as the Wii and Kinect, may be responsible for the predominance of interactive music/dance performances and installations that utilise full-body motion capture. By contrast, microinteraction is associated with bodily movement at a miniature scale, that is, very close to the boundary of what is controllable and perceptible [Jensenius, 2017, p. 428]. A number of art-focused projects have explored the creative potential of microinteraction

in the context of music and/or dance performance [Erdem et al., 2019, Jensenius, 2015, 2017, Martin et al., 2018] and installation art [Françoise et al., 2017, Gonzalez Sanchez et al., 2018]. These projects use either high-resolution motion capture systems [Jensenius, 2015, 2017], devices such as the Myo armband based on electromyography [Erdem et al., 2019, Françoise et al., 2017, Martin et al., 2018] or infrared distance sensors [Gonzalez Sanchez et al., 2018] to detect bodily activity on a micro scale.

Arguably, microinteraction is a quality of many sound art installations. Due to the emergent complexity of acoustic phenomena produced as a multi-channel composition sounds within a particular architecture, even very small bodily movements become coupled with perceptible sonic variation. Outlining the motivations for this PhD in Chapter 1, I drew on the Sine Wave Orchestra's *Stay* [Jo et al., 2005] as an example and proposed that by harnessing the acoustic entanglement of a listener with sound and augmenting the sound art paradigm of installation with new technology design, artworks might be created that afford detailed interaction on a micro scale.

I am inspired by microinteractive installations that are designed to sensitise a listener to the nuances of their movement and its relation to sonic feedback. Inverse mappings are also a prominent design theme here, with attributes associated with the magnitude of sound, such as amplitude and scale of auditory feedback, corresponding to moments of stillness. In the installation *Sverm-Resons*, sound only appears when audiences are standing still [Gonzalez Sanchez et al., 2018]. The installation *Still, moving* is designed to foreground kinesthetic awareness and heighten the perception of one's micro-movements. It adopts an adaptive mapping strategy that scales the sensitivity of the system dynamically according to the volume of muscle activity over a particular frame of time. Standing still gradually increases the system's sensitivity, 'eventually sonifying every slight muscle contraction'. The authors liken the effect of this adaptive mapping to a kind of auditory 'zoom' into the detail of the body's tiniest movements [Françoise et al., 2017, p. 5174].

2.2.3 *Human-Matter Interaction*

Writing from a SID perspective and extending the ideas of Dutch biologist and media theorist Arjen Mulder, Franinovic and Salter [2013, p. 42] argue that the phenomena of sound suggests an alternate, enactive definition of interaction as:

> '(1) a spatiotemporal-material process, (2) an act of poiesis or making that is an active process or formation, (3) situated, concrete, and embodied, (4) performative and emergent in that it constitutes itself in time through different agencies operating in tandem with each other, and (5) nonrepresentational (i.e., not reducible to an act of mimesis, imitation, or purely symbolic processing).'

Throughout this thesis, I will argue that the relational experience of sound in listening suggests an alternate model of interaction, in line with the above quotation, that might inspire the design of interactive sound installations without recourse to the mappings-based paradigm of interactivity. This move has some precedent in corners of NIME and HCI-related literature concerned with materiality and musical interaction.

In the paper 'Sound Design as Human Matter Interaction' Sha et al. [2013] describe sound design practices that blend computational techniques with the materiality of acoustic space. Nicolas Collins' installation piece *Pea Soup* exemplifies this approach. Here, 'a self-stabilizing network of analog circuitry nudges the pitch of audio feedback to a different resonant frequency every time the feedback starts to build', producing 'architectural melodies' that are influenced by any disturbances to air in the space [Collins, 2021, p. 168]. Further examples of technological assemblies that harness the complex and nonlinear properties of audio may be found in Di Scipio's ecosystemic interfaces [Di Scipio, 2003] and the extensive field of feedback musicianship and instrument design [Eldridge et al., 2021, Magnusson et al., 2022, Mudd, 2019, 2023]. Here, musical tools become the material of interaction and are viewed as sites for exploration rather than expression:

> 'The instrument is sounded experimentally, and the sounding results are not necessarily fully anticipated by the musician. The possibility of finding something unexpected becomes an important factor. The idiosyncratic particularities of the material are dwelled on rather than avoided.'
> Mudd [2019, pp. 128-129]

These practices produce instances of what Mudd [2019] refers to as 'material-oriented musical interaction' and what Sha et al. [2013] term 'human-matter interaction': rich interactive experiences in which human action is entangled with the sonic. For Sha et al. [2013], *human-matter interaction* entails a shift in attitude to consider the direct interaction of a human with a material medium as a site

of analogue computation. This implies thinking spatially or topologically about computation (p. 2017). There is no unidirectional, sequential processing, no 'non-grammatical' action (p. 2011) and a temporal immediacy compared with digital tools, with systems responsive to all human movement on all scales.

2.2.3.1 *Human-Sound Interaction*

The title proper of this thesis *Human-Sound Interaction* is intended to make an explicit link to the field of human-computer interaction and to 'human-matter interaction' [Sha et al., 2013]. Since choosing *Human-Sound Interaction* for this thesis, I have discovered its use in the title of Donato et al. [2020]. The authors' emphasis on human factors and 'direct, engaging, natural and embodied interaction with sound that takes into account one's abilities to perceive sound' (p. 2) also resonates with this PhD research.

Note that Chapter 5 reviews sonic artworks that directly relate to the design of the ultrasonic listening technology developed through this PhD research.

2.3 EXPERIENCE AS RELATIONAL

Etymologically, the word 'experience' entails an orientation toward life as lived and felt in all its richness and detail. It attempts to accommodate 'both the intensity of a moment of awe and the journey that is a lifetime' [Wright et al., 2008, p. 3]. This PhD takes a relational view of experience as emerging in the relationship between an individual and her environment, between subject and object. This relational account is grounded in pragmatist aesthetics as articulated by John Dewey, an American philosopher, psychologist and educational reformer working in the first part of the 20th century. Dewey is perhaps best known for his contributions to educational theory, where he argued that learning should be active, democratic, and rooted in real-life problem-solving rather than passive and mechanical memorisation [Dewey, 1916]. Dewey's book 'Art as Experience' [Dewey, 1934] is particularly relevant to this PhD research, in its argument that aesthetic experience arises in the interaction of a culturally and socially situated individual with the artwork and its wider environment.

2.3.1 *Pragmatist Aesthetics*

An analytical approach to aesthetics examines the qualities of an object embodied in the artefact itself as a result of its appearance, look and feel independent of its context and the people who interact with it [Shusterman, 2000, pp. 22-52]. By contrast, pragmatism views aesthetics as a particular form of experience arising from the interaction of the human, context, culture, and history [Dewey, 1925, p. 22]. It is not regarded as a property of the artefact or the observer in isolation. Instead, 'it emerges in the construction of relations between artefact and viewer, subject and object, user and tool' [Wright et al., 2008, p. 2].

Dewey's philosophy brings a relational and holistic approach to the understanding of experience, rejecting accounts that reduce it to private mental content. Influenced by Darwin and the theory of evolution, Dewey viewed organisms as agents in an ongoing transactional interaction with their environment, emphasising the reciprocal nature of these co-determining influences [Dewey, 1925, pp. 339-343]. Influenced by the work of Hegel, he emphasised the culturally determined nature of the human environment, with our experiences shaped by and unfolding through ongoing social interactions. Finally, influenced by the philosopher William James, Dewey adopted a 'radically empirical approach' in his work that acknowledges the relevance of personal experiences, with 'the full range of its dimensions, including felt and immediate qualities' [Candau and Schiphorst, 2020, p. 5]. Thus, a pragmatist account of experience is fundamentally relational and distributed, emerging in the interplay between a subject and their environment.

2.3.2 *Art as Experience*

Dewey makes an important distinction between *experience* and *having an experience*. By *having an experience*, he means a pattern of intensified experience that has a particular structure and is marked out as a whole against the general stream of our experience. That structure is described as having a temporal unfolding and distinct narrative arc with an endpoint and final resolution. The content of *experience* unfolding along this arc is described as 'a field within which diffuse structures can be delineated: an underlying background or surrounding horizon of tacit feeling, a pervasive quality that binds everything together that is experienced, and then potential articulations through shared and communicable symbols' [Candau and Schiphorst, 2020, p. 6] (paraphrasing Dewey [1934]).

Dewey also made an important distinction between physical *art objects*, such as paintings and statues, and the *work of art*, which he conceived as what engaging with the artefact actually 'does with and in experience' [Candau and Schiphorst, 2020, p. 6]. When we encounter an artwork, we have an experience. As a result of its form and substance, the artwork can 'enter into the experiences of others and enable them to have more intense and more fully rounded out experiences' [Dewey, 1934, p. 326].

Through the art object, Dewey proposed that the artist and their audience meet each other and that 'the work of art is complete only as it works in the experience of others' [Dewey, 1934, p. 114]. Thus, he draws a connection between the processes of creative making, the 'doing' and the experience of the work by others, the 'undergoing'. For Dewey, 'cycles of doing and undergoing in interaction with the environment characterise both the artistic creation and the reception of art' [Keylin, 2020, p. 102]. This notion influences the philosopher Alva Noe when he suggests that the artist is an 'experience engineer' [Noë, 2002, p. 5].

2.3.3 *Pre-Reflective Experience*

Importantly, a pragmatist philosophy does not 'force us to cast aside the insights of phenomenological approaches', it is complementary to them rather than in opposition [Keylin, 2020, p. 101]. Phenomenology, and particularly that of Merleau-Ponty [1945], is, arguably, the dominant philosophy with which the lived experience of sound art [Voegelin, 2010, 2021] and embodied interactions with technology are considered [Dourish, 2001, Svanæs, 2013]. Rejecting the Cartesian mind-body dualism, Merleau-Ponty emphasises the embodied character of lived experience; the body is the medium through which we engage with the world, but also inherently relational since it exists in constant interaction with the surrounding environment. Perception and meaning arise through this interplay between body and world [Merleau-Ponty, 1945].

Dewey also emphasises the importance of felt life to the pragmatic approach, arguing that sensation and emotion are the 'cement that holds experience together' [Wright et al., 2008, p. 2] (paraphrasing Dewey [1934]). His discussion of the immediate and qualitative dimensions of experience is in accord with Merleau-Ponty's conception of the 'pre-reflective' [Candau and Schiphorst, 2020, p. 7]. The notion of pre-reflective experience is grasped most readily when contrasted with reflective experience. If asked to describe the sensation of pain or what I was thinking about

a moment ago, I would need to reflect upon it and, therefore, take up a perspective that was removed, or separated, from the actual experience of the pain or thought [Gallagher and Zahavi, 2021]. By contrast, 'pre-reflective' refers to an awareness of the sensation that we have before we reflect on an experience. It describes the immediate and first-person 'given-ness' of experiential phenomena. 'Given-ness' here refers to the fact that whenever we feel an emotion or consciously perceive something, these experiences are 'given to us as our own' [Ciaunica, 2016, p. 422]. For Sartre, the pre-reflective dimension of experience and self-consciousness is not merely an accessory to the experience but 'constitutes the very mode of being of the experience' [Gallagher and Zahavi, 2021]. Section 3.5.3 of the next chapter introduces the micro-phenomenological interview technique [Petitmengin, 2006], a method for articulating the pre-reflective dimensions of lived experience.

2.3.4 *Pragmatism in HCI*

While Candau and Schiphorst [2020] argue that as a philosophy of *experience*, Dewey's pragmatism is underappreciated, it has become influential on HCI research, underpinning frameworks for experience-centred design [McCarthy and Wright, 2005, Wright et al., 2008], somaesthetic appreciation design [Höök et al., 2016] and materials experience [Giaccardi and Karana, 2015]. Dewey's ideas also inform interactive art research, where the artwork is seen to be incomplete in its material form (visual, auditory features and physical components). The audience 'completes' the work through their interaction with it [Candy, 2014, p. 13]. Sidestepping into the field of sound studies, Keylin [2021, pp. 105-113] argues that the relationship of listening and sound-making closely reflect cycles of 'doing' and 'undergoing', making Dewey's philosophy well-suited to a discussion of participation in sound art contexts.

2.4 EXPERIENCE AS MORE-THAN-HUMAN

Keylin [2020, p. 102] also describes pragmatism as a kind of middle way: 'an alternative to phenomenology's subject-centredness and new materialism's fascination with the objects'. As such, a pragmatist account of experience is relevant to third-wave *and* the proposed fourth-wave of HCI. The 'third-wave' of HCI that emerged in the early 2000s marked a shift from utilitarian uses of technology, aspects of usability and optimisation, toward a 'phenomenologically-situated' [Harrison et al.,

2007, pp. 5-21] focus on individual experiences embedded in the culturally and socially determined environments of everyday life [Bødker, 2006, pp. 1-2].

As technologies reach further into our lives and bodies, a cluster of posthuman and new materialist philosophies that Frauenberger [2019] subsumes under the umbrella of 'entanglement theories' have become pertinent to human-technology relations. These include actor-network theory [Latour, 2005], post-phenomenology [Ihde, 1990], object-oriented ontology [Harman, 2015] and agential realism [Barad, 2007], all of which emphasise that humans and their things are 'ontologically inseparable' [Introna, 2013, p. 33]. Broadly, these perspectives serve to 'decentre the human as the sole source of activity and to elevate the role of the non-human world from a passive backdrop to human activity to active contributors to relational action as it unfolds' [Frauenberger, 2019, p. 21].

Aligning with Homewood et al. [2021, p. 7], I use the term 'more-than-human' to refer to entanglement theories in general. For HCI, these theories redefine interaction as co-produced by entangled agencies, entail a shift from 'user-centred' to 'more-than-human' concerns in design [Homewood et al., 2021, pp. 2-4] and challenge the positivist epistemological basis of traditional HCI methods. How epistemological implications of more-than-human theories might be addressed in HCI is a topic of contemporary debate [Coskun et al., 2022, Yoo et al., 2023]. Of the many more-than-human perspectives and theories outlined in the previous paragraph, I find Barad's agential realism [Barad, 2007] particularly relevant to the notion of sound as a relational material that is co-produced by the act of listening. The epistemological implications of this philosophy are considered in the latter stages of this research, in Chapters 7 and 8.

2.4.1 *Agential Realism*

The radically relational ontology of feminist science scholar Karen Barad has been widely adopted by HCI practitioners and sound studies theorists. Agential realism is a total rejection of representationalism. For Barad, bounded entities do not exist independently of their relations, and so the primary ontological units of reality are not subjects and objects but *phenomena* that come to exist via *intra-actions* across *agential cuts* within human and material configurations [Barad, 2007].

Experiences with technology may be described as the result of specific agential cuts, which are co-produced in the moment of intra-action according to the meeting of a singular human with a particular material configuration. Equally, the

research methods and apparatuses that we employ to articulate those experiences, such as survey, body mapping, talk-aloud, experience sampling, or phenomenological interview, make particular *cuts*. Barad's notion of intra-action entails an entangled and distributed view of agencies that is useful for demarcating the interactivity afforded by sound art installations. Intra-action avoids situating agency in either the listener or the installation as an artefact and emphasises that it is negotiated and co-produced in their encounter.

2.4.2 *The Co-Production of Knowledge*

For Barad, discursive practices (i.e. concepts, meanings, and the way that they are acted on and circulated within cultures) are also 'ongoing material [re]configurings of the world. Discursive practices and material phenomena do not stand in a relationship of externality to each other; rather... matter and meaning are mutually articulated' [Barad, 2007, p.151-152]. Therefore, data or knowledge about particular phenomena is co-produced by the research apparatus, which we can broadly define as a 'material-discursive' assemblage [Barad, 2007, pp. 146-153]. This agential realist stance runs counter to the positivist assumption 'that experiments reveal the preexisting determinate nature of the entity being measured': the so-called 'commodity-fiction' of data [Gitelman, 2013, p. 165].

The co-production of knowledge by research methods is also addressed from a new materialist perspective in the work of Fox and Alldred [2015]. Drawing specifically on a Deleuzo-Guattarian ontology [Deleuze and Guattari, 1988], *assemblages* become the unit of analysis rather than human agents. This leads to a focus on 'the capacities for action, interaction, feeling and desire produced in bodies or groups of bodies by affective flows' that occur within relations (p. 402). Fox and Alldred [2015, p. 403] argue that if 'we see researcher and data (along with many other relations) as a 'research-assemblage' with its own affect economy, we begin to recognise research as a territorialisation that shapes the knowledge it produces according to the particular flows of affect produced by its methodology and methods'. Arguably, it would be flawed to subscribe to relational and new materialist ontologies to conceptualise interactions with technology without acknowledging these epistemological consequences: research is not a neutral event, and data is co-constituted by the research-assemblage. Fox and Alldred [2015, pp. 406-407] propose that the key objectives of new materialist research are to 'reveal relations,

affects and affect economies in assemblages', with an orientation towards 'what things do, rather than what they are'.

Returning to agential realism, Barad adopts Haraway's articulation of diffraction [Haraway, 1991], as the basis for an analysis method that is attuned to 'differences that our knowledge-making practices make and the effects they have on the world' [Barad, 2007, p.72]. Adopting diffraction as a metaphor for analysis entails an examination of interference patterns, i.e. *how* data is co-produced by the research apparatus. Mazzei frames this as a shift in qualitative methods that spreads thought in 'unpredictable patterns producing different knowledge' [Mazzei, 2014, p. 472]. Diffractive methodologies are explored in this thesis and reviewed more fully in Section 3.6.2 of the next chapter.

2.4.3 *The More-Than-Human Body*

More-than-human theories are commonly described as post- or non-anthropocentric, meaning that the human is no longer placed in the centre. This is not to deny the 'social construction of our knowledge about the world, but to emphasise that the world is no passive object in this process' [Frauenberger, 2019, p. 4]. In the context of Barad's agential realism, objectivity is a decidedly posthumanist notion arising amid the entanglement of the observer and the observed. A position that has been criticised by Calvert-Minor [2014, p. 136] as 'epistemologically untenable', arguing that it overlooks the ineradicable role of human communicative understanding as a prerequisite for rationality and objective knowledge. The author advocates for embodied objectivity as a means to interface between human subjectivity and the material world. This humanistic critique of agential realism provides a bridge - via the body - between more-than-human theories and experience-centred HCI research, drawing together human-centred and posthuman foci.

Homewood et al. [2021] articulate an emergent and very recent move toward consideration of 'more-than-human bodies' within HCI research, i.e. bodily perspectives that highlight the co-constitutive role of non-human aspects. This implies 'decentering' human subjectivities, a topic that Nicenboim et al. [2023] explore the enactment of in design research and HCI. Analysing a corpus of publications found in the ACM Digital Library[5] they identify several related practices, such as decentering human privilege to support cohabitation with multispecies (e.g. Biggs

5 ACM is the acronym used for the Association of Computing Machinery and its library of associated publications is found at https://dl.acm.org/

et al. [2021], Liu et al. [2018]), decentering the designers' perspective to account for more-than-human senses, such as the perspectives and agencies of objects (e.g. Akmal and Coulton [2020], Wakkary et al. [2017]), and decentering human intention and accounting for the vitality and agencies materials (e.g. Nordmoen et al. [2019], Stricklin and Nitsche [2020]). Wakkary's concept of 'designing-with' captures the relational disposition of such practices. 'Designing-with' is a perspective that acknowledges the agency of non-human factors and the interdependencies between humans and the broader ecosystem, recognising that outcomes of design arise from these relationships rather than from isolated human intentions [Wakkary, 2021, pp. 233-252].

In the context of somatic [Höök et al., 2016] and experience-centred design [Wright and McCarthy, 2022], consideration of the more-than-human body entails perhaps a more subtle shift toward a bodily understanding that is not wholly one's own, sensing and feeling one's entanglement with other nonhuman agencies. This shift is explored by Ryding et al. [2023] through the design of *LYDSPOR*, two sound installations and an app-based soundwalk for the city of Elsinore in Denmark. The result of soma design explorations, the project aims to 'allow people to feel and sense in their bodies certain narrative fragments of the history of the city' (p. 1), thereby 'extending bodily awareness through time and space' (p. 11). Other soma design projects that make a similar move towards the more-than-human body include Tsaknaki et al. [2021], where the authors articulate the sensations of a shape-changing wearable extending the body, and Kilic Afsar et al. [2023], which describes the development of a shape-changing corset deployed in operatic performance to enable audience members to experience somatic 'reminiscents' of the performer's vocalisation via haptic feedback, thereby creating 'a feeling of shared intercorporeal experience' (p. 1).

I highlight more-than-human theories and particularly these extended conceptions of the body, as they provide a theoretical framework that resonates with relational theories of sounding and listening. These are described in Section 7.2 and are drawn into the data analysis in that chapter.

2.5 THE STUDY OF INTERACTIVE ART EXPERIENCE

The following section focuses on work in the domain of interactive art and video-based studies of conduct arising around artworks and museum exhibits. Both fields emphasise the importance of understanding how ordinary visitors encounter

artworks in public art contexts. They do so via qualitative methodologies, including observation, survey and interview, and their methods inform studies conducted in this PhD. However, the perceptual and embodied character of listening is particular to this research, and the challenges of eliciting sonic experience along with a review of existing approaches in included in Section 2.5.4.

2.5.1 *Research In Context*

In the fields of HCI and Interactive Art, it is widely acknowledged that a person's experience of a technology is influenced by its context of use [Blomberg et al., 2017, Mackay and Fayard, 1997]. Hutchins [1995] notion of 'cognition in the wild' has been influential on HCI studies [Hollan et al., 2000] and emphasises that the analysis of cognition in real settings would be different to experimental settings. Ssozi-Mugarura et al. [2016] express deep discomfort with the term 'in the wild' from an African perspective due to its colonial connotations. Instead, we might simply refer to *research in context* as a means to signal that a technology is being studied in an appropriate and authentic real-world setting.

Benford et al. [2013, p. 6] emphasise the importance of deploying cultural experiences in bona fide cultural venues such as galleries, festivals or theatres where they are experienced as cultural artefacts rather than lab prototypes and as genuinely belonging to the cultural setting. It is for this reason that interactive art researchers seek to - wherever possible - conduct studies in locations appropriate to the art experience, such as galleries, museums and performance spaces. Candy notes, however, that these kinds of public art environments are 'complex and multi-layered and, therefore, not easy to control' [Candy and Ferguson, 2014, p. 3]. Bengler and Bryan-Kinns [2014, p. 44] note several practical issues that the researcher has to attend to when conducting studies in public art contexts, such as spatial constraints, complying with institutional regulations, ethics and health and safety.

Additionally, participants tend to behave differently if they know their behaviours are under scrutiny, recorded or observed by a researcher. Indeed, Costello et al. [2005] found that visitors to an interactive art exhibit behaved differently under lab-based conditions compared with the general public encountering the same artwork in the context of an exhibition space. Knowingly under study conditions, 'the participants stayed longer, did more and were more careful that they had activated all the aspects of the artwork' (p. 5).

2.5.2 *Interactive Art Evaluation*

The field of interactive art research (IAR) is practice-based, and the creation of artefacts is considered key to understanding and negotiating the complexities of working with interactive technologies [Candy, 2014, p. 27]. However, given the role of the audience in *completing* the artwork, researchers are equally concerned with experience, in particular how the audience interacts with the artwork and the factors that might influence engagement [Edmonds, 2014, pp. 14-15]. IAR considers evaluation key to the technical improvement of systems and to understanding and strengthening audience engagement. The criteria for evaluation could focus on the artist's intention for how the audience should behave or experience the work in a particular physical environment [Bengler, 2015, Candy, 2012]. In interactive art research, experience is understood simply as *what takes place*; pre-reflective aspects of experience are not probed by studies.

Interactive art evaluation uses methods drawn from HCI, ethnography and social science. Studies typically take a multimethod approach, in which multiple qualitative methods are combined to form a detailed picture of experience and engagement. These might include direct observations in the art context, interviews and workshops, whereby groups are invited to discuss the artwork shortly after experiencing it. Video-cued recall has been widely adopted by interactive art researchers. Video-cued recall is a method for collecting detailed verbal data relating to a participant's interaction after it has happened. The aim is to help the subject to re-experience precisely what went on for them during their experience by replaying a recording of the interaction. It has proved useful for gaining insights into the situated experience of art and how that experience is constructed by the audience [Alarcón-Díaz et al., 2014, Bilda et al., 2006, 2007, Costello et al., 2005, Muller et al., 2006].

2.5.3 *Ethnomethodological Studies*

Pioneered by Harold Garfinkel in the 1960s [Garfinkel, 1967], ethnomethodology examines how social order is constructed and maintained through everyday actions and interactions. The Work, Interaction and Technology (WIT) Group refers to a group of researchers based at King's College London in the early 2000s. Taking an ethnomethodological approach, they conducted video-based observational studies of human interactions around technologies in public contexts. The group

is responsible for influential studies of the London Underground control rooms, looking at tacit work practices and task coordination around technologies [Heath and Luff, 1991, 1992]. Of particular relevance to this research is the group's video-based field studies of visitor interactions with and around artworks and museum exhibits. Some of these studies focused on traditional artworks or historical exhibits [Heath and Vom Lehn, 2004, Vom Lehn, 2006, Vom Lehn and Heath, 2016], others examined visitor encounters with interactive exhibits [Heath and Vom Lehn, 2008, Heath et al., 2005], a multi-media installation [Heath et al., 2002], Personal Digital Assistants (PDAs) and touchscreen information kiosks [Vom Lehn and Heath, 2005].

Each of these studies explores the ways that experience emerges 'in and through social interaction... [and] how people, in collaboration with others, reflexively constitute the sense and significance of objects and artefacts' [Heath et al., 2002, p. 11]. Visitors to museums and galleries are often in a party with friends and family, and share the space with other visitors, displaying 'an extraordinary sensitivity to the conduct and experience of others' [Heath et al., 2002, p. 15]. Indeed, a key finding that persists across the different studies conducted by the WIT group in museums and galleries is how encounters with, and experience of, museum and art exhibits emerges 'in and through' interaction between people within 'perceptual range of the event' [Goffman, 1981, p. 2], i.e. not just between visitors who arrived together, but also with other people 'who just happen to be within the same space' [Vom Lehn et al., 2001, p. 190].

A 2002 paper examining visitor interactions with a mixed-media installation called *Deus Oculi*, Heath et al. [2002] found that co-visitors subtly 'configure' each other's engagement with the installation. This may be via vocal interaction or bodily gestures, or in more subtle ways. The authors suggest that the ways visitors move around, orient to, glance at and comment upon the installation may encourage others in the same space to notice something of interest that might otherwise have been ignored (p. 20). The installation has a role to play here, in that it allows visitors to make sense of the conduct of others. Their behaviours become 'sensible' by virtue of their relationship to the installation (p. 29). Heath et al. [2002] characterise the social mileu around the installation as an ecology that emerges moment by moment in selective ways according to the conduct of people within perceptual range.

2.5.4 *Eliciting Sonic Experience*

Sound artists and installation artists, in particular, explore the materiality of sound in their work, which Cox [2018, p. 14] claims, is fundamentally nonrepresentational: 'How does one talk about such work, which has no fixed duration, is site-specific and sculptural, and is fundamentally concerned with sound as a physical, intensive force?'. This might account for the lack of phenomenological studies focused on listening and the public's experience of sound art, described earlier in this Chapter in Section 2.1.5.

A key contribution of this PhD thesis lies in discovering the most effective research methods for eliciting the structure of audience experience. Concurrent, think-aloud reporting methods would not be suitable in this context for obvious reasons: talking about listening would disrupt the activity of listening. Furthermore, think-aloud methods are discouraged as an evaluation method for musical interactions more broadly due to the cognitive load and conflict of mental processes [O'Modhrain, 2011, Stowell et al., 2009].

Formal approaches that seek to understand the listening experience of audiences to sound art are few in number. Cabrera took a controlled lab-based approach to explore the emotional response of listeners to resonant sound art via listening tests [Cabrera, 1997]. To support the development of new compositional approaches using the icosahedral loudspeaker (IKO), Wendt et al. [2017] conducted listening experiments to provide evidence for a common perception of spatial phenomena produced by the IKO.

The retrospective reporting of listening experiences has some precedent. Altavilla developed the Sonic Incident technique [Altavilla, 2018, Caramiaux et al., 2015] for use by sonic interaction design researchers, which entails 'retro-active listening': the act of describing a past listening experience. Altavilla [2018, pp. 148-151] suggests this method as a foundation for investigating the embodied and kinaesthetic dimensions of listening by designers who wish to delve into the phenomenological, subjective aspects of a user's sonic experience. Petitmengin and Bitbol [2009] use the explication interview technique to recall past listening and to describe the pre-reflective part of experience with precision. This enables the authors to identify experiential structures relating to listening attention.

2.6 CONCLUSION

This chapter has introduced the key practices and concepts to which this PhD thesis relates: spatial and site-specific installations in the sound art tradition, the study of (more-than-)human experience. Necessarily, this chapter has fractured these concerns into discrete sections. Rather than recapitulating them in a linear fashion, I wish to highlight connections and entangled concerns that cut across the content presented in this chapter, thereby underscoring the cross-disciplinary nature of this research.

First, I perceive a strong connection between the site-specific practices of sound artists, who enter into a dialogue with and explore the materiality of sound (Section 2.1.3) and more-than-human design practitioners who design-with material agencies, thereby decentering human agency in the process (Section 2.4.3). Second, I would argue that in certain circumstances, sound art installations produce examples of human-matter interaction, as described in Section 2.2.3. I introduced the concept of microinteraction within the context of interactive systems that afford perceptual change to audio output in response to bodily movement at a very small scale. Due to the direct human-sound engagement afforded by sound art installations and instances of human-matter interaction, these systems are responsive to human movement on all scales, including the micro.

I have presented more-than-human theories in relation to design research and HCI in this chapter, but they also underscore the material-oriented musical practices described in Section 2.2.3 and feature prominently within sound art discourse. As will be explored later in this PhD (Chapter 7), the case of listening is ripe for exploring the *more-than-human body* without displacing human perspectives.

For clarity and legibility, reviews of art practice and interaction design have been presented separately from the frameworks and study of experience. This thesis explores their interrelation: how design shapes experience and how experience informs design. The act of writing forces separation and makes a cut when, really, they are two sides of the same coin. Dewey connects the processes of making, the 'doing' and the experience of the work by others, the 'undergoing', and characterises both the artistic creation and reception of art as cycles of doing and undergoing in interaction with the environment [Dewey, 1934, Keylin, 2020]. These interconnections underscore the relational focus of this thesis.

Finally, this chapter described gaps in the literature regarding the practical details of making sound art installations and the articulation of listening experiences

by audience members (Section 2.1.5), both of which are explored by this thesis. In the next chapter, I will describe the methodologies and approaches used to address these aspects.

3

METHODOLOGY

> Rather than simply taking the methodologies of HCI to music, we should be mindful to bring the awareness of embodied experience and the richness of musical experiences to HCI and use this to problematise areas where we see naïve positivism. This is not to undermine the methodologies of HCI but to enrich them.
>
> Tanaka and Parkinson [2018, p. 173]

The work of this PhD is interdisciplinary, enacted across and between [Lury et al., 2018] the disciplines of sonic arts and human-computer interaction (HCI). The activity of listening is perceptual and cannot be observed. To elicit data that is truly reflective of a listener's experience requires a careful consideration of research methodology. Audience perspectives and studies of listening experience are largely absent from sonic art discourses. By contrast, the field of HCI is replete with methodological approaches for articulating user experiences and perspectives. HCI methodologies are employed in this thesis to examine the rich, embodied and entangled experience of listening to sound installation art. The interactive experience (without sensors) afforded by installations in the sound art tradition is proposed as a phenomenon of interest to design and HCI. Echoing the Tanaka and Parkinson [2018] quote that opens this chapter, sound art practices are also positioned as a means to *problematise* and *enrich* the methodologies of HCI. The interdisciplinarity enacted in this thesis is, therefore, not a simple borrowing. By drawing together differing fields of practice, interdisciplinary knowledge 'emerges through interferences between disciplines and between disciplines and other forms of knowledge' [Lury et al., 2018].

In this chapter, I map out the methodological detail of this interdisciplinary terrain. I begin by situating myself in the research, articulating the epistemic positions and assumptions in this thesis that guide methodological choices (3.1) before relating the research topic to my own past experiences, interests and embodiment (3.2). Research activity in this PhD is exercised through artistic practice (3.3) and four

participant studies, each examining particular relational forces in the design and experience of a sound installation (3.4). In the latter sections of this chapter, I describe key data collection (3.5) and analysis methodologies (3.6), including survey (3.5.1), micro-phenomenological interview (3.5.3), thematic (3.6.1) and diffractive analysis (3.6.2), before considering research ethics (3.7) and terminology (3.8).

3.1 EPISTEMIC POSITIONS

> Critical thinking means that you can, so to speak, see your glasses. You can look at the world, or you can back up and look at the framework of concepts and assumptions and practices *through* which you look at the world.
> Agre [2000]

In the following section, I wish to articulate my epistemic positions, that is, the particular standpoints and perspectives that I take concerning knowledge production in this thesis. In the words of Philip Agre as per the above quotation, this is an attempt to *see my own glasses*. My use of the term *epistemic position* is deliberate, rooted as it is in feminist perspectives, which - like the sound installation - emphasises the embodied and situated character of knowledge. In the following text, I articulate my epistemic position as pragmatic (3.1.1), aligning with the phenomena of listening and installation practices to foreground the production of subjective and embodied (3.1.2), situated and partial knowledges (3.1.3).

3.1.1 *Pragmatic Epistemology*

On a macro scale, the epistemic approach taken in this PhD may be described as aligning with the pragmatic paradigm. Pragmatic research does not fall neatly into any of the dominant three paradigms of positivist, interpretivist or critical research, but instead borrows elements from each according to the particular needs of the research. Briefly, positivist research is associated with scientific inquiry and assumes that experimental findings may be quantified and generalised across contexts. Critical research is associated with political, social and economic dynamics (e.g. ethnomethodology and action research) and treats research as an act of construction rather than discovery [Kivunja and Kuyini, 2017]. This PhD research is largely interpretivist, focusing on the subjective world of human experience and employing qualitative research methods to do so. However, it does so in the con-

text of HCI, where the design and dissemination of research studies are shaped by its positivist roots. These disciplinary forces and expectations are perpetuated through peer review and publication standards and inevitably shape epistemological aspects of this research to some extent.

Methods are chosen that are best suited to shed light on the actual behaviours and experiences of making and listening to sound installations. Over the course of the PhD, methodological approaches are refined as I come to better understand the phenomenon; what the installation is and does, what listening entails and how it feels. I find Mol [2008]'s notion of 'logic' useful as a means to describe the rational correspondence of installation phenomena to the research methodology that I am seeking:

> I am after the rationality, or rather the rationale, of the practices I am studying. Here the term 'logic' helps. It asks for something that one might also call a style. It invites the exploration of what it is appropriate or logical to do in some site or situation and what is not. It seeks a local, fragile and yet pertinent coherence.
> [Mol, 2008, p. 8]

While Chapter 7 *explicitly* considers the relationship of epistemology to sound-based art practice and the specific design of the ultrasonic installation described in Chapter 5 installation phenomena, that same logic is *implicit* throughout the PhD. In the following subsections, I will describe key aspects of installations (in the sound art tradition) that inform the nature and scope of knowledge production in this thesis.

3.1.2 *Subjective, Experiential and Embodied Knowledge*

Sound installations are experienced through active listening and tend to address individual rather than collective experience. The artwork manifests in the listener's perception, according to their particular behaviours and dispositions. Seeking epistemic coherence with this paradigm, this PhD research seeks the articulation of subjective, experiential and embodied knowledge. It is interpretivist since its central endeavour is to understand the subjective world of human experience. It focuses on personal experiences, valuing the depth of individual meaning and rich description of perceptions, emotions and thought processes while also acknowledging that meaning is embedded in social and material contexts.

Listening to and interacting with a sound installation entails moving the body to explore its spatiality. Listening is an embodied act. This PhD, therefore, takes an embodied view of cognition: knowledge and understanding are rooted in the body and in sensory experience, not just in abstract thought. A key challenge will be finding methods that help a listener to articulate embodied and experiential knowledge that is tacit, refusing 'every explanatory gaze' [Borgdorff et al., 2011, p. 97] or pre-linguistic, to do with sensory impression before reflective thought.

Each of the research studies undertaken during this PhD is human-centred, employing qualitative methods including observation, survey and interview. Indeed, even in Chapters 7 and 8, which consider the influence of nonhuman agencies, the focus is still on human perspectives while acknowledging that we share the stage with other things.

3.1.3 *Situated Knowledge*

> I am arguing for politics and epistemologies of location, positioning and situating, where partiality and not universality is the condition of being heard to make rational knowledge claims.
> Haraway [1988, p. 589]

The experience of an installation is contingent on the listener's embodied position and spatial orientation to it. In the sound art tradition, installations are enmeshed with the place in which they are sited and the listener is enveloped by a spatial composition. Such installations can never be heard in totality or from a distant perspective, only from within. Listenings are partial and situated, intimately contingent on listener behaviour and their entanglement with the installation. I believe that sound installations make our partial and situated knowing of the world more discernible or *tangible*. I perceive a strong connection between the installation experience and Haraway's feminist view of knowledge as always partial and incomplete. She posits that neutral and objective positions in relation to knowledge production, i.e. the 'view from nowhere' commonly associated with the positivist paradigm, is a fallacy, a *God-trick* [Haraway, 1988, p. 581].

Seeking a pragmatic alignment between the phenomenon of sound installation and epistemology - 'what is appropriate or logical' [Mol, 2008, p. 8] - I take a situated view of knowledge production in this PhD. As a consequence, the subjective accounts of experience that are produced through qualitative research activities are co-produced in relation to the social, material and temporal context. There-

fore, I do not claim the generalisability of knowledge to wider populations, other sound installations or even to the same installation experience occurring within a different contextual frame.

For Haraway [1988, p. 581], rational knowledge claims are those that are located in relation to contexts, social positions and nonhuman agencies; 'feminist objectivity means quite simply situated knowledges'. I attempt to practice feminist objectivity in this thesis by attending to the power relations and politics of the research context along with my emotional investment and entanglement with the subject matter (Section 3.2) to yield more accountable outcomes [Lorenz-Meyer, 2004]. Additionally, I attempt feminist objectivity by asking of installation practices: *how does this work?* technically, socially and psychically [Haraway, 1988, p. 583]; how does the knowledge come about? How does it relate to the situated context, to the methods by which it has been produced? This relational epistemology has come into focus over the course of the research and is a key influence on the design research in Chapters 7 and 8.

3.2 RESEARCHER POSITIONALITY

I am a white, female and able-bodied postgraduate student, educated within a Western epistemic context. My choice of topic and philosophical and critical stance are undoubtedly mediated by my lived experience. In this statement, I will focus on two aspects of my identity that, I believe, are pertinent to this project: 1. embodied understanding of musical interaction accumulated through decades of cello playing, and 2. my interdisciplinary position at the 'hyphen of insider-outsider' [Kanuha, 2000, p. 443].

As already stated, this research is motivated by the experience of listening to sound installations that afford intimate, embodied interaction with sonic phenomena. I am aware that the research privileges particular modes of embodied interaction that are, ordinarily, valued in musical instrument design. Values such as direct control on a micro scale, subtlety, detail and nuance. I believe that my sensitivity to certain embodied modes of listening and understanding of musical interaction (even in this sound installation context) stems from my experience as a cellist.

I began learning to play the instrument when I was nine years old and invested considerable hours through my teenage and undergraduate years in the practice room. The work of practising with the cello entails close attention to the minutiae of embodied sensations in relation to the quality of sound that they produce.

Hours of attentive practice might be spent, for example, attending to micro adjustments of posture, bow hold or the shape, pressure and quality of movement as the left-hand makes a shift up the fingerboard. The physical size and shape of the cello and its close position to the musician's body as they play - resting on the chest, the fingerboard and pegs curling around the neck - mean that you feel its vibration and materiality up close. Listening is as bodily as it is cochlear, a sensation wonderfully characterised in this quotation by Ingold:

> Sitting with the instrument between my knees and its endpin piercing the floor, I have become the equivalent of a centaur, with human arms and head, a trunk of wood and strings, and an endpin for a leg. Body and instrument are tightly conjoined into an anatomical unity. Yet in the moment I begin to play, something else happens. The instrument itself seems to explode into its constituent materials – of wood, varnish, metallic strings, bow hair, rosin and resonant air. Nor is it only the instrument that explodes. I do too! I am no longer a body with mouth, hands, arms and ears; rather my entire body, in its movements and sensibilities, becomes mouth, hand, arm or ear. I am mouth-body-becoming (breathing), hand-body-becoming (fingering), arm-body-becoming (bowing) and ear-body-becoming (listening). Ingold [2020, p. 214]

Although I no longer dedicate so much time to cello playing, I believe that experience resides within my body as tacit knowledge and continues to inform my understanding of embodied listening.

It also feels pertinent to position myself in relation to the disciplines of sound art and HCI. Berger [2015, p. 219] argues that 'reflexivity in qualitative research is affected by whether the researcher is part of the researched and shares the participants' experience'. As described in Section 1.1, I arrived at this PhD with an academic and professional background in music and immediately following the completion of a master's degree in Sonic Arts. I had begun coding and working with interactive media, but never in the disciplinary context of computer science or HCI. It is tempting to describe my position and membership as an insider to sonic arts practice and an outsider to HCI, but this would be an oversimplification. As Dwyer and Buckle [2009, p. 60] note, 'holding membership in a group does not denote complete sameness within that group. Likewise, not being a member of a group does not denote complete difference'. I identify with the more complex and dialectical position that is 'researching at the hyphen of insider-outsider' [Kanuha,

2000, p. 443]. The hyphen here implies a space in-between, a space of ambiguity, conjunction and disjunction [Dwyer and Buckle, 2009].

The primary impetus for the design of sound installations in this thesis is interaction quality, striving for this intimate felt quality, which has been described so many times already. However, perhaps due to my background as a sound artist and composer, matters of musical aesthetic and meaning are valued and seen to be of keen significance to the experience of interaction.

I intend that the participants in my research studies are what might crudely be described as the target audience for a sound installation artwork; listeners who choose to engage with this kind of work, often sound artists themselves. I, myself, am a member of that community and share a frame of reference concerning the history, traditions and values of sound art practice. But this relationship is not without tension; I am also the artist and have created the work that I am then querying them about. I do so from my position within an electrical engineering and computer science department, employing methods that would not ordinarily be employed within sound art discourses. I have always felt somewhat of an outsider within my department, and even after five years working in this context, I feel my disciplinary *difference* quite keenly. At times, this has felt like a negative tension, but I now perceive the interdisciplinary position of this PhD to be productive.

3.3 PRACTICE RESEARCH

Although my research is arts-led, it is not 'practice-based research', which would conventionally be an outcome of fine art, sound art, or music PhDs. As an EPSRC[1]-funded student in the Media and Arts Technology programme[2], this research is examined from a STEM perspective, and its presentation is mediated by conventions associated with the dissemination of HCI and interaction design research, which - though richly interdisciplinary fields - are grounded in scientific enquiry. Therefore, the two sound installation artworks created through this research are not submitted for examination as part of this PhD's contribution to knowledge.

Nevertheless, considerable practical work was involved in their making, and throughout this project, there is a commitment to the idea that knowledge is created in and through the practice of making art, in and through listening experi-

1 Engineering and Physical Sciences Research Council (EPSRC) https://www.ukri.org/councils/epsrc/

2 https://mat.qmul.ac.uk/

ences. This stance is influenced by epistemological discussions in related fields. In sound studies, the ethnomusicologist Steven Feld coined the term 'acoustemology' to describe a 'knowing with and knowing through the audible' [Feld, 2015].

Throughout the PhD, central research questions are explored through the practice of developing the ultrasonic installation technology (first described in Chapter 5) and working with its particular relational quirks and affordances to create two sound installations *Being With The Waves* and *Sonographies*. These installations are conceived both as artworks and research probes, deployed in participant studies to elicit and articulate entangled listening experiences. The practices of creating those installations are, therefore, entangled with the study of their experience. Practice does have an important methodological and epistemological role in this research.

How, exactly, the practical work of this PhD should be described has been a point of ongoing thought and negotiation. For a period, I characterised the design and making-led work involved in this PhD as Research through Practice (RtP) [Fdili Alaoui, 2019]: drawing together the methodology of Research through Design (RtD) with artistic practice. My rationale was that the technical work of this PhD falls within the remit of interaction design, but 'practice' captures the artistic impetus and development of the installation over many years. However, I realise now that this choice was guided by institutional expectations and, like many of the interviewed researchers in [Bulley and Sahin, 2021], I share a weariness regarding discussions of terminology. Instead, I welcome the simple, umbrella term *practice research* proposed by Bulley and Şahin in their 2021 report commissioned by PRAG-UK[3] and Research England[4], which avoids needless discipline specificity.

3.3.1 *Installation as Research Probe*

The installations created during this PhD are conceived both as artworks and research probes. Like technology probes [Hutchinson et al., 2003], the installations are instruments to be deployed in real-world settings as part of participant studies to explore the nature of interactive experience while also field testing the technology. However, where technology probes are viewed as simple and flexible tools deployed in early design explorations that help the designer to determine the de-

3 The Practice Research Advisory Group (PRAG-UK) is an independent body which has been established by members of the academic community in the UK, to increase the visibility and accessibility of practice research, see: https://prag-uk.org.

4 Research England is a research council within UK Research and Innovation (UKRI), see: https://re.ukri.org

velopment of future technologies, the installations presented to listeners in this thesis are fully realised interactive artworks and relatively complex assemblages of technology, sonic composition and curation. Naturally, the findings of participant studies feed into future iterations, but the installations are primarily used to probe embodied modes of interactive listening rather than engage listeners in participatory design processes.

The installations *Being With The Waves* (see Section 5.6) and *Sonographies* (see Section 8.2) are intended as provocations to listen, to attend to the dimensions and attributes of sound, and to notice the perceptual activity involved in doing so. Positioned as artworks rather than design or research products [Jack et al., 2020, Odom et al., 2016], the installations are what the philosopher Alva Noë describes as 'strange tools'; non-functional and alien artefacts that disrupt our ordinary mode of being in the world Noë [2017]. Listeners, encountering the installations for the first time, work to make sense of their strangeness, asking 'What is it?' [Noë, 2017]. The activities of listening and sense-making are thereby brought into the foreground of experience to be questioned and explored in post-listening surveys and interviews.

3.4 PARTICIPANT-LED RESEARCH STUDIES

Four participant studies (Chapters 4, 6, 7, 8) are conducted as part of this thesis and each explores the relational design and experience of sound installation. Broadly, Chapters 4 and 8 centre on sound installation practice in relation to the material context of site, as well as the relationship of practice to listener experience as a secondary focus. Chapters 6 and 7 focus on listener perspectives and the lived experience of interaction. While Chapter 4 surveys the practices of other sound artists, Chapters 6, 7, and 8 explore the design and experience of entangled sonic interaction with the ultrasonic art installation described in Chapter 5.

Each study employs a different methodology related to a subfield of HCI. Chapter 6 employs the methodologies of interactive art research (survey, observation) and (arguably as a result) entails a focus on the socially mediated character of listening. Chapter 7 zooms in on the sensory and felt quality of entangled listening, employing the micro-phenomenological interview technique to produce rich descriptions of interactive experience. Chapter 8 employs first-person methods associated with interaction design research to examine the influence of material agencies on creative practice.

It should be noted that a primary focus on listening as a specific, individual experience is implicit throughout this thesis. Hence, while it might have been a fruitful alternative approach with the potential to engage diverse listeners and address the ethical issues described later in Section 3.7 of this chapter, I did not consider designing the installation with the involvement of listeners, using action research, participatory or co-design methods.

3.4.1 *Overview of Participant Studies*

There are many points of connection and difference across the four studies of this thesis, which may be discerned via the brief descriptions and comparison shown in Table 3.1. In particular, note the epistemological shift that occurs in Chapter 7 to feminist new materialism, inspired by the work of Barad [2007] and Haraway [1988].

Chapter 4: Interviews with Situated Sound Art Practitioners
January - September 2020
An exploratory study, surveying 10 sound artists to learn about the relationship of artistic practice to site.

Chapter 6: The Experience of *Being With The Waves* at a Public Art Festival
September- December 2021
Study 2 explores the relational experience of listening in a public art context, with a particular focus on the influence of social factors.

Chapter 7: Examining Sonic Entanglement as Lived Experience
March 2022 (data collection), May- August 2023 (analysis and write-up)
Study 3 explores the pre-reflective dimension of experience and seeks to uncover the felt quality of listening to and interacting with *Being With The Waves*.

Chapter 8: Examining the Situated Design and Gallery Curation of Sonographies
January- September 2024
Study 4 primarily examines the relationship between artistic practice and site as an active influence. It also explores listener interpretations of the installation as a secondary focus.

C*	Focus	Location	Epistemologies	Methods
4	Practice: Other artists	Various	Interpretivism Constructivism	Interviews Thematic analysis
6	Experience Sociality	Public: Art festival	Interpretivism Social constructivism	Surveys Thematic analysis Video observations Interaction analysis
7	Experience	Hybrid: QMUL lab spaces	Feminist new materialism	Interviews Micro-phenomenology Diffractive analysis
8	Practice: My own	Public: Art gallery	Feminist new materialism	Design journal Surveys Diffractive analysis

Table 3.1: An overview of the four participant studies, mapping out the different foci, study locations, epistemologies, data-collection and analysis methods.
* Note that the column heading 'C' abbreviates 'Chapter'.

3.4.2 *Location of Studies*

This research explores the relational design and experience of listening to sound art, which is fundamentally situated: sound art installations are defined by their sensitive relationship to location and site [Seiffarth, 2012], the experience of listening is contingent on the position and orientation of the listener in relation to the artwork. The contexts and locations in which participant studies take place are, therefore, an important consideration.

In this PhD, listener behaviour and experience will be studied *in context* (see Section 2.5.1) wherever possible, with the installation positioned primarily as an art experience rather than a research activity. The implementation of this approach, however, gives rise to a series of practical issues related to how and when the participant becomes aware of the research, how they are approached, and how they provide ethical consent. Bengler and Bryan-Kinns [2014] advise that the interactive art researcher should keep in mind that from the point of view of the curator or visitor, the art object under study is primarily thought of as an exhibit and the interests of the researcher may have no direct relevance to them: 'Therefore, we have to consider carefully to what extent we want to "interfere with" these expec-

tations when conducting our research' [Bengler and Bryan-Kinns, 2014, p. 172]. If audiences are approached after an art experience to take part in a research study, then, realistically, only a short or lightweight research activity can be proposed. Where participation is arranged in advance of the art experience and audiences knowingly participate, then longer and more detailed research activities, such as interviews, may be planned. Research in context, therefore, entails a trade-off: naturalistic behaviour versus depth of research engagement. Practical and ethical considerations of research in context are discussed further in Section 6.1.2.1 of Chapter 6 and in Section 9.2.1 of Chapter 9.

Studies 2 and 4 of this PhD take place in an exhibition context, at *Ramsgate Festival of Sound* and *no format Gallery* respectively. In each of these studies, visitors are introduced to the research study after listening to the installation and invited to participate by completing a short survey about their experience. Study 3 elicits richer and more detailed descriptions of experience during hour-long interviews employing the micro-phenomenological interview method. Technically, this study takes place in a lab-based setting, but the space is presented as though it were a gallery. Listeners encounter a curatorial text upon entry, the space is lit theatrically and everyday equipment betraying its identity as a working lab space is hidden from view. My intention here is to create a *hybrid* study location, combining the cultural expectations of an art encounter with the controlled lab environment. There is precedent for this in interactive art research. For example, Beta_Space at the University of Sydney is a purpose-built venue for exhibiting and evaluating interactive digital art at various stages during their development [Muller and Edmonds, 2006]. Similarly, Höök et al. [2003, p. 244] describe the essentially lab-based evaluation of the 'influencing machine' as taking place in a room that deliberately did not look like a laboratory or office: 'Instead the room was in an old house, it had a Dutch tile stove, arts on the walls, and shelves with books'.

3.5 ARTICULATING EXPERIENCE: DATA COLLECTION

3.5.1 *Survey and Observation*

The studies described in Chapters 6 and 8 are conducted at a public art festival and a contemporary art gallery, respectively. Each of these studies aims to elicit insights into the situated experience of listeners encountering the installation, employing a survey as the primary method for gathering experiential descriptions

following a listener's interaction with the artwork. Following Bengler [2015, p. 82], these surveys are designed to have 'as low interference as possible' with a visitor's experience and allow for 'quick, on-the-spot completion', taking only 5 minutes to complete. The surveys employed in Chapter 6 and 8 each invite free responses to a short set of questions immediately upon exiting the installation. They differ in length, format and mode of response. In Chapter 6, participants complete a written, paper survey while sitting in the foyer of the installation venue. In Chapter 8, participants complete a digital survey using their own mobile devices that invites spoken responses using the Phonic.ai platform[5]. Here, participants record their responses while standing or walking outside the gallery.

In addition to the survey, Chapter 6 also employs the method of video observation to examine the visible behaviour of listeners. This is a key method in interactive art research and ethnomethodological studies and leads to a focus in that study on the socially mediated character of interaction.

3.5.2 *Interviews*

I believe that the surveys just described are well suited to the quickfire collection of data immediately following a listener's interaction with a sound installation. However, the brevity of the survey and its structured format constrain the scope of descriptions given in response. Also, 'meanings and interpretive frames that go beyond the predetermined structure are left out, with the risk that the researcher cannot understand what actually goes on' [Brinkmann, 2014, p. 285]. Qualitative interviews are a key methodology in this thesis, used across multiple studies to gather in-depth insights into the perspectives and complex subjective experiences of participants. In Chapter 4, interviews are used to gain insight into the working practices and experiences of sound installation artists. In Chapter 7, they are used to probe the inner, subjective experience of listeners and in Chapter 8 as a means to document the collaborative curation of *Sonographies*.

Brinkmann [2014] notes that it is common to distinguish between structured, semi-structured and unstructured interviews but argues that instead, we should think of a 'continuum from relatively structured to relatively unstructured formats' [p. 285]. Completely unstructured interviews rarely exist as the interviewer always

5 https://www.phonic.ai/ is an online platform for creating digital surveys that capture audio and video responses. At the time of writing, the company has just announced that it will be discontinued as of June 2025.

has some idea about what will take place and interviews are rarely completely structured 'because people always say things that spill beyond the structure, before the interview starts and when the recorder has been turned off' [Parker, 2004, p.53]. Indeed, responses that 'spill beyond the structure' are often key to understanding an interviewee's answer or viewpoint. Latour [2000] finds that human participants are too readily mastered by the researcher's agenda, which can result in trivial and predictable research. In this light, Parker [2004, p.116] argues that participants should be encouraged to be 'interested, active, disobedient, fully involved in what is said about themselves by others'. This implies careful preparation of the interview and the importance of a supportive environment to actively involve interviewees, provoke them in a respectful manner, and thereby bring unexpected and contrasting perspectives to light. Each of the interviews conducted in this thesis aims to provide flexibility and space for interviewees to express their viewpoints in their own words and to deviate from any fixed questions to follow interesting trails of thought.

3.5.3 *Micro-Phenomenology*

Micro-phenomenology (M-P) is an interview method for eliciting fine-grained accounts of lived experience. It is developed by Claire Petitmengin as a scientific method for capturing and analysing subjective experiences [Petitmengin, 2006] and has its roots in phenomenology and neuroscience. From the phenomenology of Husserl, M-P engages with the technique of 'phenomenological reduction' or 'bracketing', i.e. setting aside assumptions and judgements about the external world. From the work of Merleau-Ponty [1945] on embodied perception and the work of Varela et al. [1991] on enactive views of cognition, M-P inherits a focus on bodily sensations, movements and spatial relations as integral to experience, emphasising the indivisibility of consciousness and physical dimensions of being. Petitmengin was a student of Francisco Varela, and M-P builds directly on his neurophenomenological interview methods for studying cognition [Lanfranco et al., 2023] as well as the creation and employment of 'explicitation' interviews by Vermersch [1994].

M-P has been deployed in HCI research since 2001 [Prpa et al., 2020], for example, to study sensory modalities [Dalsgaard et al., 2022, Françoise et al., 2017, Obrist et al., 2013, 2014, Petreca et al., 2015] and relational characteristics of interactive experience such as interconnection [Stepanova et al., 2019] and inter-

corporeality [Kilic Afsar et al., 2023]. Where somaesthetic appreciation design ('soma design') describes an embodied methodology for developing technology prototypes, which includes a concern for the articulation of experience [Höök et al., 2016] via methods such as trajectories [Tennent et al., 2021] or body mapping [Anne Cochrane et al., 2022], M-P is solely a method for articulating pre-reflective experience in fine detail. M-P is used as a tool for artistic research, notably for eliciting experiential descriptions of Olafur Eliasson's artwork [Anderson, 2016, Heimann, 2021] and dimensions of embodied reflection in dance performance [Buttingsrud, 2021]. The inner experience of listening to spatial sound art has (to date, and to the best of my knowledge) not been studied using qualitative methods and certainly not using micro-phenomenology.

3.5.3.1 *M-P Interview Methodology*

M-P aims to elicit rich descriptions of lived experience by drawing the participant's attention to pre-reflective experiential content, i.e. immediate perceptions and aspects of the experience that are not available via reflection on past events. The data that this method produces is from a second-person perspective. The interviewer has an active role in helping the interviewee to convey their experience, arguably balancing first and third-person perspectives [Reed et al., 2022]. An M-P interview is highly structured, and the method specifies a series of key steps. First, the interviewer and interviewee decide upon a particular past moment (of a few seconds to a minute in length) situated in space and time on which to focus the interview. The interviewer then works to induce the 'evocation' state such that the interviewee becomes more present in the past experience being evoked than in their present situation. This is done by inviting the participant to return to the past moment and describe the detail of that moment in ever greater detail; what could be seen, heard and felt in the moment.

Once the evocation state has been induced, descriptions of the experience under study are elicited in phases. At first, the researcher guides the interviewee to unfold the *diachronic* dimension, which reveals the temporal structure and phases of the experience. This is probed by asking questions such as 'How do you start?' and 'What do you do then?'. These temporal phases of the experience are considered to be 'containers' for the *synchronic* dimension, which refers to a 'specific configuration of the experiential space (...) at a given moment of time' [Prpa et al., 2020, p. 3]. To probe this dimension, the interviewer might ask questions such as 'At that moment when you do x, what do you do? Did any feelings/ images/

auditory cues arise, and if yes, how?' [Hogan et al., 2017]. The interviewer works to deepen descriptions to the level of precision that is required for the study by posing 'content-free' questions that refer directly to aspects already described.

I describe my work with M-P in this thesis as 'micro-phenomenologically inspired' as I have not yet completed all aspects of the training to become a certified practitioner. A week-long training course in the interview technique was completed in April 2021, and throughout this PhD, I have engaged in around 50 hours of interview practice. In this thesis, M-P is first employed as a means to collect experiential accounts of 'being-with' the sea, which are heard in the installation *Being With The Waves*. It is then the central research method used in Chapter 7 to probe the experience of listening to *Being With The Waves*. Due to the phenomenological 'bracketing' of experience that the M-P interview method affords, the focus of that study is on the inner, subjective experience and felt quality of interaction rather than the mediation of experience by external factors. While the phenomena of listening throws up challenges to M-P (see below) and the precise implementation requires further exploration, it is, arguably, the research method best suited to the retrospective elicitation of lived experience.

3.5.3.2 *Considerations and Limitations*

M-P data can only be considered reliable when participants truly evoke or re-live their past experience during the interview, and this can only be the case when the interview is focused on a singular experience. Additionally, the interview must focus on only a moment or short slice of time since the detail that it is possible to mine during an M-P interview on an experience of just a few seconds is quite astonishing - an entire hour could easily be spent investigating the detail of a few seconds worth of experience. My review of M-P studies in HCI contexts found that authors either tend not to describe how the moments to be investigated were decided upon, focus the interview on short provoked experiences with a stimulus or use the M-P technique in a less focused fashion to question participants about their experience in general rather than about singular moments in time. M-P will be used in this thesis to elicit the experiential detail of a moment within a longer interaction with the ultrasonic art installation. A key consideration, then, is how to help the interviewee articulate that moment after the experience has ended. Indeed, is it even possible to do so given that the installation has a homogeneous quality? There are long periods when the sound design and prominence of interactive effects are consistent. The precise implementation of M-P in study 3 was given

much consideration, the detail of which may be found in Section 7.3.3 of Chapter 7.

Given that M-P interviews focus on the singular details of an individual's experience, sensory and felt qualities certainly cannot be taken as generalisable to the whole human population. Rather than focusing on commonality, I have sought for the singular and situational character of the data to persist and this is a motivating factor for employing diffractive analysis in Chapter 7. Given that the data is collected from a second-person perspective, the interviewer has an active role to play in helping the interviewee to unfold the experience. As ever, there is potential for their influence to bias the data, but in M-P their role is very much to guide and not lead the interviewee. As noted already, M-P emphasises the use of content-free questions that recapitulate what the interviewee has already said. In the analysis of M-P interviews, the researcher should recognise leading questions and remove any affected question-answer pairs from the transcript before analysis. A key consideration in the use of M-P is that sonic, embodied and felt qualities of experience are notoriously difficult to describe; tacit experience evades direct linguistic representation. Potentially, some participants will be more responsive to the M-P method than others, finding it easier to reach the evocation state or find the language to translate the sensory qualities of their experience. This responsiveness might depend on the interviewer's ability and experience practising M-P and supporting interviewees, but also individual dispositions, prior engagement with somatic and meditative practices, and social and cultural differences.

3.6 INTERPRETATION: DATA ANALYSIS

The qualitative analysis of text-based data - be that raw survey responses or the transcribed audio recordings of interviews - accounts for the majority of data analysis in this thesis[6]. Thematic analysis is employed in Chapters 4 and 6, while diffractive methodologies are implemented in Chapters 7 and 8. This analytic split mid-way through the PhD research occurred after the data collection phase of Chapter 7, as I was reading through the detailed accounts of sensory experience produced through the M-P interviews. The codes produced through thematic analysis are an abstraction away from the raw data. They untether meaning from its

6 With 2 notable exceptions. In Chapter 6, the method of interaction analysis is employed for the interpretation of video observations. In Chapter 8, first-person documentation of practice is presented as a design journey, which is a selective and interpretative account, thereby involving analytic work.

context within the frame of a longer description and fragment the text, poorly suited to describing events that happen over time. Additionally, thematising implies the drawing together of similar perspectives rather than emphasising specificity and difference. That juncture in the research is marked by a shift toward relational theories, the work of Karen Barad in particular and a heightened epistemological awareness. Much more than before, I was keen to consider the epistemological implications of the phenomena at hand - sound, listening, physical entanglement - and sought an alignment with the research methods I employ. Ultimately, this led me to explore diffractive modes of analysis in Chapters 7 and 8.

Despite their underlying epistemic differences, I found the practical work of analysis to be broadly similar across thematic and diffractive methods. Interview data was transcribed via automated means[7] and then manually corrected. The analyses always began with a period of familiarisation: multiple readings of the data, and writing notes in response to capture early impressions and interrogate the analytic direction. This was then followed by a period of close critical engagement, either coding the data over multiple iterations in the case of TA or allowing the analysis to develop through memo writing, sustained thought and engagement in a less linear fashion in the case of DA.

In their 2020 paper, 'One size fits all? What counts as quality practice in (reflexive) thematic analysis?' Braun and Clarke advocate for 'theoretically sensitive, and reflexive and deliberative engagement with TA, of whatever variety' [Braun and Clarke, 2021, p. 329], pointing to a spectrum of different approaches from positivist/ quantitative to qualitative paradigms. Data analyses in this PhD are rooted in a 'Big Q' [Kidder and Fine, 1987] qualitative paradigm, which emphasises reflexivity, depth of insight, trustworthiness, and the researcher's subjectivity. The findings and outcomes of these analyses are the result of my particular engagement with the data. I do not claim repeatability, these analyses may differ in some respects were they to be carried out by someone else.

Within a qualitative paradigm, data validation is treated quite differently from traditional notions of reliability in quantitative/ positivist research. Instead of measures like inter-rater reliability, validation comes from transparency in the analysis process, documenting how codes and themes are developed and ensuring themes are coherent, meaningful, grounded in the data and analytically rich, rather than

7 Two methods of automated transcription were used during this PhD. 1) By creating a static video file from the interview audio, uploading it to https://www.youtube.com/ and then downloading the automatically generated transcription file. 2) By using the transcription software https://otter.ai/

simply frequent [Braun and Clarke, 2021]. I aimed to produce valid and trustworthy analyses through reflexive journaling and a rigorous, thoughtful engagement with the data. I also engaged in member checking and internal interrogation of these qualitative criteria via PhD stage reviews and weekly supervisor meetings, and external checking through peer review of submitted publications.

3.6.1 *Thematic Analysis*

Thematic analysis (TA) is a flexible method for coding qualitative data and organising those codes in order to find themes: patterns of shared meaning that cut across the interviews and capture something important about the data that have relevance for the study's research aims. TA is widely used in HCI and the social sciences; for example, to analyse interview data relating to the creative process in different artistic disciplines [Glaveanu et al., 2013] and in interactive art research to analyse video capture and interview data of audience experiences [Bilda et al., 2006].

TA is developed by Braun and Clarke and articulated as a *six-phase process* for data engagement, coding and theme development [Braun and Clarke, 2021]. Wherever TA is used in this thesis, the process outlined in [Braun and Clarke, 2006] is followed. This involves 1) familiarising oneself with the dataset through repeated reading and note-taking; 2) systematically coding the data over multiple iterations through the data set, which in practice entails adding short labels that capture pertinent information or insights within the data; 3) generating initial themes from coded and collated data; 4) reviewing and developing those themes; 5) defining and naming them and 6) writing-up the analysis as a report. Importantly, the development of codes into themes in TA is not quantitative: the largest cluster of related codes does not necessarily make a theme, indeed themes of a single code could exist if that data point was deemed to make a pertinent contribution to understanding the participant or research question.

The flexibility of TA means that a series of decisions need to be made in relation to the type and scope of analysis to be undertaken. For example, whether it should produce a rich account of the entire dataset or detailed description of one particular aspect. Additionally, a thematic analysis can be data-driven or theoretically-driven. In a data-driven or *inductive* analysis, a bottom-up approach is taken whereby codes and themes are strongly linked to the data itself. By contrast, a theoretical or *deductive* analysis is guided by particular research questions,

theories and analytic interests, tending toward a narrower focus on particular aspects of the data. Braun and Clarke [2006, p. 84] are keen to note that 'data is not coded in an epistemological vacuum', researchers are not passive and cannot free themselves from theoretical and disciplinary commitments; a purely inductive analysis is an impossibility. Rather, analysis approaches are more or less inductive or deductive approaches and these are a continuum, not a dichotomy [Braun and Clarke, 2021].

A largely inductive approach to TA is employed in Chapter 4 to analyse and produce a rich description of around 10 hours of interview data. TA is also used in Chapter 6 to analyse survey responses of listeners to *Being With The Waves* following their interaction with the installation at Ramsgate Festival of Sound. Here a more deductive approach is taken, adapting an existing code framework that has been developed through interactive art research [Bilda et al., 2006]. The qualitative analysis software MAXQDA[8] was used in each of these studies to manage the coding of data and clustering of codes to iteratively develop themes.

3.6.2 *Diffractive Analysis*

Diffraction is a methodological sensitivity suited to the examination of relationships and entanglements. The term diffraction is lifted from physics and refers to the way that waves interfere and combine as they overlap and the bending and spreading out of waves upon meeting an obstruction [Barad, 2007, p. 74]. It has been adopted as a metaphor for analysis by feminist theorists because it moves away from oppositional or binary frameworks, which often fail to adequately represent the intertwined, shifting, and fluid nature of social identities and structures. Where traditional research methods tend to rely on reflection as a metaphor, diffraction emphasises how things interact and transform through one another, producing complex, layered patterns rather than simple reflections:

> Diffraction does not produce 'the same' displaced as reflection and refraction do. Diffraction is a mapping of interference, not of replication, reflection, or reproduction. A diffraction pattern does not map where differences appear, but rather maps where the *effects* of difference appear. [Haraway, 1991, p. 300]

8 https://www.maxqda.com/

Barad adopts Haraway's articulation of diffraction (above) as the basis for an analysis method that attunes with their relational and materialist ontology of agential realism (see Section 2.4). In recent years, diffractive analysis has been gaining traction across the social sciences, but its implementation within a research project is far from straightforward. Firstly, DA requires close engagement with complex theories from quantum physics, philosophy and feminist theory, making the methodology difficult to grasp. Unlike conventional qualitative methods, there is no step-by-step procedure for performing a diffractive analysis. It resists fixed methods and encourages flexible, context-specific approaches whereby its application depends on the unique entanglements present in each research scenario. DA, therefore, places greater responsibility on the researcher to determine what the analysis looks like in practice. Additionally, if we try to blend diffractive methods with more traditional approaches like grounded theory or thematic analysis, the ontological assumptions underlying these methodologies can be incompatible. For example, while thematic analysis seeks patterns that can be generalised, DA resists generalisation in favour of multiplicity, capturing the detail of specific, situated interactions. Attempts at integration might dilute the theoretical contributions of diffractive methodologies or make them difficult to apply in a way that fully respects their foundational principles.

Diffractive analysis is a comparatively new and emerging field of qualitative study and has only entered the sphere of HCI since 2020. Diffractive analysis is well documented in social science domains [Jackson and Mazzei, 2013, Mazzei, 2014, Taguchi, 2012] and has been implemented by HCI researchers to examine difference [Rajcic et al., 2024] by reading data through theoretical insights [Clark and Thorpe, 2020], disciplinary perspectives [Morrison and McPherson, 2024, Nordmoen and McPherson, 2022, Zayas-Garin et al., 2023] and subjectivities [Lazar et al., 2021]. Diffraction has also inspired slow and open-ended engagements with 'lived data' in design [Sanches et al., 2022] and cast light on the interdependencies of technologies and animal species in more-than-human design [Wakkary et al., 2023].

3.6.3 *Performing Diffractive Analysis*

As just described, diffractive analysis places greater responsibility on the researcher to define how it looks. My implementation of DA is inspired by post qualitative inquiry [Lather and St. Pierre, 2013, St. Pierre, 2019, St. Pierre and Jackson, 2014] in

the social sciences rather than prior HCI work. Challenging the assumptions and methods of humanist qualitative research and responding to the rise of posthuman and new material thought, post qualitative inquiry draws on an ontology of immanence, within which 'one becomes less interested in what is and more interested in what might be and what is coming into being' [St. Pierre, 2019, p. 4]. It is within this broader context of experimental qualitative research that diffractive approaches informed by Haraway and Barad may be situated.

The particular perspectives and agencies entangled in the DA studies in this thesis were generated organically through an engagement with the data, informed by my wider reading of theoretical texts and diffractive research. I did not set out with a fixed idea of how the analyses would be undertaken. They *came into being* through cycles of experimentation, setting the data into conversation with different theories and approaches. Ultimately, the final processes presented in this thesis were determined by my sense that they faithfully articulate the data most pertinent to my research questions while accounting for key contingencies.

In Chapter 7, the diffractive analysis explores the relationship of M-P descriptions to the materiality of sound specifically. Theories of sounding and listening are 'plugged in' to the data. Theory informs the articulation of experiential data along with interferences - 'effects of difference' - produced by bringing the fields of sound studies and HCI into conversation. This approach is influenced by diffractive analyses that use theory as an agent to juxtapose and diffract the meaning of data. The theory is treated as active, as a tool for analysis, something that can be plugged in [Jackson and Mazzei, 2013]. For example, in Taguchi [2012, p. 267], 'Alaimo's concept of the transcorporeal together with Deleuze and Guattari's thinking on the process of becoming-minoritarian' are 'put to work' in the analysis. Similarly, Jackson and Mazzei [2013] use the concept of 'plugging in' from Deleuze and Guattari, as a machine-like process that works against conventional coding approaches in qualitative analysis. 'Plugging one text into another' entails creating new diffractive assemblages that reveal data and theory to be 'supple', with 'machinic potential to interrupt and transform other machines, other data, and other knowledge projects' [p. 267].

In Chapter 8, the diffractive analysis explores the relationship of survey data to material qualities of the installation, the material circumstance of the post-listening survey and my entanglement in the data as artist-researcher. It is inspired by the notion of the 'researcher as transducer', proposed in Barla [2023], which emphasises the performative power of research and allows for an understanding of the

researcher as materialising in the research in intra-action with other human and non-human agencies. The diffractive analysis is also informed by analyses that foreground the influence of nonhuman agencies on qualitative accounts and particularly the work of Taguchi [2012]. For example, in their analysis of an interview with a six-year-old boy at school, Taguchi explores how meaning is co-constituted by the 'matter' of the interview environment:

> I install myself in the space where the adult interviewer brings one child at a time to a table to perform an interview. In this space, the table and chairs enact a space of interviewing. An event of sitting is enacted, where talking becomes formal rather than the informal talking that was the intention of the interviewer. The table actively separates and distances the adult from the child. The table can be felt to agentially enact distance, formality and seriousness together with the adults' materially-discursively performed talking.
> Taguchi [2012, p. 275]

Further details on the diffractive analyses may be found in the relevant study chapters, see 7.3.6 and 8.1.5.

3.7 RESEARCH ETHICS

The studies in this thesis received ethical approval from Queen Mary Ethics of Research Committee prior to commencement[9] All were deemed to be low-risk

9 https://www.jrmo.org.uk/performing-research/conducting-research-with-human-participants-outside-the-nhs/.

studies, ensuring the safe and ethical treatment of human participants. The relevant approval codes and links to documentation may be found below:

QMREC2334 *Site-Specific Sound Art: Design Approaches & Audience Interaction*
Granted 06/02/2020, for documentation see Appendix B.1

QMERC20.483 *Exploring the experience of listening to a spatial sound art installation in the context of a public art festival*
Granted 31/08/2021, for documentation see Appendix D.1

QMERC20.016 *Exploring the Experience of Listening to a Spatial Sound Art Installation*
Granted 08/04/2022, for documentation see Appendix E.1

QME23.0190 *Examining the Curation of a Sound Installation and Methodology for Eliciting Listening Experiences*
Granted 20/12/2023, for documentation see Appendix F.1

It must be acknowledged, however, that some ethical standards and responsibilities fall outside of the remit of institutional review panels. In 2023, the NIME community published a set of ethical principles which extend beyond matters of consent, safety and data privacy to include accessibility, inclusion and the environment [Morreale et al., 2023]. Here, inspired by the work of Katta Spiel [Spiel, 2021, Spiel et al., 2022], I wish to reflect on ethical matters relating to inclusivity and meet Spiel's challenge to check my own privileges and name normative tendencies in my work.

I acknowledge that my position as a PhD researcher and sound artist is one of privilege, supported by the epistemic and material legacies of colonialism and race. I recognise that potentially harmful perspectives and behaviours are systematically entrenched within myself, my institution and the disciplinary discourses from which this research stems. These have likely influenced my research in ways I was unaware of, despite good intentions. For example, Stadler [2015] draws attention to the 'underlying whiteness' of sound studies, arguing that the broad terms that carry so much currency — such as 'the listener,' 'the body,' 'the ear' - perpetuate notions of sound as phenomena in and of itself, potentially negating the possibility of diverse listenings, particularly along the lines of racial difference. Stadler [2015] asks: 'What does an ever-nearer, ever-louder police siren sound like in an urban

neighborhood, depending on the listener's racial identity? Rescue or invasion? Impending succour or potential violence?'.

I believe that the relational focus of this thesis, its emphasis on situated, individual experiences and attunement to difference and multiplicity, is an ethical stance, one that opens the possibility of foregrounding marginalised perspectives. However, I did not actively seek those diverse voices and participation in my studies depended on individuals already being a member of sonic arts communities, be that professional artists (study 1), sound art audiences (studies 2 and 4) or social media followers (study 3). For sure, this has emphasised normative, white and economically privileged perspectives in study outcomes. I recognise now that this is a bias of the research, and action is needed to share the sonic arts with more diverse listeners and improve access through education and engagement initiatives. In future, I hope to share my work in schools and with communities. One of the artists interviewed in study 1, Jeroen Vandesande, suggested that many people don't know how to listen to sound art and proposed spatial listening workshops in schools to support appreciation from a young age. This could be one of many potential strategies for bridging cultural divides and addressing the whiteness of sound art.

3.8 A NOTE ON TERMINOLOGY

Thorough consideration has been given to the terminology used in this PhD to refer to the people who interact with the sound installations and engage in research studies. Traditionally, the central figure of HCI research is the *user*, but this tends to reduce a complex, multifaceted human being to a mere 'adjunct to' a technological system [Bannon, 1995, Satchell and Dourish, 2009]. While the research studies in this PhD adopt HCI methodologies, they eschew user-centric terminology. The humans that encounter installations are entangled *with* the system, and their engagement might be characterised more in terms of active perception, experience and awareness of their entanglement.

During the interviews reported on in Chapter 4, sound artists were questioned about their preferred words and invited to reason about their choice. Artists emphasised the active disposition of listeners and suggested that an ideal word may not exist. The term 'audience' was critiqued as being too passive, suggesting a group of listeners sat in front of a stage, as in the traditional theatre paradigm. Roswitha von den Driesch and Jens-Uwe Dyffort articulated a preference for the

term 'visitor'. Like 'audience', however, 'visitor' does not capture the active role involved in listening to sound installation art. It implies attendance and presence but not active involvement. While it is strongly tied to the context of art galleries and museums, it does not feel appropriate to this research.

From Chapter 5 onwards, i.e. informed by the interview study, the terms chosen for use in this project are 'listener' and 'participant'. 'Listener' is used to describe those who engage with the installations. Whereas 'hearing' refers to the simple ability to perceive sound, 'listening' implies an attentive disposition. The listener is inherently active in relation to sounds that are present. I acknowledge that this term does not capture the physical activity and embodied mode of listening foregrounded in this PhD, however it does centre the ear as the locus of interactive experience. As will be shown in 5, this is a defining feature of the ultrasonic installations, marking them as distinct from interactive sound installations that map the movements of limbs to variations of sound design. The term 'participant' is used to refer to people who take part in the studies in acknowledgement of their contribution to the research. Hence, where participants are anonymised, they are referred to by a numerical identifier prefixed with the letter 'P', for example 'P23'.

4

STUDY 1: INTERVIEWS WITH SITUATED SOUND ART PRACTITIONERS

This chapter is built on material reported in "On Mediating Space, Sound and Experience: Interviews with situated sound art practitioners", by Robson, Bryan-Kinns and McPherson, originally published in Organised Sound, 28(1) [Robson et al., 2023].

This chapter reports on an interview-based study with ten experienced sound artists to learn about their artistic processes, attitudes to the audience and understanding of their experience. Intended as a scoping activity, these interviews explore the concrete details of installation practices in the sound art tradition. All artists are engaged in 'situated sonic practices': artistic forms that emphasise the place-based aspects of sonic experience [Ouzounian, 2006]. These include installations, sound walks, spatial performances and workshop practices. The art practices referred to in this article are often described as site-specific, site-responsive, site-sound, or contextual in the sense that the artist draws upon aspects of place as inspiration. The use of *situated* implies a subtle shift of emphasis toward the relationship of a body or material thing to its location and foregrounds the subjective experience of a listener embedded in that context. Following the definition proposed by Spinks [2013], I take the word 'process' to include all aspects of method, such as the thinking, making, use of tools and materials, as well as the reception of the artwork and how it comes to be experienced by an audience. Thus, reception is the final stage of the process; it follows on from and is determined by the practical stages of making.

I propose that situated sonic artworks engage the ear and shape possible interactions by modulating the relationship between sound, the space in which it is heard and the people who hear it. The term 'modulating' is used here to emphasise a relational dynamic that becomes clearer as this chapter progresses: artists work *with* the materials of sound and space rather than staging an intervention in it, imposing form and artistic agency upon it. I am drawing, metaphorically, on audio modulation and imagining the artist as modifying, amplifying and altering the sonic qualities of a particular place through their audio artwork, as it unfolds in time. The following interview study was designed to examine how that

modulation is achieved. It addresses RQ1 of this thesis through the design of a semi-structured interview that probes its two subquestions.

RQ1: What can be learned from experienced sound artists about the relationship of practice to the site of an installation and subsequent reception of the work by a listening audience? (Chapter 4)

(a) How is site addressed in their process via methods, tools, and technologies?

(b) What do artists understand about the audience's behaviour and experience?

4.1 STUDY DESIGN

The following subsections outline the design of the study. I begin by introducing the sound artists who participated before describing the design of interviews and the interpretation of collected data using thematic analysis.

4.1.1 *Participants*

I aimed to recruit well-established sound artists and composers at various points in their careers, for whom acoustic space and site-specificity are key concerns. This study was conducted in 2019 before videoconferencing became the norm following the COVID-19 pandemic. Primarily, I sought to conduct interviews in person, and 5 of the 10 interviews were conducted with London-based artists whose work I was aware of before this study. German sound art, or 'klangkunst', tends to emphasise site-specificity and the sound material's relation to spatial location over aesthetics and concepts [Engström and Stjerna, 2009]. Therefore, I deliberately sought German perspectives and referred to a catalogue of exhibitions [Seiffarth and Steffens, 2010] at Singuhr gallery in Berlin[1] - a renowned centre for site-specific sound art - to find suitable artists to contact. I sought a cross-section of female and male artists, as well as a diverse set of practices and approaches within the narrow criteria for site-specific working. I acknowledge that recruitment for this study was highly selective, foregrounding European perspectives and culturally specific notions of sound art. The selected participants reflect the wider field of sound art, which, like sound studies, lamentably suffers from an 'underlying whiteness' [Stadler, 2015].

1 https://singuhr.de/en/main/

Twelve artists were contacted via email, all of whom responded, and nine interviews were agreed to take place within the necessary time period. Each artist is introduced below. Their name is followed by a shorthand code in parentheses derived from their initials. This code is used to reference their contributions to the outcomes of this study in Section 4.2. A summary of their practice is then provided, along with key examples of their work. Note that these summaries are based on descriptions collected during the interviews and, taken together, portray the multifaceted nature of situated sound art practices and different ways that artists perceive their work.

James Bulley[2] (JB)
Sound artist, London, UK.
Live composition, outdoor installation work, engaging with ecologies and the spatiality of sound, e.g. *Living Symphonies* (2014-) and *Tactus* (2011-).

Alex De Little[3] (ADL)
Artist and composer, Leeds, UK.
Sounding and listening as a way of interrogating, understanding and engaging with architectural spaces, e.g. *Spatial Listening* (2017-), *Spatial Drone* (2017), *Auricula Alium/ Auricula Suum* (2018).

Roswitha von den Driesch and Jens-Uwe Dyffort[4] (DD)
Sound artists, Berlin, Germany.
Working collaboratively to make site-specific sound installations in public and gallery spaces, e.g. *Kupferdraht mit Lautsprechen - Copper Wire with Loudspeakers* (1996), *Punktierte Umgebung - Dotted Surroundings* (2001/2002), *Geordnete Verhältnisse - Orderly Conditions* (2019).

Lisa Hall[5] (JH)
Sound-based artist, London, UK.
Performative, installation or intervention-based sound works that explore urban

2 https://www.jamesbulley.com/
3 http://www.alexdelittle.com/
4 https://www.dyffort-driesch.de/
5 http://www.lisa--hall.co.uk/

environments, e.g. *Virtual Voices* (2018), *Sound Map* (2017), *Walking With Crickets* (2016), *Audio Roulette* (2014).

Sebastian Kite[6] **(SK)**
Installation artist, London, UK.
Immersive installation artworks employing light, sound and material elements. Engaging with perceptions of time and space, e.g. *Inner, Outer, Other* (2020), *We will meet in the place where there is no darkness* (2017), *Enclosure* (2011-12).

Emma-Kate Matthews[7] **(EKM)**
Architect and composer, London, UK.
Spatialised compositions which exploit an acoustic condition or make conceptual parallels between ideas of space in architecture and ideas of space in music, e.g. *Construction 002: Tracing* (2017), *Construction 003: Axial/ Regional* (2019-20).

Gerriet K. Sharma[8] **(GS)**
Composer and sound artist, Berlin, Germany.
Site-specific sound installations and multichannel compositions exploring spatiality and the sculptural qualities of sound, e.g. *Oblivious to Gravity* (2010-2015), *Loose Ends* (2010-12), *Staircase* (2008).

Jeroen Vandesande[9] **(GS)**
Sound artist, Ghent, Belgium.
Sound installations and performances, working with analogue sounds and feedback, e.g. *Circuit03* (2015- 16), *Circuit04- Feedback Studies* (2015).

John Wynne[10] **(JW)**
Sound artist, London, UK.
Site-specific installations and sound sculptures, socially engaged art practice working with e.g. organ transplant patients, e.g. *Installations for high and low frequen-*

6 https://sebastiankite.com/
7 https://www.ekmworks.com/
8 https://www.gksh.net/
9 https://www.jeroenvandesande.be/
10 https://www.sensitivebrigade.com/

cies (2011-14), *Installation for 300 speakers, Pianola and vacuum cleaner* (2009-10), *The Sound of Sirens* (1997).

Participation in the study was not anonymous so as to credit the intellectual contributions of artists and support their viewpoints with examples of their work. All interviews were conducted in English and with individuals, except in the case of Jens-Uwe Dyffort and Roswitha von den Driesch who have worked collaboratively since the 1990s.

4.1.2 *Interview Design*

The interviews were semi-structured (though more structured than not, see 3.5.2) around a set of twelve questions decided upon in advance to probe the relationship of artist practices to the sites in which they make work and to audience experience. The questions were carefully planned to address the research questions articulated at the start of this chapter and elicit in-depth responses. The planning and decision-making process entailed iterative drafting of questions and revision following discussions in supervisory meetings.

Each interview began by asking the artist(s) to provide an overview of their practice and to describe the process of making a piece in practical detail. With a view to understanding the extent to which sound artists consider the future listener and their experience as part of the creative process, they were then asked questions, such as 'who is your audience? And do they require any specialist knowledge or training?' and 'what kinds of audience behaviour have you observed?', 'have you asked audience members about their experience of the work?'. These questions were also included with the next study (Chapter 6) in mind, given the need to consider who my participants should be. Two further questions invited artists to reflect on language use and meaning in relation to audience role and their process of making: 'I've been using the word "audience" to describe those who experience your work. Would you use an alternative term?' and 'What verb would you use to describe the act of creating your works? For example, I might say you are "designing", would you use an alternative?.' Partly, these questions were included to help define the terminology to be used in this thesis but also as a provocation for artists to critically examine the nature of their artistic practice along with the role of the listener.

In most cases, the questions were asked sequentially, diverging from the list as necessary to document the artists' complete views on a topic or to follow a trail of thought that might lead to interesting new insights. Artists responded to all questions, with two exceptions where time was short. Interviews lasted between 60 and 90 minutes. Five were conducted in person and four over video conferencing with artists who were not based in London. All interviews were audio recorded and then transcribed by hand[11].

4.1.3 *Analysis*

I chose to conduct a thematic analysis [Braun and Clarke, 2006] (see Section 3.6.1 of Chapter 3), taking an inductive approach whereby the structure of the analysis was guided by the data itself rather than a predetermined coding scheme. The process involved coding all interesting data items in two initial sweeps through the transcriptions before iteratively re-evaluating the code system and grouping related codes to find themes. A reflective journal was kept during the analysis process to document decision-making, and a draft write-up of the results was sent back to artists for their feedback to check the fit between their views and our representation of them, which were confirmed as accurate [Nowell et al., 2017].

4.2 FINDINGS

The result of the analysis is four high-level themes: (1) The artist acts as a mediator of site and experience, (2) The audience has an active relationship to the work, (3) The artwork shapes behaviour and perceptual experience, and (4) Engagement challenges. Not all themes relate to the work of all artists but reflect the most prominent patterns of shared meaning across the data set as a whole.

4.2.1 *T1: The Artist Acts as a Mediator of Site and Experience*

4.2.1.1 *Artists work to understand the potential of a site*

The coded responses to process-oriented questions suggest that artists have a mediatory role, working 'in-between' site and audience experience. Specifically, artists seek to understand and then harness the sonic, spatial or experiential potential of

11 Automatic transcription (as described in Chapter 3) was used in all subsequent studies

a site. Artists, therefore, try to spend as much time as possible working in situ on a piece because, as JW suggests, 'the way to make something that really explores and works with a space is to really know the space.' However, continuous access for a period of weeks or months is rarely possible. Instead, artists might visit often and make field recordings, drawings, 3D models of spaces and written notes before testing ideas either in situ or at similar sites. As an alternative to 'being there', EKM uses acoustic modelling software to 'hypothesise' or simulate the acoustic response of a particular site to sound sources placed within it. However, she acknowledges the limitations of this approach; the software cannot replicate the true effect of a space upon a musical idea.

JW, JV and GS describe long periods of time spent simply listening to learn about the sounds that exist natively inside a space, such as the sounds of pipework, machinery, doors opening or floorboards as they shift underfoot. They also listen for characteristic sounds of the outside environment, especially those that occur only periodically during the day. GS describes 'really listening to bus schedules or church bells or pedestrians... There was a dog, every day at 12 o clock... from behind the building'. These sounds might then become sonic material to be used in the work, creating a strong relationship to the site and leading to situations in which it is not clear where the artwork ends and the site begins. JW describes bringing the sounds of train wheels on the tracks outside of the gallery into the installation: 'The sound sometimes seemed to start outside and then come in, and it would suddenly be moving around the space.'

For most artists (ADL, EKM, GS, JW, DD, JV, SK), the acoustic response of a site is an active influence on the development of their work and listening, in itself, may not expose the full acoustic potential of an environment. Artists develop their own routines for understanding by 'probing' or putting sound into a site. Some (EKM, JW, ADL) make traditional acoustic analyses, while ADL and GS describe programming their own routines using software such as Max MSP or Supercollider. EKM describes using spectrograms to ascertain which parts of the frequency spectrum the room is most reflective to. This 'starts to influence the instrumentation I might use and also the range in which I make that music.'

Many artist routines for probing a site go beyond objective analyses and foreground the importance of an extended embodied experience. As ADL describes, simply clapping, shouting or singing in a reverberant space reveals only so much, a 'sort of understanding, but not understanding.' His *Spatial Listening* exercises make the process of understanding a space by sounding and listening to the work

itself: 'They're site-generic sets of instructions. In which the site-specificity emerges through the process of uncovering and then when you're satisfied with that, the piece is over.'

LH describes her practice as site-specific to a body rather than physical location, and as such, her creative process involves immersing herself in the situation of her artwork to understand what it does and how it changes her listening perception. She describes the process of making the piece *Walking With Crickets*:

> I then just started putting them in my pocket and walking around. I would wear them anywhere, just take them with me. I would walk to work, walk to the shops, walk to whatever I was doing, and have them playing all the time. Just through that continuous doing, the research started unfolding.

GS describes a meticulous process of 'surveying' the sites of his building sound compositions that takes many weeks, starting with walking through the site, talking and recording his verbal impressions and gradually building up a sonic mental image of the place. This process informs the spatial positioning of a loudspeaker array, through which impulses are emitted using one or more speakers, causing the building to react with its acoustic properties: 'as if you were walking around and taking a hammer – tak tak tak, tak tak tak, tak tak – and by this I had this question and answer game with the building.'

4.2.1.2 *Bringing together and working with*

Some artists characterise the process of making as a 'bringing together' of relationships or existing sonic materials. Others describe working in such a way that the final piece is not preconceived but gradually shaped into being. These descriptions provide further evidence for the mediatory role of artists, whose 'ground-up' approach to making is actively influenced by site.

Artists were asked to choose a verb that would best describe the process of creating their work, and each responded differently. While JB and JW chose the more expected 'composing' and 'sound designing', other responses suggest a practice that is less about invention or bringing an imagined artwork to fruition. Instead, a number of verbs evoke building practices and manual labour. LH describes her practice as 'assembling', as 'an alignment of things', SK chooses 'grafting' and EKM 'constructing'. She names her pieces 'constructions' in order to define her compositional role as creating relationships between space, sound and experience,

explaining that 'it's the construction of the score and the construction of the relationships between the musicians and the construction of the relationships between the music and the space.'

Similarly, ADL's choice of verb, 'making emergent', emphasises that it's an interaction between people and spaces that his process of making facilitates. Something that lies dormant, such as acoustic phenomena or a participant's capacity to listen spatially, is made to emerge through an interaction. Other responses suggest a 'ground-up' approach to making, in which the final artwork is not preconceived but shaped gradually into being. DD describe their process as 'developing' and 'working towards something'. JV responded instantly with the Dutch verb 'knutselen', which translates literally as 'crafting', but in Dutch, 'is more like how children do crafting or something… putting stuff together, crafting things, following intuition.'

4.2.2 *T2: The Audience has an Active Relationship to the Work*

Artists describe audience members as having an active relationship to the artwork, either by virtue of their immersion in the work, by becoming aware of their spatial orientation to it, or by needing to 'do something' to uncover the work's potential. The nuanced variety of artist responses, when asked about their chosen term to describe the audience, suggests that an ideal word does not exist to describe the role of listeners in spatial works. Artist justifications for preferred terminology reveal different aspects and interpretations of the audience's active role.

The term 'audience' was critiqued by many of the artists as being too tied to the traditional theatre or concert paradigm of the audience as a collective, sitting in front of a stage where the action itself happens. The separation of the audience from the work motivates JV's preference for the term 'visitor', which, for him, suggests a more inclusive meaning, bringing the audience and artist together. For SK and DD, the word 'audience' suggests a passive role, whereby you are rewarded with culture simply by virtue of turning up. A number of artists stress the active role of the audience member in relation to the artwork. For DD, you cannot consume art, especially not sound installations, without playing an active role: '[Visitors] need to do something to bring the whole installation together, move around and fetch different parts.' For EKM, it's the immersive and relational aspect of spatial sound work that makes the term 'audience' so problematic and suggests that an entirely new word might be needed:

> I'm thinking about a sort of visual analogue... about anamorphic paintings, where if you're face on to something, it might not make sense, but if you turn to the side, it foreshortens, so you're implicated in the understanding of the piece depending on your location to it.... [Anamorphic] describes the moment when it makes sense because of that spatial relationship between the person and the thing.

The 'anamorphic receiver' is active and implicated in making sense of the piece according to their spatial relationship to it. This definition aligns with DD's call to recognise the active role of the audience, to retrieve and make sense of the work's spatial dimension. For SK, visitors to his installations are 'participant' by virtue of their spatial presence in the work: 'It's about participating, and that can be even if you stand on the outside of it, even if you're just stood in the doorway here, you're already in it.' No single word could encompass all the possible meanings of the audience and their role in relation to situated sonic practices.

> The conceptualisation of the audience has to evolve with the nuances of a given mode of enquiry. There's no fixed sense of what an audience is... And I think a lack of sensitivity to that limits the possibility of the work and it also does down the complexity of what an audience might be (ADL).

4.2.3 *T3: The Artwork Shapes Behaviour and Perceptual Experience*

Through their practice, artists build a tacit understanding of sonic (such as the choice of sound sources, articulation, volume, and spatial position) and staging devices (such as lighting and arrangement of physical objects) to guide the audience's experience of their work. These might encourage active listening, particular physical behaviours or emphasise the embodied nature of experience and encourage an inward focus on listening and perception. Even the level of freedom given to audiences to explore work and create their own experience is an artistic choice. JV notes that 'I decide they are free; I decide the level of freedom'. Aspects of behaviour and experience can be determined by even very simple choices in the physical layout of the exhibition space, for example placing a cushion on the floor suggests to audiences that they ought to sit.

4.2.3.1 *Engaging the ear*

To foreground the act of listening, some artists described experiments with darkened spaces or blindfolded experiences but acknowledge that it is not practical to deny vision as audiences may need visual reassurance in order to navigate the space. Artists develop novel methods for engaging the ears of visitors and harness the multimodal nature of an installation to enhance or direct the listening experience. JV intentionally removes any unnecessary visual elements that might act as a distraction from his installations, obsessively hiding all cabling from view: 'I want to eliminate everything that can be a distraction from the essence of the work.' SK describes 'all these little tactics… to try and isolate your senses or choose to focus on one sense at a time.' For example, sounding moments in his installation *We Will Meet In A Place Where There Is No Darkness* correspond to very hot and bright tungsten lights switching on, forcing visitors to close their eyes (see Figure 4.1). GS emphasises the importance of lighting in sound installations to bring focus to listening and draw listening attention to a particular location in space. In his piece *Loose Ends*, he attempts to fix the eyes in order to 'open' the ears:

> I need a spot of yellow light hanging over this island of foils with loudspeakers underneath, so that the whole room is almost pitch black and then all your senses are concentrated on this golden island, and you are fixed by the light… your ears open for what is happening spatially.

Artists also develop sonic methods for directing the listening attention of audiences to spatial locations or drawing attention to the processes of listening itself. GS finds that short, transient sounds have the effect of attracting listening attention. The audience member might be standing still in one spot, but the spatial presence of these clicks means that the 'ear is jumping through the whole living room… [or] drawn to the kitchen that is six rooms away while you are sitting in the former bedroom.' Quiet sounds are used deliberately by DD so that audiences must listen attentively to hear them and as a result the richness of environmental sounds also becomes apparent. LH finds that carrying or wearing sound with a fixed volume 'really reveals your changing hearing'. Like a sonic measure or lens for listening through, 'it stays the same and reveals how everything else including me is moving and changing all the time.'

4.2.3.2 *Inducing a meditative state*

SK, ADL, LH and JW all describe creative devices for inducing a meditative state in visitors to their work. The meditative qualities described by artists, such as turning inward, being in the present moment, aware of spatial presence, are encouraged to focus attention onto perceptual processes and the visitor's embodied experience. SK describes his practice as 'a way of just trying to slow that sense of time right down and to really focus on being in that environment.' ADL describes his workshops as akin to a meditation class. The *Spatial Listening* pieces work to make participants act in the 'present', they're 'present-making' activities. As the exercise goes on, he has the sense that participants are 'reaching further and further into the sonic realm, and that they're inhabiting it, because the pieces necessarily perpetuate attention.' By straining to hear for acoustic cues, participants become fixed on the present moment.

Artists also encourage the audience to become aware of their spatial and bodily presence in the work. ADL notes that in his work 'technology is always employed in order to bring people more into their embodied physical present state, rather than something like VR that takes you out of it.' Spatial presence might be enhanced by an awareness of bodily sound, such as the sound of one's own footsteps. GS and EKM note that this may cause some visitors to move more slowly or tentatively, or even to take off their shoes so as not to destroy the auditory scene for others. For SK it is important to emphasise the visitor's presence in the work, because that *is* the interaction: 'the moment you're in it you're already interacting, by physically being present.' For the installation *Inner, Outer, Other*, SK flooded the atrium of a bank, which had the effect of drawing visitor's attention to their physical presence in the space because 'the moment you touch the water you're creating sound'. He contrasts this heightened sense of presence with interactive artworks employing motion capture sensors, for example: 'You don't have to wave your hand around and expect it to respond, that's naff, and that's mimicry, it's not actually telling you anything.'

SK and JW describe deliberate attempts to slow people down and encourage them to dwell in the artwork. For the installation *Enclosure*, SK describes using heat, slow sound and slow light to make audiences feel lethargic as 'basically a trap to keep you there!'. JW describes using slow and time-stretched audio to slow people down, which is apparently effective: gallery invigilators have reported visitors dwelling for 20-30 minutes in his sound installations.

4.2.4 *T4: Engagement Challenges*

All interviewed artists intend for their work to appeal to a broad audience but some voice concerns that sound art faces engagement challenges due to our cultural bias toward the visual, the inexperience of listening audiences and diversity of cultural associations. Many artists expressed a desire to better understand the experience of their audiences. Unfortunately, written and verbal feedback has proved limited, potentially due to the difficulty of articulating bodily and sonic experience verbally. Observation of audiences reveals little about the inner experience of visitors. A number of artists suggest ways of addressing or meeting potential engagement challenges in the design of the artwork itself.

4.2.4.1 *Challenges to broad engagement*

Some artists (ADL, DD, JB, SK) strongly emphasise that their work is intended for the broadest possible audience. When asked if audiences require any specialist knowledge or skills, SK responded 'none whatsoever, my audience is everyone and anyone.' While other artists (EKM, GS, JW, LH, JV) intend for their work to appeal broadly, they suggest that for a variety of reasons the engagement of audiences with little prior exposure to sound art and spatial audio might be a challenge. LH, JW and GS acknowledge that audiences with a sound art interest might have a different experience or understanding. EKM and JV propose that audiences simply do not know 'how' to listen, especially to spatial works where sound is coming from all directions.

ADL, JV and GS suggest that sound art faces engagement issues due to ocular bias, the cultural dominance of vision over audition in Western cultures. JV routinely runs listening workshops with people of all ages and finds that 'people just really don't tend to use their ears at all.' Furthermore, JB and ADL note that everybody comes to the experience of listening with different degrees of natural hearing ability and a variety of different cultural relationships to the sounds they are listening to. For JB, it is crucial that artists are aware of the diverse cultural meaning of sounds and is bemused by the idea that sine tones are free of association due to being 'the purest form of sound':

> If you ask any person on the street, pretty much bar people who are knowledgeable about electronic music and say what does that sound like? They'd say space, because of the 1960s, because of the way that

sine tones in early synthesis were used and their relationship to programmes about space.

Perhaps for this reason, exhibiting sound-based artworks can be problematic and particularly in public spaces. GS and JW reported instances where members of the public have threatened to call the police, or installations have been banned. GS suggests that while visual artists can get away with throwing pretty much anything at an audience's eyes, 'as a sound artist you can't. If you play a high frequency everyone's like "eurgh"... people react very, very drastically sometimes.'

4.2.4.2 *Limitations of audience feedback*

Of the 7 artists with experience collecting written or verbal audience feedback, SK, JV, EMK and JB find that it's of limited use. Audiences tend to use general terms to describe their experience and particularly when talking to the artist directly, are likely to politely express that the piece was enjoyable or interesting. ADL, JB and EKM suggest that obtaining useful feedback is problematic because people lack the vocabulary for describing sonic experience. JB describes written feedback as 'quite infuriating... some of the difficulty is that the language around listening is very stunted... I'd say about 80 percent of responses are one word, such as "beautiful", "peaceful", [or] ... "different"!'. To elicit more detailed descriptions of experience, JB suggests that you have to engage visitors in conversation and 'not give them the language, but... say that it's okay to describe it in their own terms.' The difficulty of describing sonic experience may explain why artists are more likely to act on feedback from peers and curators, rather than audiences (SK, LH, JW, JV).

4.2.4.3 *Limitations of observation*

A number of artists expressed the limitations of observing audiences because 'there isn't really a pattern to it' (JB) or they intend to create open situations where the audience is free to act however they are most comfortable (JV, ADL). Artists reported a number of generic behaviours that they considered typical but reveal very little about audience experience. For example, visitors are observed to settle into a comfortable way of being in the space, they might seek to find the boundaries and if the speakers are visible, they are likely to move between them listening to each. Depending on available space, visitors are likely to stand back and listen to the whole piece from different perspectives. Adults stand still for periods, they walk around, they might sit or lie on the floor. They're likely to be quiet, they might take

down their glasses, close their eyes or bow the head. Children are more expressive with their movement.

4.2.4.4 *Artist suggestions for improving engagement*

JV suggests that installations should create a situation that allows the audience to have their own experience, to be in their 'unknowingness'. The work should be supportive and inviting, so that even if audiences feel reticent, they're still happy and willing to step inside and be open to the experience. He suggests that 'you have to take them by the hand in some sort of way, help them out a little bit, fade into the whole thing.' EKM suggests engaging audiences through Q&A sessions prior to a performance, offering listening suggestions and instruction (EKM, LH). JB stresses the importance of communicating with local communities, to strengthen engagement and so that they feel invested in the artwork. To sensitise audiences to sound-based artworks, JV suggests leading listening exercises prior to engaging with an artwork. He suggests that it may only take a few minutes 'to get people to realise what they are actually doing with ears. And the reactions are amazing, I mean the whole world opens up.' EKM suggests that artists could conduct spatial listening workshops in schools with children from an early age, so that immersive sonic experiences become less strange and novel to the public.

4.3 DISCUSSION

Many of the artists that I interviewed acknowledge the influence of places and things on their process, and this led me to describe the artist's role as mediatory in Theme 1. By referring to mediation, my intention is to position the artist as acting in-between site and experience, as an intermediary who assembles, aligns or brings together the artwork rather than creating something apart from its context to be imposed upon it. The notion of mediation is key to Latour's Actor-Network Theory, where it is understood as the meeting of agencies between human and nonhuman actors [Latour, 1994]. The role of material agencies in the activity of music-making has recently been explored by music sociologist Krogh. Presenting a case study of Danish musician DJ Static, they argue that music-making is a highly situated activity. The layout of the studio and the material things that fill it have an active influence on DJ Static's working practices and compositions: 'the beat is a hybrid', a manifestation of material and social circumstances [Krogh,

2018]. I propose that situated sonic artworks embrace this hybridity and represent a coming together of the artist, material agencies and social circumstances.

While articulating artist processes as 'mediatory' is worthwhile, this finding is hardly surprising. Sound installation is historically defined by the close relationship of the artwork to its site of presentation [Seiffarth, 2012], and many artists continue to work in this tradition. Also, as described in Section 2.1.3, artists working with site have described entering into a dialogue with the associative and acoustic qualities of a place as an important part of the creative process [Fløe, 2018, Hayes, 2017, Klein, 2009]. The kinds of strategies that interviewees described for bringing traces of location into the artwork also resonate with LaBelle's description of Max Neuhaus's sound installations of the 1970s, which direct the ear to the found, bring it into relief by raising its volume and create an interplay between sounds placed and those already present [LaBelle, 2015].

A more surprising finding is the mediation of artists' own listening experiences to become that of their audience, leading to a symmetry of process and reception. Artists emphasised the need to immerse themselves in a site for long periods of time and methods that enable an embodied understanding were emphasised over objective analyses of a site. For example, Lisa Hall's process of 'assembling' the piece *Walking with Crickets* involved putting herself in the shoes of an audience member, walking and listening to understand how the piece operates on her own perception in different locations and circumstances. Her own embodied understanding shaped the artwork and, in turn, that of the audience. In *Art as Enaction* the philosopher Alva Noe describes the artist as an 'experience engineer' because the act of making a picture, for example, involves careful observation of the world, and 'an activity of reflection on what you see and what you have to do to see. The painter literally enacts the content of a possible experience' [Noë, 2002, p. 5]. The activity of the process of situated sound artists can be described in very similar terms: by carefully listening and reflecting on listening, the artwork has the capacity to transfer the perceptual experience of the artist to the experience of their audience.

The importance of material objects and 'staging' devices was another unexpected finding, especially since I didn't ask about these directly, and yet they were prominent across the interviews as a whole. Earlier, I described situated sonic artworks as unfolding in the audience's listening according to their objective spatial position and auditory attention. The artists that I interviewed (particularly those making installations) described methods for engaging and directing the listening

attention of audiences, either (explicitly) by verbal instruction or (implicitly) using lighting and the placement of material things. In spatial pieces, the audience is apparently free, but in fact, their experience is shaped by the artwork and the way that it is framed. In this way, artists influence or 'mediate' the perceptual experience of audiences. As Jeroen Vandesande noted: 'I decide the level of freedom'.

I suggest that artists shape the affordances for particular modes of listening for prolonged or exploratory engagement with their works. The *Barely* installation described in Section 2.1.5, for example, afforded close attentive listening by use of certain, very detailed sound materials. ' Affordance' is a term established by Gibson as a central concept in his work on ecological psychology: 'Affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill' [Gibson, 1979]. Keylin suggests that participatory sound art fosters affordances for creativity, exploration and connectivity [Keylin, 2020]. None of the artists I spoke to refer to these kinds of action possibilities, perhaps because their work isn't participatory in the sense that audiences are actively involved in sound-making. However, I suggest that many of the artists I interviewed work to foster affordances for perceptual action. Rather than physical behaviours, they describe the possibility for particular perceptual activities as a result of the artwork's design, such as a focused and meditative disposition to listening, sensitivity to bodily presence or an active acknowledgement of one's spatial relationship to the artwork.

It is important to note that affordances are relational and describe possibilities for action specific to the context and the individuals involved. Therefore, affordance delimits the effect of an artwork to its particular situation in which it comes to matter for certain people with certain preconditions [Krogh, 2018]. This is relevant to the engagement challenges faced by sound artists that were described in Theme 4. Not only does the specificity of affordances account for 'situatedness', but also a tension between experiences afforded to the artist, academic or curator and those available to somebody who has not encountered sonic artworks before. Furthermore, audiences arrive at an artwork with diverse listening abilities [Drever, 2019], formative experiences and cultural reference points. As James Bulley highlighted, sounds have different meanings for different people. A more thorough understanding of affordances in sound art might, therefore, help to pinpoint engagement issues.

4.4 CONCLUSION

In this chapter, I presented a series of interviews that were conducted with sound artists and composers, all engaged with situated sonic practices. By focusing on the practicalities of process, I hoped to understand how the activities of artists shape the reception of the work. A thematic analysis of interview transcriptions led to the formation of four themes, which represent patterns of shared meaning across the data set. Key findings include the characterisation of artist processes as mediatory, in the sense that they act *in-between* site and audience experience and are guided by the nonhuman agencies of settings and material things. Artists described working to understand the potential of a site through their sustained presence in it via close listening, probing the acoustic with bursts of sound or via more traditional acoustic analyses. Artists also described novel methods for engaging the ears of visitors through sonic devices and by harnessing the multimodal nature of an installation (through curation) to enhance or direct the listening experience. I likened sound artists to 'experience engineers' in the sense that their own embodied listening to a site is (to some extent) transferred to the experience of listeners via the design of the artwork. These findings inform my creative work throughout the PhD and are directly considered in relation to my own practice in the final study, described in Chapter 8.

The interviews have also defined aspects of perceptual behaviour that constitute active engagement with sound installations. Artists described the need for audiences to explore and bring together different spatial perspectives and to be actively aware of their changing orientation to sound as they move. Many artists described attempts to induce a meditative or inward focus and to sensitise audiences to sound, using sonic devices (volume, sound materials, spatial articulation) and staging devices (removing visual distractions, using light to focus gaze). These insights are valuable and directly inform the design of the ultrasonic installation technology described in the next chapter, along with artistic intentions for the two artworks made with the technology.

Whether or not these qualities are actually experienced by audiences is not known. The difficulty of eliciting feedback and tapping into the experience of audiences to sound-based artworks was noted by the interviewees. Observable behaviours such as walking, standing, and sitting are not distinctive enough to provide useful insights, while written and verbal feedback might also be of limited use because audiences lack the terminology to describe sonic experience. Further-

more, post-event audience reflections are time-sensitive and may not capture the temporal unfolding of an experience. These insights motivate my desire to test the effectiveness of the micro-phenomenology interview technique for eliciting the experience of spatial sound installations in rich detail, which is the focus of Chapter 7.

5

AN ULTRASONIC ART INSTALLATION ENABLING INTERACTION WITHOUT SENSORS

This chapter is built on material published in "Being With The Waves: An Ultrasonic Art Installation Enabling Rich Interaction Without Sensors", by Robson, McPherson and Bryan-Kinns, originally published at NIME 2022 [Robson et al., 2022] and parts of "Thinking with Sound: Exploring the Experience of Listening to an Ultrasonic Art Installation", by Robson, McPherson and Bryan-Kinns, originally published at CHI 2024 [Robson et al., 2024].

This chapter describes the design of an ultrasonic installation technology that has been developed throughout this PhD. Informed by a review of installation practices in the sound art tradition in Section 2.1 and practitioner insights described in Chapter 4, this chapter explores the interactive potential of installations that are 'static' [Cornock and Edmonds, 1973, p. 13] in the sense that emitted sounds do not change as a result of listener movement via computational processes. There are no movement sensors, programmed interactivity, mappings or feedback loops. Instead, the experience of listening may be perceived as interactive due to the spatial arrangement of sound sources and the close entanglement of the listener with sound phenomena physically present in the air. The interactive experience emerges as an embodied sensory experience determined by the listener's orientation to sounds, physical movement, and perceptual behaviour. In sum, the practice of designing the technology and composing with it addresses the research question:

RQ2: How might the entanglement of a listener with the physical phenomena of sound be harnessed in the design of an interactive sound installation to promote rich sensory experience?

Following a brief review of related artworks and technologies (Section 5.1), I articulate a series of key design intentions (Section 5.2) before describing the technical implementation (Section 5.4). Employing ultrasound, the installation sounds acoustically but mostly inaudibly in the exhibition space, and a hidden multi-

channel musical composition may only be heard via specially designed sets of headphones. The process of shifting sounds between the audible and ultrasonic range using amplitude modulation alters the spatial appearance of sound and exaggerates the Doppler effect, such that listeners hear sounds bend and shift in a manner intimately connected with their bodily position, orientation and movement in the installation space.

The strong mediation of sound by the system transforms its spatial and interactive appearance. Early experimentation to learn *how* to compose with the technology is described and discussed in Section 5.5. Two artworks are created using the technology. The first, *Being With The Waves*, is described in Section 5.6 of this chapter before its involvement as a research probe (see 3.3.1) in Chapters 6 and 7. The situated practice of creating the second artwork, *Sonographies* is the focus of Chapter 8.

5.1 RELATED WORK

The installation described in this chapter allows the listener to explore physically present but inaudible phenomena via a custom device that augments the ear for superhuman listening. The listener's experience is determined by the orientation of a sensing device to the environment. This format is not without precedent. For example, Kubisch's *Electrical Walks* invites audiences to explore urban environments using headphones that convert electromagnetic signals into sound [Cox, 2006]. Presented at NIME 2015, the *PHOX Ears* listening device consists of two parabolic microphones mounted on a helmet, allowing the wearer to hear distant sound sources [Kleinberger et al., 2015].

Van der Heide's *Radioscape* (2000-) is a strong influence on the installation technology developed through this PhD. *Radioscape* is an interactive sound installation operating in public space, whereby a composition is emitted via a number of transmitters in the electromagnetic spectrum. Using a long wavelength of 175m for the transmission of signals, buildings become not just reflectors but also conductors and resonators. In this way, 'the physical environment gets excited by the transmitted radio waves' [van der Heide, 2013, p. 16]. Visitors explore the installation using a handheld receiver with two antennae, one vertical and one coil. These have different sensitivities and relate to the electronic and magnetic components of the electromagnetic field, respectively. The perceived spatial image is not broadcast but created by the receiver and results from the spatial positions of individ-

ual transmitters. Listeners determine the composition of the sounds. By walking around, certain signals become louder while others fade. Movements of the receiver allow more nuanced reorientations of perspective and enable the listener to explore space. Van der Heide notes that 'the scale and the speed of change match the space that the participant's hand and arm movements describe' and this close and intuitive coupling of action and sound makes the space itself 'almost tangible' [van der Heide, 2013, p. 16].

Ultrasound typically refers to sounds with a frequency higher than 20kHz, phenomena that are physically present but imperceptible due to the limits of human hearing. Ultrasonic distance sensors are widely used in digital musical instruments (DMIs) and interactive devices (e.g. The Overtone Violin by Overholt [2005]), but arguably the technical and creative potential of ultrasound has been underexplored. At NIME 2010, Ciglar introduced a musical interface allowing mid-air, haptic manipulation of audio material emitted via an array of ultrasonic transducers [Ciglar, 2010]. Raes [1999] describes a system for sensing the gestures or bodily movements of a musical performer based on the continuous reflection of ultrasonic waves from their body. Utilising the Doppler effect, the system senses the dynamics of motion rather than positional information, a paradigm that the author argues is well suited for implementation in musical instruments.

Many artists have used directional sound in installations via the use of parametric speakers such as the Audio Spotlight [Yoneyama et al., 1983], which consists of an array of ultrasonic transducers and allows sound to be projected in a hyper-directional beam. Artists such as Pampin et al. [2007], Alunno [2018], and Rijnierse and Bothof [2016] have worked closely with this technology to create installations that exploit the strong directivity and reflectivity of ultrasound. In Alunno's *The Soundhouse*, for example, a rotating parametric speaker projects a soundscape around its environment like a lighthouse casts a beam of light across the sea [Alunno, 2018].

5.2 DESIGN INTENTIONS

Inspired by installations in the sound art tradition and informed by the findings of Chapter 4, this section articulates key design intentions for the sound installation technology described in this chapter.

5.2.0.1 *Acoustic Interaction*

The first design intention concerns how sound, space and listener should interrelate thanks to the use of technology to mediate listening. Inspired by installation practices in the sound art tradition, the design process was guided by the intention to implement interaction through the configuration of acoustic properties; **to preserve the acoustic entanglement of body, sound, and space as the origin of interactivity, rather than programmed event-loops and mappings**. In short, to design an *acoustic interaction* but augment this paradigm using digital technology as a mediating layer that transforms the appearance of sound. This approach is at odds with interactive systems comprising movement sensors, mappings and auditory feedback, which imply a separation of body and sound.

5.2.0.2 *Spatial and Embodied Awareness*

While not wishing to limit or restrict listener behaviour, I sought to encourage spatial interaction on both a macro (moving across the whole space) and micro scale (via tiny head movements or adjustments to body position). Therefore, **the spatiality of sound and its physical presence in the installation space** should be emphasised through the installation's design. It should create a situation whereby sounds have distinct locations in the space and bodily movement leads to clearly discernible sonic variation, with even very small adjustments to bodily position. Auditory feedback should be tightly and intuitively coupled to listener movements. Drawing on the interview findings in Chapter 4, listeners should be encouraged to be perceptually active. The installation should **encourage close and attentive listening together with an active awareness of the body's relationship to sound and its physicality**.

5.2.0.3 *Contextualise Interaction*

Third, the design process was guided by the intention to **contextualise interaction within a sound design schema**, such that the two aspects are perceived as a conceptual whole rather than separate parts of the installation. This point relates more to the practice of creating artworks *with* the ultrasonic technology. Throughout the process of developing *Being With The Waves* and *Sonographies*, the questions: 'why is this technology used in this context?', 'How might it contribute to meaning-making in the work?' and 'What kind of sounds complement the technology?' are asked continually.

In papers that describe technology-oriented installation designs, the rationale for sound design choices is rarely described, and a greater emphasis is placed on the interface design and mapping strategies. Quite often, supposedly 'neutral' sounds are chosen - soundscapes, field recordings, simple melodies, drones. In Chapter 4, James Bulley noted that no sound design choice is neutral; all sounds have meaningful associations. It was therefore acknowledged in this design process that the selection and composition of sounds would be instrumental in configuring the interaction and should be treated as such, rather than as tacked on to the technology. This approach reflects the wider intention to consider the experiential whole in the design process, to design a coherent ecology of relations rather than a series of gestures or inputs, mappings and sonic outputs as separate parts of the system.

5.3 IDEATION AND EXPERIMENTATION

The development of the technology for configuring the interaction came before specific, sonic and conceptual ideas for installation artworks. This was not a conscious decision; the development of the practical work in the chapter unfolded quite organically and was no doubt influenced by our affiliation with technical fields of sonic interaction and music HCI research.

In the early stages of development, discussions focused not on the technology itself but on more abstract thought experiments led by questions such as: 'How could listeners be encouraged to actively listen?', 'Could an installation be designed whereby you don't hear it unless you are active?' and 'Could sound be hidden in some way so that listeners need to be active, to *do something*, to hear the piece at all?'. The idea of hiding sound and revealing it to the active listener led to a consideration of ultrasound and experiments with amplitude modulation. Rather than sound being acoustically present to the naked ear - *just there* - the listener would have to do something to hear the piece. Even though this might entail simply placing headphones over the ears and recognising the spatial presence of sounds, this act represents a clear transition from not participating in the piece to participating. To hear the installation at all, necessitates some kind of listener engagement.

As well as keeping the acoustic presence of sound phenomena hidden, it was suggested early on that the speakers should not be visible, instead concealed behind other objects, or placed in a darkened space. Therefore, listeners must come

to recognise the spatial placement of sounds in the space through the act of listening, rather than relying on the visible presence of a multi-channel speaker setup to acknowledge the piece as spatial and to show the listener where sounds are emanating from.

While experiments with ultrasound were undertaken primarily with the idea of hiding sound in mind, I discovered unexpected effects in the process, which emphasise the listener's bodily entanglement in the field of sound and, therefore, work to meet the design criteria set out above.

5.4 TECHNICAL IMPLEMENTATION

The installation system may be broadly conceived in terms of emitter and receiver side technologies and is described in Figure 5.1. Please note that small changes were later made to the hardware and circuitry. Since these impact the design of the second artwork, *Sonographies*, they are described in Section 8.2.3 of Chapter 8.

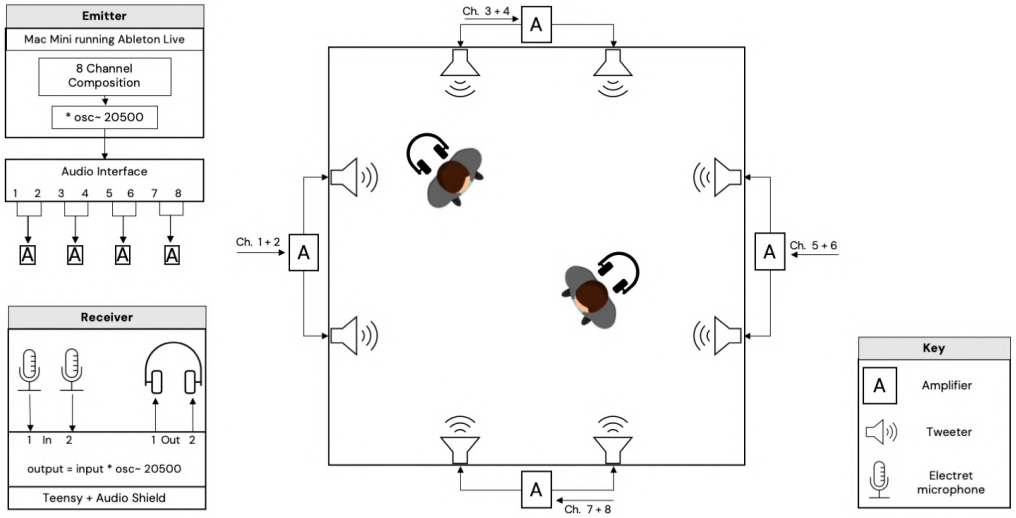


Figure 5.1: *Being With The Waves* system design. On the emitter side, a multi-channel composition is shifted to the ultrasonic range before sounding in the space. On the receiver side, audio signals taken from microphones housed on the outside of headphone earcups are routed to a microcontroller, demodulated back into audibility, and output to the headphones.

5.4.1 *Emitter*

The installation consists of audio playback into the space via a series of tweeters suited to the transmission of ultrasound. Eight individual audio tracks are composed in the audible range and arranged in time (rather than procedurally generated) using the digital audio workstation Ableton Live[2]. Each track is shifted into the ultrasonic range using the technique of amplitude modulation. This is implemented by a Max for Live device[3] on each audio channel that multiplies the audio signal by a sine wave with a frequency of 20.5kHz, shifting the signal by this amount. Each modulated signal is output via an audio interface to an amplification circuit and emitted into the installation space by an individual tweeter.

5.4.2 *Receiver*

The multi-channel composition sounds physically but inaudibly in the space. Listeners hear the installation by wearing specially designed sets of headphones, seen in Figure 5.2. Sound phenomena are captured by 10mm omnidirectional electret microphone capsules[1], housed on the outside of headphone earcups, approximating a binaural arrangement. Signals are amplified via a custom amplifier circuit and routed to a Teensy 3.6 microcontroller[2] via its audio shield. A Teensy sketch running at a sample rate of 96kHz demodulates each microphone signal via the same process of amplitude modulation, before outputting the signal through the corresponding ear of the headphones. An Adafruit Powerboost 500[3] powered by a rechargeable Lipo battery supplies 5V to the Teensy and the amplifier circuit.

Implementation of the system requires careful attention to the frequency response of components and the availability of high sample rates. On the emitter side, the wide frequency response of the RME Fireface 800 interface[4] allowed experimentation with carrier frequencies of up to 40kHz. On the receiver side, the Teensy 3.6 was chosen because, although its audio shield is advertised as running

2 Ableton Live is a software sequencer for producing, arranging, mixing and performing with audio: https://www.ableton.com/

3 Max for Live devices integrate the functionality of the visual programming language Max, within Ableton Live, allowing users to create custom audio effects and instruments: https://www.ableton.com/en/live/max-for-live/

1 https://micbooster.com/microphone-capsules/199-222-primo-em272.html

2 https://www.pjrc.com/store/teensy36.html

3 https://www.adafruit.com/product/1944

4 https://archiv.rme-audio.de/en/products/fireface_800.php

at a fixed sample rate of 44.1kHz, PJRC forum users have shared the code to enable high sample rates up to 192kHz[5].

During experimentation, it was noted that the carrier frequency used in the process of amplitude modulation influences the directivity of the sound source, i.e. how localised a sound is to its speaker in the installation. Early on, I found myself settling on a carrier frequency of 20.5kHz - definitely inaudible to the naked ear, but low enough to be unaffected by the roll off of microphone frequency response. With much higher carrier frequencies of e.g. 40kHz, sounds are heard within a much narrower area and could therefore be 'hidden' within the installation. The trade-off, however, is that due to the roll-off of the microphone frequency response, these sounds must be output from the interface at a much higher volume.

To emphasise the act of listening, the headphones should recede into the background of perceptual awareness. Listeners should not need to hold anything or be continuously aware of the technology's presence. Therefore, a small acrylic box was designed to be worn around the neck, as seen in Figure 5.2. This houses all electronic components, includes an on/off switch and a rotary knob for volume control.

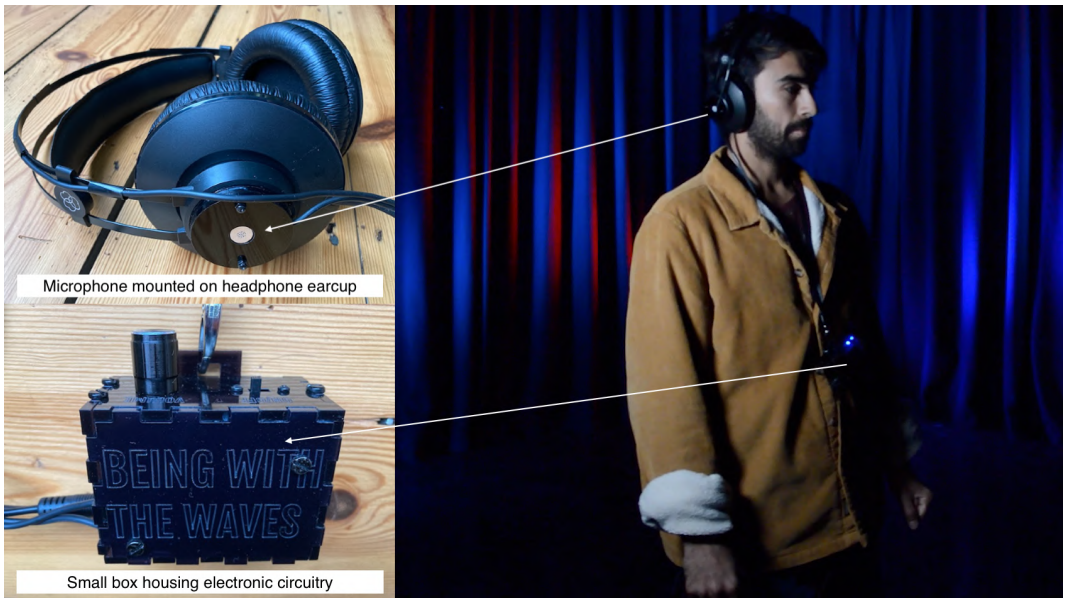


Figure 5.2: The modified headphone sets designed for *Being With The Waves*. Small electret microphones are mounted on the outside of headphone earcups. Ultrasonic signals are routed to an amplification circuit and Teensy microcontroller housed in the small black box. This is worn around the neck of listeners and includes an on/off switch and volume control knob.

5 See post 13 by user 'DD4WH' https://forum.pjrc.com/index.php?threads/bat-detector.38988/

5.4.3 *Modulation Effects*

Following demodulation, the audio fidelity of the original multi-channel composition remains remarkably intact but is coloured by room acoustics, bodily presences, and the materiality of electronic components. The spatial appearance of sounds, however, is transformed. A feature of ultrasound is that it has a tighter directivity in its transmission than lower-frequency sounds. Listening through the microphones entails some flattening of the spatial dimension. Sounds appear closer, with a lack of depth (see Appendix C.1.4 for details). It should also be noted that while the placement of microphones on the outside of the headphone earcups was designed to approximate a binaural setup and produce as natural a spatial representation as possible, in fact, the relatively very short wavelengths and process of demodulation completely distort the spatial presentation of sounds. Achieving the accurate localisation of spatial sound sources from pitch-shifted ultrasonic signals requires close attention to the placement of microphones on something like a tiny model head, along with dedicated processing. This is demonstrated in the work of Pulkki et al. [2021], but not implemented in this project.

Arguably, the most dramatic effect of ultrasonic modulation in the system is that the Doppler effect becomes exaggerated. The Doppler effect is a familiar process where the perceived frequency of a sound changes when the sound source moves toward or away from the listener, owing to the finite speed of sound in air [Reiss and McPherson, 2014]. In everyday life, it is often most noticeable with moving vehicles, where an approaching vehicle's sound will be shifted upward in pitch, and a receding vehicle's sound will be shifted downward. Doppler shift functions as a ratio in frequency, where each frequency component is multiplied by a factor that depends on the velocity between the source and the listener. Consider a source signal of frequency $f_s = 1000\text{Hz}$, a carrier of frequency $f_c = 25000\text{Hz}$, and a Doppler shift ratio $r = 1.01$ from the motion of the microphone with respect to the tweeter. Without ultrasonic modulation, the perceived frequency would be $rf_s = 1010\text{Hz}$.

With ultrasonic modulation, the tweeter will emit frequency components at $f_c \pm f_s$, in this case 24kHz and 26kHz. Doppler shift will cause the received frequencies at the microphone to be $r(f_c \pm f_s)$, or 24.24kHz and 26.26kHz. When these signals are demodulated, the resulting frequencies will be $f_c - r(f_c \pm f_s)$: 1260Hz and 760Hz. What was previously a change of just 1% in frequency is now an audible shift of around 25%, and split into two tones owing to the two sidebands of the

modulation process. Of course, this effect is still entirely dependent on movement: a completely static position will not introduce any Doppler shift.

The exaggerated Doppler effects that result from ultrasonic modulation mean that bodily movements are heard as pitch shifts and timbral distortions to the spatial composition; listeners hear the audio warp and shudder in a manner that is hypersensitive and intimately connected to their bodily behaviour. For emphasis, a listener's movement does not alter the sonic composition emitted into the space. Effects are heard by individual listeners, determined by their physical movement and spatial orientation to sound sources.

5.5 SOUND DESIGN EXPERIMENTS

In Chapter 4, sound artists described the early phases of their process in terms of an ongoing exploration in which they seek to understand and then harness the experiential potential of a site. Many artists emphasised the importance of their own extended embodied experience in this process. Notably, Lisa Hall described her practice as site-specific to a body rather than physical location and as such, her creative process involves immersing herself in the situation of her artwork to understand what it does and how it changes her listening perception.

Composing with the installation technology requires a similar approach. While the modulation process maintains audio fidelity, it alters the spatial characteristics of sounds due to the heightened directivity of ultrasound, the properties of the material components, and the acoustic qualities of the installation environment. When listening through this system, sounds become peculiar and exhibit unfamiliar behaviours.

Once I had a working prototype of the ultrasonic installation technology, the design process entailed listening to different sound materials in order to understand their spatial appearance. Over time, I came to understand the types of sounds that work effectively with the technology (and those that do not), how they impact physical and perceptual listening behaviours and the felt quality of interaction. This period of exploration, learning and practising with the system was a crucial stage of the design process and shaped the underlying concept of the first artwork created with the technology, *Being With The Waves*.

Simple sustained sounds such as sine tones or harmonic instrumental tones appear to fill the space as an ambient presence. The Doppler effect is very prominent; tiny sonic fluctuations may be appreciated via micro-movements, and more promi-

nent distortions to the sound are heard as a result of quicker movements over a larger area. By contrast, inharmonic, articulated, and transient-rich sounds have a well-defined spatial profile. Turning on the spot, the listener becomes aware of their changing orientation to sounds, but the system distorts their perception of distance. Speech, for example, sounds broadcast as though on the radio, but with the signal coming from a very particular, narrow location and perceived close to the ear rather than originating from a faraway source. For more detail, see Appendix C.1.

5.6 ARTWORK 1: BEING WITH THE WAVES

The first artwork created with the ultrasonic installation technology is called *Being With The Waves*. Having listened to and experimented with a variety of different sound materials through the technology, I sought to establish a kind of sonic language; ways of composing sound for and with the ultrasonic technology that would also reinforce experiential qualities of interaction. This was a key motivation for the work and a new creative challenge. I had not previously explored the relationship between sound design and the felt quality of interaction so explicitly.

Being With The Waves was conceived in response to a call for artworks to be included in the Ramsgate Festival of Sound. I live in Ramsgate, and at the time when the call was publicised (May 2021), the UK had only recently emerged from COVID-19 restrictions. The opportunity to exhibit the work without the need to travel was appealing. The festival theme was to be 'Stories from the Sea', and proposals that responded to that theme were considered favourably. This theme connected with the sensation of sustained sound as a kind of fluid matter and the suitability of the installation to speech and environmental sound recordings.

I work quite regularly with spoken word and oral histories in other parts of my creative practice and - thanks to the festival theme - saw an opportunity to bring that experience into the making of the installation. Excerpts from micro-phenomenological interviews conducted with Ramsgate residents exploring sensory experiences in and with the sea - how it feels to catch a wave, float, or be submersed - are interwoven with an immersive musical composition of drones, instrumental textures and field recordings. The installation, therefore, through the felt quality of movement-sound interaction, is intended to *elicit* for the listener an experience of fluidity and of being with the phenomena of sound. Through the field recordings of waves and boats clanking, the installation also *signifies* the

themes of sea, fluidity and bodily experience. In this way, I met my design intention (described in Section 5.2.0.3) to contextualise interactive effects within a sound design schema. Artistically, I was interested in the interplay between these felt and representational qualities in the installation - their presentation, arrangement and balance - and how these would translate, i.e. be felt, experienced and understood by listeners.

5.6.1 *Sound Design*

Please refer to `https://nicolerobson.com/being-with-documentation` for video footage of the installation. Headphone listening is recommended to hear the same audio that was fed to the listener during their interaction.

The process of composing and arranging sounds for the installation was guided by the wish to encourage physically and perceptually active listening behaviours. Specifically, I wanted the sound design to support listeners in experiencing the feeling of being immersed in sound, becoming aware of their presence in the installation, and appreciating the fixed spatial arrangement of sounds. The process of exploring and coming to understand the embodied experience of different sound materials in the installation enabled me to pair sounds with these types of encouraged listening behaviours. This led to the idea of structuring the installation around a series of scenes, each composed using a particular type of sound material, to encourage particular modes of interaction.

The final composition is a 25-minute loop consisting of five scenes, which are described below. They are not defined in the composition as separate sections; there are gradual transitions from one to the next.

1. **Pulled Under The Waves**
   The story of an RNLI lifeguard being pulled under the waves and then dumped onto the beach is heard along with field recordings from Ramsgate harbour: the sound of lapping waves, the ambience of the harbour and the creaking of boats moored there.

2. **Fog Horns**
   A foghorn sounds from one side of the installation, and a similar bassoon tone is heard in response shortly afterwards, sounding from the opposite side of the space. These gestures are repeated, and gradually, the fog horn

becomes elongated and begins to fill the space as a continuous presence. A collection of sine tones whose pitches are derived from a spectral analysis of the fog horn slowly ramping up in amplitude.

3. **Underwater Colours**
   The horns disappear, leaving a landscape of sine tones - each emitted from a different tweeter, fading in and out at random to create a pleasing sense of both continuity and ebb in the space. With her head submerged, a sea swimmer describes the colours and visual qualities of the water and then the sounds that can be heard as she moves through the water.

4. **Catching the Wind**
   Field recordings from the harbour return, this time accompanied by bell-like piano notes, each sounding from a different speaker in the installation. A sailor describes the sensation of catching wind in the sails and being carried smoothly through the water.

5. **Textured Space**
   The sound of waves remains and, along with two textured violin drones, becomes louder and more prominent in the installation, filling the space. The violins are recorded close up to the string so that you hear the hair of the bow and changes of the bow stroke.

Being With The Waves is intended to encourage macro-scale interaction to discover the spatial locations of different sound materials. The spoken word parts are only audible in proximity to the speaker from which they are emitted. This mode of interaction is particularly emphasised in scenes 1 and 4, though it is part of the experience whenever there are voices. The feeling of being immersed in sound is strongest and most aesthetically pleasing (in my opinion) when the tweeters each emit sustained tones of different frequencies, collectively forming a complex chord of some kind. The prominence of the Doppler effect encourages the exploration of sound with bodily movement and appreciation of sonic fluctuations at the micro-scale. This mode of interaction is emphasised in scenes 2,3, and 5.

The number and position of tweeters, final arrangement, placement and mix of sounds, together with staging aspects such as lighting, must be determined in situ. It is my experience that the piece cannot be lifted from one space and placed into another without a rearrangement and re-mixing of the installation file.

5.6.1.1 *System Noise*

The level of noise and whine in the implementation described in this chapter is workable and does not interfere with the listening experience, but it is audible when the Teensy is set to higher volumes. The principal source of this whine is the Adafruit board powering the project. The whine is demodulated into audibility and doesn't have a stable pitch. Some notch filtering works to quieten the whine, but at the expense of the audio fidelity in general. These issues are addressed later in the thesis, in Section 8.2.3.

5.7 DISCUSSION

From my perspective as a creative practitioner, the process of designing *Being With The Waves* was different to any other compositional process that I have taken part in. Due to the use of ultrasound, modulation processes in the system and microphone-mediated listening, the material of sound became strange to my ears. A large part of the compositional process entailed familiarising myself with the presentation of sound when listened to through the installation. I could only begin choosing, creating and arranging sounds once I *understood* this new and unfamiliar sonic material.

Ordinarily, when composing, the choice of sound materials to be used is led by an aesthetic choice relating to the context, atmosphere or extra-musical meaning that I want to create. In *Being With The Waves*, these were secondary considerations. The selection of sound materials was guided by experiential knowledge accrued over time by listening to different types of sounds located and oriented in the installation in different ways. All the time attending to the *feel* of interaction, whether sounds are engaging and interesting to the listener when mediated by the system. Only once I had identified the most appropriate or effective sound materials (from my own embodied perspective) that extra-musical meaning could also be considered.

When I attempted to impose a musical or sonic concept on the installation before familiarising myself with the sound materials experientially, it did not work. To illustrate this point, consider the following anecdote. After listening to environmental field recordings (outdoor spaces punctuated by bird calls) for the first time through the system, I became excited by the experience they afforded of being transported to a different landscape, far beyond the boundaries of the room I stood in. I thought that I had made a breakthrough conceptually and imagined the

installation space as an expansive outdoor environment filled with reed beds, the visitor stepping among them and listening in to the percussive impulses created as the reeds knock into each other, swaying in the breeze. Convinced this would be a beautiful way to implement the technology, I spent a day collecting closely mic'ed recordings of reed beds at a local nature reserve (see Figure 5.3). I assembled a sketch for the installation the next day, placing different recordings throughout the space, but it sounded horrendous. The recordings sounded thin and localised to spots in the installation. There was no sense of being transported to another landscape. Plus, the sound of the reeds essentially created white noise, which is highly sensitive to the Doppler Effect, juddering with the listener's movement.

Figure 5.3: Recording the reed beds at Oare Marshes in Kent

My imagined idea of how the field recordings would sound was not grounded in experience of the installation system, but of composing for audible speaker-based installations where the directivity of sound is not so focused. This wrong turning demonstrated the importance of a bottom-up compositional process, whereby the sonic content is guided by the affordances and constraints of the installation rather than by an imposed conceptual or aesthetic idea. This necessitated a much more open-ended design process and a willingness to be guided by the material.

In this respect, my findings resonate with Tim Ingold's perspectives on material-led design, calling for the material to serve as a guide that actively influences the process of formation. Ingold [2010] argues against the 'hylomorphic' model of creation, whereby making is conceived as the imposition of form on the material world by an artist/ agent with some pre-existing design in mind (p. 92). Instead, proposing that 'the forms of things arise within fields of force and flows of material. It is by intervening in these force fields and following the lines of flow that practitioners make things' (p. 91). Borrowing the example of the woodman's axe from Deleuze and Guattari [1988], Ingold cites the woodman's ability to follow the grain of the wood with his axe strokes (p. 92). Approaches to the design of musical interactions that champion this approach have also been noted in Nordmoen et al. [2019], Tuuri et al. [2017] and Thorn and Wei [2019].

For Ingold, the artist is (from the outset) a 'participant in amongst a world of active materials wherein a process of making, the maker "joins forces" with the materials, splitting them, bringing them together in anticipation of what might emerge' [Ingold, 2013, p. 21]. However, the artist is not passive, blindly fumbling about until the materials show them the way. Having developed 'a highly acute sensitivity and tacit understanding of the affordances and constraints of the materials at hand' [Frankjaer and Dalsgaard, 2020, p. 4], the artist is in a state of anticipation, they can 'see forward' [Ingold, 2013, p. 69] and stay 'one step ahead of the material' [Sennett, 2008, p. 175]. Reflecting on the process of composing *Being With The Waves*, it was only once I had developed this kind of *acute sensitivity and tacit understanding* of the installation described above that I could see a way forward, working *with* the material.

In *Being With The Waves*, the art material is not simply sound itself, but sound as mediated through the installation system, acoustic properties of the space, and by the listener's movement and perceptual activities. It is inherently relational but also somewhat mysterious; invisible, ephemeral and time-based. Whereas a physical, tangible material may be relied upon to feel and behave the same way in one room compared with another, sound cannot. The same sound may be emitted via the same technologies, using the same components and yet, experientially, feel very different depending on the material and acoustic properties of the space in which it is installed.

5.8 CONCLUSION

This chapter introduced the ultrasonic installation technology and the first artwork created with it, *Being With The Waves*. It described the intentions and influences that guided ideation and the development of a novel installation design, which, inspired by installation practices in the sound art tradition, is sensor-free and harnesses the materiality of sound. Nevertheless, it is perceived as interactive due to the spatial arrangement of sounds and the close entanglement of the listener with acoustic phenomena. These aspects are emphasised by ultrasonic modulation, which leads to exaggerated Doppler effects. The listener hears the direct consequence of their bodily movements in relation to sounds fixed in space.

To the best of my knowledge and informed by a review of headphone-mediated and ultrasonic artworks, the installation technology described in this chapter is novel: the only sound installation whereby a hidden ultrasonic composition is revealed to listeners wearing specially designed headphones. Technical details were described, including the processes of amplitude modulation and demodulation and the prominence of the Doppler effect, which, together with the work's spatial arrangement, produces the sensations of dynamic, embodied interaction without the use of sensors and mappings. The process of composing for the installation was described and discussed, highlighting the need to gain material knowledge of sound as mediated by the installation technology before establishing compositional methods.

Finally, *Being With The Waves* was introduced. This is the first of two artworks created with the technology during this PhD and is employed as a research probe in the following chapter, which explores the experience of listening to the installation in the context of a public art festival.

6

STUDY 2: EXPERIENCING BEING WITH THE WAVES AT A PUBLIC ART FESTIVAL

This chapter includes material published in "Listening Together-Apart: The Social Mediation of Sound Installation Listening", by Robson, McPherson and Bryan-Kinns at Audio Mostly 2025 [Robson et al., 2025a].

It is widely acknowledged in HCI and interactive art research that a person's experience of technology is strongly influenced by its context [Benford et al., 2013, Blomberg et al., 2017, Mackay and Fayard, 1997]. Lab-based studies do not account for conditions that emerge in public exhibition spaces, nor the influence of social factors. This chapter describes a research study conducted during the presentation of *Being With The Waves* during *Ramsgate Festival of Sound* in September 2021.

Being With The Waves is, arguably, *antisocial* by design, foregrounding private rather than collective experience. Inaudible to the naked ear, the artwork is heard via custom headphones and, as an experience, manifests differently for individual listeners according to their spatial orientation to speakers, body position, movement, and perceptual behaviour [Robson et al., 2022, 2024]. Unlike interactive sound installations such as *DETOUR* [Charitos et al., 2006] and *SoundPlay* [Mushiba, 2018], *Being With The Waves* is not designed to instigate social interactions between members of the public. However, during a public exhibition, up to six listeners may experience the installation simultaneously, creating a social dimension that inevitably mediates behaviour.

The research study reported in this chapter was designed to explore listener engagement, physical behaviour and their mediation by the public exhibition context. This chapter addresses RQ3:

RQ3: How do listeners experience a sound installation in the context of a public art festival?

(a) What do listeners do? In terms of:

  (i) Physical behaviour (e.g. movement, bodily dispositions)

  (ii) Perceptual activity (e.g. directing attention, intention setting)

(b) How do the material and social context mediate behaviour?

This study is designed to collect data relating to the experience and behaviour of listeners in the context of a public exhibition and to collect feedback from a self-selecting group of participants who have an existing interest in sound and installation art (outside of London). Taking an ethnomethodological approach, the installation space is filmed to observe behaviours and, inspired by interactive art research [Bilda et al., 2006, Candy, 2014, Costello et al., 2005], visitors are invited to complete a short survey about their experience of the artwork. These research methods are critically adopted and chosen primarily as they have low interference [Bengler, 2015] with the listener's experience of the artwork. Our findings identify important ways in which the physical behaviour of listeners appears to be mediated by the presence (or not) of other people in the exhibition space. Our analysis indicates that the local social dynamic has a strong impact on how listeners move and use their bodies, which in turn impacts the extent to which they can discover and explore spatial and interactive effects of the installation.

6.1 STUDY DESIGN

Study 2 took place from the 2nd to the 5th of September 2021 when *Being With The Waves* was exhibited as part of the Ramsgate Festival of Sound[1], an annual community-focused event showcasing sonic artworks, theatre and musical performances. The installation's selection in the festival was the result of a successful application to an open call for artworks to be part of the *Sonic Trail*, whereby seven sonic artworks were installed at different venues throughout the town. Visitors to the festival were given a map showing the location of each installation and could choose to walk between them. *Being With The Waves* was installed in the auditorium space at Ramsgate Music Hall[2], a small music venue in the centre of Ramsgate. I greeted visitors upon arrival at the venue, introducing the installation verbally using the brief curatorial text that I had supplied to the festival as a guide:

> Explore sound as a fluid presence that fills the space around you and discover stories of seaborne experience woven into an immersive composition that bends and shifts with your movement. To the naked ear, the installation *Being With The Waves* appears silent, but a hidden world

1 https://www.ramsgatefestival.org/
2 https://www.ramsgatemusichall.com/

of voices, instrumental tones, and maritime sounds is revealed through wearing special headphones.

6.1.1 *Installation Set-Up*

Since the venue was not very big (32.5m2), a six-channel arrangement of ultrasonic transducers was chosen, with two spaced along each side wall and two placed along the centre of the space. Figure 6.2 shows the arrangement of the speakers and the house lights that were used to illuminate the installation, re-fitted with red and blue bulbs. It also shows the position of two ledges on the left and right walls of the room that are ordinarily used as places for gig-goers to put their drinks but that were acted upon by listeners to the installation as objects to lean on or hold onto. As far as possible, the space was made to feel like a 'black box' – the stage was curtained off, and signage was covered, but the space's materiality as a live music venue could not be erased. The ceiling supported a truss carrying cabling, theatrical lights, security cameras and ultrasonic speakers for the installation. The speakers could be seen if you really looked for them but were placed above the eye-line and concealed among other objects.

Figure 6.1: An image of the installation space captured by the GoPro used to record video observations.

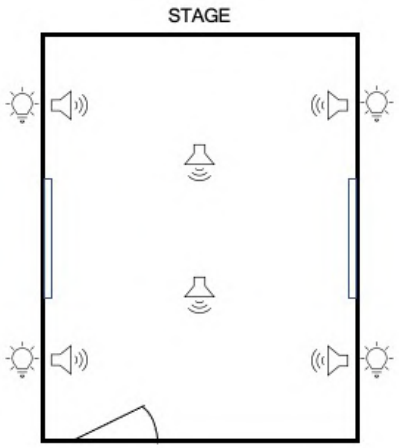


Figure 6.2: The installation's spatial arrangement at Ramsgate Festival

6.1.2 *Data Collection Methods*

A multimethod approach was chosen, informed by a review of methods in the field of interactive art research, ethical issues, and practical considerations. Whereas a mixed method approach to research combines qualitative and quantitative research methods, multimethod research employs either many types of qualitative data or many types of quantitative data [Mik-Meyer, 2020]. Creswell and Creswell [2014] suggests that a combination of methods can contribute to a better understanding of a research problem compared to using only one methodological approach. Another advantage of combining qualitative methods lies in the possibility of investigating the 'multiplicity and contingency of the social world' [Moran-Ellis et al., 2006], allowing for different nuances and angles to be visible [Mik-Meyer, 2020]. Here the data-collection methods are post-experience surveys, video observations, and a visitor logbook (see Section 3.5.1).

6.1.2.1 *Practical and Ethical Considerations*

The study design was influenced by several practical considerations. In Chapter 4, sound artists noted the limited nature of written and verbal feedback. James Bulley suggested that listeners need to be engaged in conversation and helped to describe their experiences in their own language. Ideally, therefore, I would interview listeners shortly after their experience and help them to describe their

experience in fine detail. However, in this case, I was required by the festival to invigilate the installation at all times, greeting (groups of) listeners, handing out headsets and dealing with any technical problems or visitor questions. There was neither the time nor the space to conduct interviews with listeners while the installation was running. Instead, a short survey was designed for listeners to complete after listening to the installation. The venue's layout also influenced the study's design. The installation was in a separate space, and it would not be possible to observe listening behaviours directly from the researcher's position in the foyer. It is likely that the presence of an observer in the installation space would be a distraction to listeners and interfere with the social context. For this reason, it was most practical to film the installation space and make observations from the recording later.

The public context of the installation was key to the research aims. The study was therefore designed in such a way that the activities of data collection had a minimal impact on listener experiences. Context is delicate, and the intention was for listeners to approach the piece as they might any other artwork at the festival. This intention needed to be balanced with the desire to collect meaningful data in an ethical fashion, ensuring listeners' participation in the research was understood and consented to. The chosen approach was to allow visitors a free interaction with the artwork and introduce the research after they had finished listening, at which point, each listener was invited to complete a post-experience survey and consent form. During times when filming was happening, this was clearly signposted to listeners before entering the installation. Consent was sought from listeners as they exited the installation, and only footage for which the consent of listeners was given was included in the analysis.

The following section will outline the data collection methods chosen for this study: visitor logbook, post-experience survey, and video observations.

6.1.2.2 *Visitor Logbook*

A log was kept of visitor numbers and dwell times. For each new listener, the log was completed by hand with their unique listener number (e.g., P1, P2, P3...), a number (1-5) associated with the set of headphones they were given, the time that they entered and left the installation, the number of listeners in their party, and whether they completed the survey and/ or consent form. If the visitor was under 18 or in the same party as a child, the logbook was annotated accordingly.

1. I am a musical person
Not at all – slightly – moderately – fairly – very much
2. I am an experienced visitor to sound art and/ or interactive art installations
Not at all – slightly – moderately – fairly – very much
3. What did you do to listen to the installation?
For example, you could describe your physical actions, listening strategies, changes that happened over time.
4. How did you feel while listening to the installation?
For example, you could describe any emotions, bodily sensations or mental images that arose.
5. While listening did you notice the passing of time or the behaviour of other listeners in the space?
6. Is there a moment that stands out as significant in your memory of the experience?
Please describe that moment.

Table 6.1: Post-Experience Survey Questions

6.1.2.3 *Post-Experience Survey*

After their interaction with the artwork, listeners were introduced to the research and invited to complete a post-experience survey and consent form. Consent was collected after the experience so that listeners approached the installation primarily as an art experience rather than as a research activity. After their interaction, listeners then had the choice of whether to participate in research activities. The survey was designed to take a short amount of time (5 minutes) to complete. This decision was motivated by interactive art studies that suggest surveys should have 'as low interference as possible' with a listener's experience and allow for 'quick, on-the-spot completion' [Bengler, 2015]. The survey was printed on an A4 sheet, with questions on one side and participant information and consent on the reverse. It was handed to listeners on a clipboard and annotated with their listener number, making it possible to correlate survey responses with log and video data. The form is included in Appendix 2, and the questions are presented in Table 6.1.

The survey began by asking the listener to indicate their age and gender. Then, two Likert-style statements asked listeners to rate their musicality and experience listening to sound art and/ or interaction art installations on a 5-point scale. The response categories were: Not at all—slightly—moderately—fairly—very much.

The post-experience survey was designed to tap into the lived experiences of listeners. A free-response format was chosen and listeners were asked to fill the available space with as much detail as possible. Two questions were designed to tap into the listener's subjective experience of the installation, using content-free wording inspired by the micro-phenomenological interview technique [Petitmengin, 2006]. Question 3 'What did you do to listen to the installation?' was intended to probe listening behaviours and their underlying intentions. It was followed by the prompt: 'you could describe your physical actions, listening strategies, changes that happened over time.' Question 4 'How did you feel while listening to the installation?' was intended to probe aspects of felt experience and was followed by the prompt: 'you could describe any emotions, bodily sensations or mental images that arose'.

The question 'While listening, did you notice the passing of time or the behaviour of other listeners in the space?' was designed to probe people's sense of flow and presence in the experience. The final question 'Is there a moment that stands out as significant in your memory of the experience?' was included to inform the design of a subsequent micro-phenomenological interview study, in which listeners would be interviewed about the most salient or memorable moments of their experience.

6.1.2.4 *Video Observations*

A GoPro video camera was set up in the installation space to capture the whole room from a position above head height at one end of the space (see Figure 6.1). Since the installation is not audible to the naked ear, the video only captured visible behaviour and very occasional talking between listeners. The installation space was filmed during the Friday and Saturday of the festival. Signage in the entrance hall made listeners aware that filming was in progress for research purposes, instructing them to ask for further information if required.

6.1.3 *Participants*

The visitor logbook was completed for 91 listeners. 44 surveys were completed, and 3 hours and 15 minutes of video footage were analysed, including the interactions of 27 listeners. Of those who completed the survey, listener ages ranged from 26-75, with a mean value of 46 and a standard deviation of 15.6. There was an almost even number of male (17) and female (18) listeners. The survey asked participants to rate their musicality and experience as visitors to sound art and/ or interactive art installations. 30 out of 44 respondents rated themselves as 'fairly' or 'very much' a musical person. Although responses were more evenly distributed regarding sound/ interactive art experience, 23 out of 44 participants rated themselves as 'fairly' to 'very much' experienced whereas only 14 participants rated themselves as 'not at all' or 'slightly' experienced.

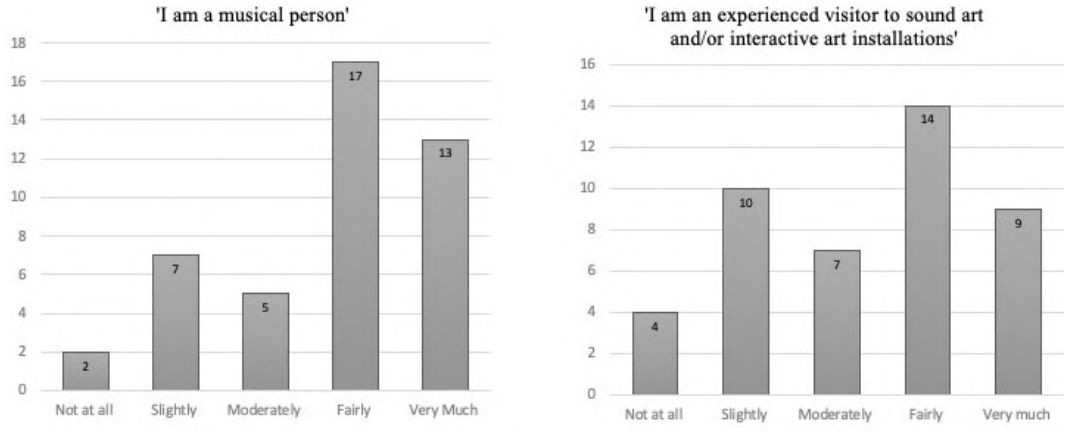


Figure 6.3: Plots showing the distribution of responses to questions 1 and 2 of the survey

Dwell time was collected as, traditionally, it is seen as an indicator of engagement with art and museum artefacts. In practice, however, some participants could only spare a few minutes to get a sense of the work, while others had no other time commitments and stayed for as long as they pleased. To some extent, this undermines the value of dwell time as a measure of engagement. Nonetheless, it is indicative. The shortest dwell time was 4 minutes, and the longest was 37 minutes, with an average of 17 minutes. It was conjectured that listeners might stay for 10-15 minutes, and so it was a pleasant surprise to find that many listeners (35) stayed for longer than 15 minutes. Of those, 14 stayed for 25 minutes or longer.

6.1.4 *Analysis Methods*

A Thematic Analysis (TA) was undertaken to discover patterns of shared experience across the survey and video datasets (see Section 3.6.1). In the process of coding video footage, it became clear that TA could not adequately account for behaviours that persist over time, nor the relationship between observed behaviours and the social context of the installation at particular moments. To capture these aspects of the data, video excerpts were transcribed, and observations were made in the process. The following section describes the analysis in more detail.

6.1.4.1 *Preparation*

The visitor log was typed into a spreadsheet. Survey data was typed up, and the document was imported to MAXQDA, a software tool for qualitative data analysis. To prepare the video footage for analysis, the files were imported into video editing software. Any periods where there were no listeners or interactions, including children or adults for whom we didn't collect consent, were removed. As the installation space was dark, the exposure was adjusted to lighten the footage and make more details visible. The edited video files were then re-exported for analysis.

6.1.4.2 *Thematic Analysis*

A thematic analysis (TA) of survey and video data was conducted, following the process outlined in Braun and Clarke [2006]. A largely deductive approach was taken to coding the data, using an existing code system developed collaboratively by researchers for the purpose of analysing interactive art experiences [Bilda et al., 2006]. The analysis process involved coding all relevant data items in two initial sweeps through the surveys and video footage, iteratively refining the code system and grouping related codes using MAXQDA's visual mapping tools to find themes.

The Bilda et al. [2006] code scheme was chosen because it was developed in the context of interactive art studies aimed at eliciting and understanding listener experiences. Importantly, the framework considers the exhibition context and includes code categories for material components of the installation and aspects of social interaction. It is designed to be flexible and applicable to the experience of different interactive artworks. It has been iteratively refined by a group of interac-

tive art researchers over the course of four case studies, each focusing on visitor experiences of different artworks.

The framework comprises seven different code categories:

1. Physical actions
2. Stated purpose of actions
3. Self-states (e.g. emotions, sensations)
4. Mentions of objects or other people around the self
5. Perception of sound/image features, and the relation between them
6. Concepts, goals and evaluations
7. Recall of previous experience or knowledge

During the process of coding the data, it became clear that some categories in the code system were not relevant to this study and other categories needed to be added. For example, the survey asked listeners about their awareness of other people in the space, which resulted in very many responses related to aspects of social interaction. Due to the large number of codes, a new category was added called 'OtherListeners', with sub-categories that capture different aspects. The code system was, therefore, iteratively refined in ways that were guided by the data.

It was not surprising to find that the code system could not be used wholesale. It had been developed in the context of multimodal interactive installations that take sensor data relating to audience presence, movement or heart rate as input to a system that maps this data to different aural and visual effects. By contrast, *Being With The Waves* is primarily a sonic artwork and has been designed to focus listeners on the act of listening. While it encourages spatial interaction and is still a technologically mediated experience, it was not described to listeners as an interactive artwork and there are no sensors capturing audience movement and mapping data to sound. These are subtle but important differences that likely impact the way that listeners approach the work and develop strategies for listening.

6.1.4.3 *Video Analysis*

While reviewing the video, longer term behaviours were observed that appeared to be dependent on contextual or social factors. The contingent nature of these behaviours could not adequately be accounted for through coding, and a method

informed by Interaction Analysis (IA) [Jordan and Henderson, 1995] was chosen to analyse these aspects of the data more closely. IA is a method for investigating the interactions of humans with each other and with their environment. Of central interest is how people make sense of each other's actions and collaborate to achieve locally sensible interaction, accounting for the situated and social nature of experience.

IA is committed to an inductive mode of analysis, whereby analytic categories are developed directly through and from the observational data. The method does not impose pre-defined analytical frameworks or dictate one method or technique for undertaking the analysis. Instead, Jordan and Henderson [1995] propose a series of typical foci that may guide the analysis process. The chosen foci for this analysis were the temporal and spatial organisation of listener activity and participant structures: the extent to which individuals appear to share a common orientation and attentional focus.

The transcription of video footage provides a descriptive account of visible listener activities in relation to the material space and each other. The transcription was guided by the foci described in the previous paragraph and broken into units of coherent activity. Each of these units is denoted in the transcription by a new timecode and marked by a shift in activity (e.g. a listener begins to move their head from side to side) or shift of spatial positioning (e.g. one or more listeners move from one position to another). Within this structure for transcription, there was a particular focus on aspects of coordination among listeners: changing bodily orientation, attentional focus and distinctive movement behaviours.

To describe a listener's spatial position in the space, a shorthand method was developed that divides the installation space into a 3x3 grid, as shown in Figure 6.4. If a listener was observed to move from the far-left area of the room to the middle-right area, this was denoted in the transcriptions as a move from F/L to M/R.

An early observation was that behaviours appeared to depend on whether there were other listeners in the space and, if so, their existing behaviours. For this reason, transcriptions were broken into phases, each corresponding to a different set of co-present listeners in the space. Therefore, for listeners who dwell in the installation for a long time, their interaction may be broken into many phases as other listeners arrive and leave the space. An example phase of video transcription is given in Table 6.2.

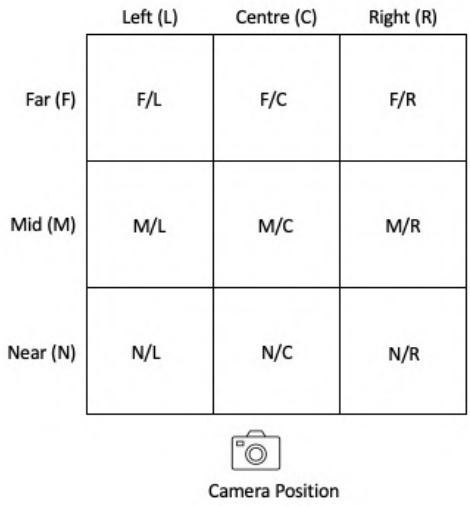


Figure 6.4: Dividing the installation space into nine areas

6.2 SURVEY FINDINGS

The thematic analysis focused on the experiences and behaviours of individual listeners and resulted in three themes: 1. Sensing, discovering and acting upon interactive spatial effects 2. Meditative engagement, and 3. Material context influences individual experiences. The video analysis focused on patterns of behaviour unfolding over time and aspects of social interaction among co-listeners. The resulting observations may be summarised as: 1. Listeners maintain own space of experience and collectively manage the shared social space 2. Solo behaviour is less inhibited, and 3. Listeners adopt or mirror the behaviours of other listeners in the space.

6.2.1 *T1: Sensing and Acting Upon Interactive Effects*

The post-experience survey invited listeners to describe what they did to listen to the installation, prompting them to consider physical behaviours and their underlying motivations. Many listeners described their behaviour in very broad terms, commonly as a combination of walking and standing. These accounts of generic behaviour reveal very little – they may imply an awareness of the piece's spatial composition or perhaps only a perception of how the listener to a sound installation ought to behave. However, some listeners described more nuanced behaviours

File: RF_Vid3.mp4
Date: 05/09/21
Phase 8 (5:17 - 10:10)
Listener(s): P58
Summary: With the space to herself, P58 explores the full area of the installation space and exhibits periods of expressive dance-like movement. Her behaviours are notably different in this phase – now alone – compared with Phases 7 and 9.
5:17 Now, with the space to herself, P58 walks diagonally across the entire space, then around the perimeter before moving to the centre of the room.
6:06 P58 pauses and adjusts volume, takes a couple of tentative steps forward and turns around 180 degrees. 6:30 She bows her head and begins rocking gently forward and back with a straight body, shifting her weight. Then, from left to right, in the same manner. Very gentle movements, with a small range of movement.
7:24 She again adjusts volume before walking slowly toward M/L, stopping briefly to rock forwards and back. She continues, walking purposefully with a little more speed to F/R.
8:05 She spends a few moments looking up at the lights/ ceiling, then walks diagonally across the room to N/L, then to N/C, facing the right wall.
8:35 A period of more expressive and dance-like movement begins here, characterised by gentle undulating movements of the whole body.
10:10 The door opens and P58 turns to look, P60 and P61 arrive in the space. She stops moving expressively and instead stands still.

Table 6.2: Example phase of video transcription

and the intentions that guided them. Some behaviours resulted from the intention to discover or verify the spatial placement of sounds and others from an understanding of the piece's spatiality that led listeners to try and 'find' sounds in the space. Some descriptions suggest an awareness of interactive effects due to the Doppler effect or that these effects were at least sensed in some manner, if not concretely described.

Sub-theme 1a: Discovering and acting upon spatial effects

Being With The Waves is a multi-channel sound installation whereby sounds are placed throughout the space to be explored via the listener's movement. Observing the video footage, listeners are seen not only walking and standing but moving in ways that suggest exploration of the work's spatial aspect. For example, listeners sometimes walk forward to a particular point and then backwards again as if comparing the sound in each place. Some listeners turn on the spot, perhaps to appreciate the changing orientation of sounds in the binaural field. As a result of the TA, two distinctive modes of spatial listening were identified: (1) discovering, exploring or trying to understand the spatial interaction and (2) seeking to find particular sounds in the space.

Some listeners described the intention to discover or understand the parameters of spatial interaction. P27 reported that 'At first I walked around, just letting it wash over me, then started to try and work out what was happening to the sound/ where it was coming from/ what was changing it.' P63 described testing the spatial interaction and then exploring the space with broader movements:

> 'I first stood still by the door then moved slightly to the right and heard the difference. I moved back to check if this was a change in the track or my position. On feeling it was my movement, I started to move around the room, often making moves to the opposite side of the room.'

Once a listener has apprehended the spatial arrangement of different sounds in the space, they may act on this understanding and seek out particular sounds in the space. P43 says, '[I] moved to try and discover the sounds and voices that I wanted to get hold of'. P47 describes moving around the space, sometimes pausing and "chasing" certain elements of the sound to try and get "closer" to some of them.' Similarly, P8 describes moving around fairly consistently at the start trying to locate the voices and as time went on I deliberately sought out the ambient noises.'

6.2.1.1 *Sub-theme 1b: Sensing interactivity*

The installation was not introduced to visitors as an interactive artwork. Listeners were not told about the technical setup or the pronounced Doppler effect that occurs as a result. Despite this, survey responses suggest that listeners sensed these

interactive effects, which are closely coupled with movement and more local to the body (rather than distributed over space). P46 reports that 'whilst moving, I could sense a dissonance that I seemed to naturally want to resolve. Once resolved, I felt satisfied and soothed.' P47 describes shaking their head a lot while listening to the installation and 'enjoying the influence I then felt I had over the sound.' P58 meanwhile describes 'overall cellular awakenings' and an awareness of '360 multidimensional body... sensors all over the body informing me of where I am and how I am in the space.' While the spatial arrangement of sounds may contribute to a heightened awareness of bodily presence in relation to the physical space, even very small movements can be 'heard' as a result of the Doppler effect. For this reason, it is likely that P58's comments are due to sensitivity and tuning in to interactive effects in the installation.

The prominence of the Doppler effect is related to the range, direction and speed of a listener's movement in relation to the stationary ultrasonic speakers. It is, therefore, likely that listeners who experiment with moving at different speeds sense the changing sonic feedback as a result of their actions. P27 reports that they 'stood in different places then played with walking diagonally, fast, slowly...'. Similarly, P53 says: '[I] swooped my arms a lot and started turning and gliding and running forwards and backwards, playing with tempo and direction.

Further evidence for the sensitivity of listeners to the Doppler effect (suggested by the thematic analysis) may be observed in the video footage. There are behaviours with a small range of movement that may occur due to a sensitivity to Doppler interactive effects. Some listeners gently rock or sway on the spot, and others slowly shake their heads from side to side. Periods of video footage when these kinds of behaviour are pronounced can be referenced with the position of the piece's loop at that time. The Doppler effect is most prominent during a section comprised mostly of sine tones, which emerge and fade in different combinations. For a 10-minute period during phase 4 of video annotations, all three listeners in the space adopt small rocking or head-turning behaviours. This period corresponds exactly to the drone section just described, which suggests that these movements are a result of the pronounced interactive effect.

Listeners were not asked directly to describe their perception of interactivity and the survey contributions above are from a small number of listeners (5). From the survey data alone, the extent to which listeners sensed interactive effects is not known. In the process of composing for the installation, listening and re-iterating, the 'watery' quality of the Doppler effect was noted in the way that sounds bend

and distort with your movement. This led to the piece's sonic composition of marine sounds and stories, within which the Doppler effect is given context. When prompted to describe mental images that arose during their experience, many listeners (12) refer to images of the sea. This is hardly surprising, given the sonic content of the piece. Of those, 8 listeners refer explicitly to underwater images or compare the listening experience to the feeling of being submersed in water. P73 says, 'I felt fully immersed in it and imagined being underwater', and P43 describes the experience as 'mesmerising, like being underwater.' It is possible that the interactive effect was sensed by listeners in a way that could not be easily described with language and that it contributes to the feeling of being immersed or submersed. This possibility needs to be investigated more fully.

6.2.2 *T2: Meditative Engagement*

A great number of survey respondents said that listening to the installation induced a feeling of calm or other effects that suggest a meditative engagement with the work. Listeners described physical and perceptual activities aimed at finding or deepening this mode of engagement, and many reported a lost sense of time, which may be symptomatic of a meditative disposition to/ mode of listening.

Sub-theme 2a: Meditative effects

The survey asked listeners to report how they felt while listening to the installation. Of those listeners who described emotions, the majority described a feeling of calm (9), relaxation (5) or peace (1). P45 states that they felt 'really relaxed! I can't honestly think now what I was thinking or picturing – I just think I was relaxed and in a different zone!'. Many listeners reported experiential states that it seems were induced by their engagement with the installation, such as being in a trance (3), mesmerised (2) or in a meditative state (4). For example, P62 reports that they 'became very still and lost in the sound – almost felt trance-like', and P80 describes the experience as 'very peaceful and calm. Reminiscent of yoga meditation.' More poetically, P72 describes the 'sensation of space getting larger and more fluid – the space in my mind.' These responses suggest that the installation acted upon lis-

teners, influenced their behaviour and induced a mode of meditative engagement.

Sub-theme 2b: Deepening meditative engagement

Listeners also described behaviours that seem intended to find or deepen this meditative engagement with the installation or to engage in a more concentrated or deeper listening. Unsurprisingly, many listeners describe finding stillness and closing their eyes in order to 'focus on the sounds' (P67). Other listeners choose to focus their gaze: 'I spent the most time looking at other peoples' shadows on the floor/ looking for dark spaces/ spots to focus my mind on the sound more' (P27). A number of participants describe attempts to focus on or slow their own breathing, for example P44 says that they 'started by gently wandering around but eventually found places to stand still and concentrate. I found myself aware of my own breathing and tried to breathe as slowly as I could.' P81 took this behaviour even further: 'Stood up and walked around, leant against the wall then sat and eventually lay on the floor with knees up and fully relaxed. I have back pain and concentrated on deep breathing and letting the sound wash over me.'

Sub-theme 2c: A lost or distorted sense of time

The survey also asked listeners whether, while listening, they had noticed the passing of time. Some listeners responded directly to the question, noting that they had not, but many others reported that their sense of time had been warped or altered in some way. P8 reported that they 'found time to be quite elastic in the experience', while P13 stated that the passing of time 'definitely became looser'. For other listeners, it seems that their grip on time slackened to such an extent that they could not judge the length of their experience with any accuracy. P46 states simply that they 'would not have been able to describe the length of my experience.' P32 found it 'very hard to judge space and time. It could have been 5 minutes or an hour and P47 found that time had passed much more quickly than they had imagined: 'Time went really quickly – I thought I had been in there 10 or so minutes, but it was more like 30!'. It is possible that these altered perceptions of time and deep, meditative engagements with the piece may account for some of the very long dwell times that we had not expected prior to presenting the installation.

6.2.3 *T3: Contextual Influences on Experience*

A key aim of this study was to understand how the public installation context might impact the listening experiences of listeners. In the survey data, there are many references to the material context (the venue) and the social context (the influence of other listeners present in the space). The venue, its features and the objects within it were perceived by listeners as part of the work and acted upon as affordances for action. Listeners sat on the stage, peered behind the curtain, leant or held on the wall-mounted ledges on the left and right sides of the space. Prior familiarity with the space as a music venue had an influence on the experience of some local listeners. Many listeners described an awareness of others in the space but paid little attention to them. Our findings suggest that a listener's experience is more likely to be disrupted by the presence of other people when there is a mismatch between their adopted behaviours in the space.

Sub-theme 3a: Material context influenced behaviour and experience
Objects in the venue became an object of visual attention for some listeners, for example P5 states that they 'continually tracked equipment/ objects/ pipes in the room'. Many listeners can be seen looking up at the ceiling or into the truss as they walk around the space. For analytical listeners, trying to 'find' the speakers, cameras, or interactive technology, the truss was a source of interest as it was packed with wiring in any case. The positions of the red and blue lights were used as a point of reference for finding sounds or assumed to relate to the spatial position of sound sources. In trying to learn and analyse patterns in the way sounds were changing, P66 describes referring these patterns to the position of the red and blue lights.

Some local listeners were very familiar with the space as a music venue and their prior understanding or experience of the place had an influence on their experience of the installation. For example, P33 describes 'being familiar with the space as a music venue and now feeling "difference"'. For P28, the material context was a distraction: 'I felt distracted by being in a venue for the first time in a while. This added an otherworldliness to the recording. I skipped between underwater

imaginings and reflections on my life and the last time I occupied the same space.'

Sub-theme 3b: Social context influenced individual experiences

A key aim of this study was to explore how listeners managed the installation as a social space and how the presence of others may have impacted the listening experience. On coding the surveys, only one reference was found to communication between listeners. P73 describes sometimes glancing at their friend and making eye contact: 'When there was a loud low droning sound… that's when I looked at my friend to see if he could hear it too!'

In the survey, listeners were asked whether they noticed the behaviour of others in the space. Respondents indicated that they were aware of other listeners but to varying degrees. For example, P51 states that the 'location of others was noted but not much attention paid to them'. Some listeners were less aware of other people because they had their eyes closed a lot of the time, such as P62, who notes: 'I occasionally noticed other people but often had my eyes closed'. Other listeners closed their eyes deliberately to avoid social interaction. P48 reports: 'I was aware of others in the space. Plus, I had met them earlier in the day, so I kept my eyes closed.'

When listeners were quite aware of other people's behaviour, it was because that behaviour was different to their own. P26 reports that 'the 3 other listeners were much more 'active'! – walking backwards and forwards, which was disconcerting'. Observing the different behaviour of other listeners also led some to question their own listening strategies or wonder whether there was something about the piece that they hadn't yet grasped for themself. For example, P60 reports: 'I saw others move that made me wonder if they had heard something different to me. Did the person standing still have a really interesting bit that I hadn't heard yet?'. For P83, others in the space were very still, and this may have inhibited their behaviour because they didn't wish to disturb them: 'I was aware that other listeners were sat down, but my own actions did not interfere with this (hopefully)'.

In each of the above examples, the behaviour of others begins to intrude on the listener's own space of experience. By contrast, some listeners reported a feeling of harmony and connection with the other people in the room. P49 described a feeling of being in tune with their surroundings and a feeling of connection with the people around them. Similarly, P47 says:

> 'When new listeners came into the space, it brought you back to reality and made you a tiny bit self-conscious in terms of not wanting to impinge on their experience, but within a few moments, that was gone, and it felt like you were all in sync.'

6.3 OBSERVATIONAL FINDINGS

The installation could accommodate up to five listeners at any one time. Some listeners had the space to themselves, and others shared it with many others. By observing the video footage, it is clear the behaviour of listeners is influenced by the presence (or lack of other listeners in the space. In summary:

1. The behaviour and body language of most listeners suggests a turning away from others in the space, towards a focus on their own perceptual experience. Yet, listeners appear to collectively negotiate the installation space to ensure that nobody's personal space is intruded upon.
2. Solo listeners and couples behave differently when they have the space to themselves, to when it is shared with strangers. They exhibit more expressive movement behaviours, attempt to communicate, and use mobile phones to document their experience.
3. Many instances are observed when listeners come to mirror the behaviour of listeners already in the space, for example adopting stillness or distinctive movement behaviours.

The following section will describe these observations in greater detail, providing examples from the data set in support.

6.3.1 *Collectively Managing Shared Space*

Theme 2 of the Thematic Analysis suggested that many listeners adopted a meditative state, turning inward to focus on and deepen their own listening experience. Theme 3 suggested that listeners paid little conscious attention to other listeners, and it was only when the behaviour of others conflicted with their own that their presence came sharply into focus. Observing the video footage, most listeners who arrive in a group move away from each other immediately as they begin to listen. They take different trajectories through the space and orient their bodies so as not

to face other listeners. Many listeners bow their heads, close their eyes, or even turn to face a wall, thus excluding other listeners from their field of view: body language that suggests a 'turn inward' or the intention to focus on one's own perceptual experience over a communal or social experience.

Despite this inward focus, groups of listeners (3 or more) appear to collectively manage the shared space to ensure that the personal space and inner experience of other listeners are not intruded upon. We see listeners spaced evenly apart from one another and moving into parts of the room where an empty space has been left. The effect of this is a kind of group-mediated choreography that occurs without conscious thought – no doubt behaviour that we practice in other social situations. For example, there is a passage during phase 2 of annotations when two listeners coordinate their movement to move repeatedly between the same two points in the installation space.

The following description is illustrated by Figure 6.5. Numbered arrows indicate the sequence of movements. P45 stands in the far left corner (F/L), and P43 is in the centre of the room (M/C). (1) P43 walks to the far right corner (F/R) and (2) back to M/C, as she walks back, P45 walks to stand at F/R. (3) In response, P43 walks backwards to F/L, where the other listener had previously been standing. (4) P43 returns to M/C and (5) P45 walks back to F/L. With F/R now vacated (6), P43 moves once more to that position.

If they notice they will converge with another person, a listener may change their trajectory through the space. For example, P58 walks down the right side of the room toward the front and pauses for a few moments before turning and beginning to walk back. As she does so, P59 moves toward the far right wall, and P58 adjusts her course, walking to the far left corner.

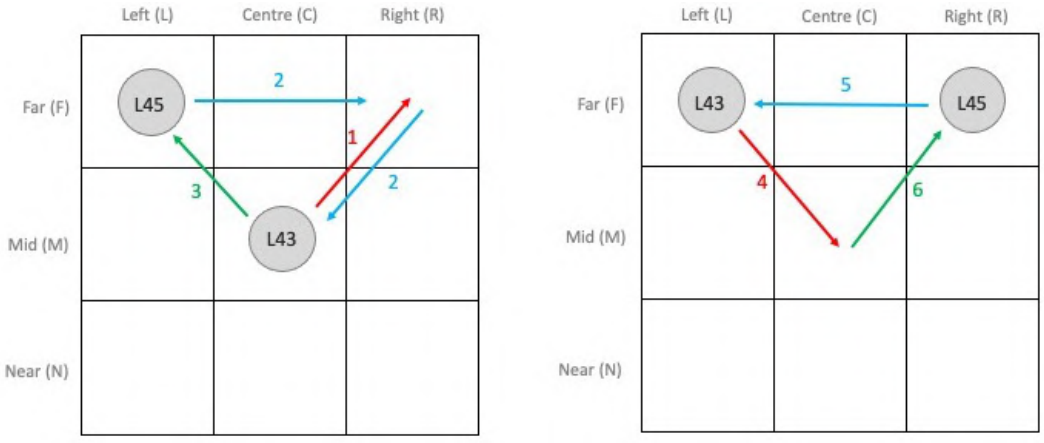


Figure 6.5: Diagrams showing a coordinated sequence of movements between P43 and P45

Perhaps to ensure that the even spacing and personal space of listeners is maintained, we often see instances of coordinated periods of walking and standing, where one person begins to move, and this has a domino effect on the room. This occurs frequently during phase 1 of annotations. For example, at 1'42", P42 begins walking around the perimeter anticlockwise. Even though P42 is not within their field of vision, P43 begins moving <1 second later, and P44 begins walking <1 second after P43 moves. The three listeners come to a standstill at the same moment, around 12 seconds later.

6.3.2 *Solo Behaviour is Less Inhibited*

Solo listeners or listener pairs (that arrived together) who were alone in the installation engaged in behaviours that were not observed when the space was shared with strangers. In these cases, it appears as though behaviour is less inhibited or bound by social conventions. The material context of the installation space (darkened, separate from the outside world and acoustically isolated) may contribute to a sense of privacy. Some solo listeners exhibit more outwardly expressive behaviours, such as full-body dance-like movement, arm gestures, and moving more quickly or more broadly through the whole space. Solo listeners also use their mobile phones for the purpose of documenting the experience, something that is not observed at all during periods when the space is occupied by three or more listeners. Pairs of listeners, who arrive in the space together (and in the cases we observed, male and female couples), attempt to share the experience and communicate verbally or gesturally with each other when alone in the space. Again, this is rarely observed at times when the space is shared with strangers.

Expressive and dance-like movement

Listeners who are alone in the space appear more likely to experiment with playful or expressive movement gestures. For example, P53 has the installation to herself for the entirety of her interaction. After a few minutes of walking and standing, she launches into a period of dance-like movement, pirouetting through the whole space, moving at different speeds, holding and swinging her outstretched arms, at times vigorously shaking her upper body (see Figure 6.6). P58 dwells in the installation for 25 minutes, during which time other listeners come and go. For a 5-minute period, she has the space to herself and, in this time, develops an expressive range of movement that becomes more inhibited upon the arrival of

other listeners in the space. As soon as she is alone, P58 walks diagonally through the whole space and then around the perimeter before coming to the centre of the room. At first, she makes gentle rocking motions with a small range of movement. After a couple of minutes, these develop into more expressive and dance-like movements, which, although rooted to the spot, involve the undulation of the whole body. As the door opens and two new listeners enter, P58 turns to look and ceases to move expressively, choosing instead to stand still.

Figure 6.6: P53 strikes a pose before pirouetting through the installation space

Mobile phone use

During the periods that were filmed, listeners rarely interacted with their mobile devices and the only instances of phone use were observed in the case of solo listeners, who appeared to document their experience in some way – filming, photographing or writing. After 1'32", P53 takes out her phone and, for the next 90 seconds, appears to write something. It is possible that she is using the phone to communicate – to write messages or emails – but from her thoughtful disposition, she may also be taking notes or writing about her experience. Shortly after this, she appears to select the camera application and positions the device on the floor to film herself moving in the space. She returns to check the phone and then places it back in her pocket - perhaps the filming was not successful. For the most part, P66 shares the space with two other listeners. Almost as soon as they leave, he takes out his mobile phone once to take photographs and then a second time, holding

the device in front of his body while he walks, as though filming the space. Note that the mobile phone will not record the sound that the listener hears.

Verbal and gestural communication

Verbal or gestural communication is only observed when a pair of listeners have the space to themselves. In these cases, it appears as though the listeners wish to share the experience rather than focus only on their own experience. Again, listeners behave in ways that they would not if they were sharing the space with strangers; P73 and P74 even stop for a kiss!

At first, P64 and P65 share the space with another pair of listeners who leave shortly after their arrival. Once alone in the space, periods of more independent movement are punctuated by moments in which they come together and communicate either verbally or gesturally. For example, (at 32:14 in the annotations of video 3), P64 moves to stand in front of P65 and says out loud, 'The sounds are really beautiful, aren't they?'. P65 doesn't seem to hear. He takes off his headphones and P65 whispers this time: 'The sounds are really beautiful.' P65 responds 'mm' before putting the headphones back on again. P64 then walks to the far-left corner and turns to face P65. She makes one breaststroke swimming movement with her arms before making a brief waving hand gesture at P65 to get his attention, and they then both make coordinated breaststroke swimming motions with their arms.

As soon as P75 and P76 are alone in the room their behaviour changes, they immediately turn to each other and communicate in whispers, and using pointing gestures. In a gesture that appears symbolic of ownership of the space, they also take off their shoes. Later, P75 stretches out her arms and moves into a forward folding stretch before rocking broadly from side to side as though manipulating her hips. When P77 enters the space, the couple barely adjust their behaviour and continue to communicate with each other. Interestingly, P77 only stays for 4 minutes, and it may be that their experience is disturbed by the behaviour of P75 and P76, who continue to act as though they are alone in the space.

6.3.3 *Behavioural Mirroring*

Observing the video footage, there are many instances in which listeners adopt similar behaviours or take on the behaviours of those already in the room. Sometimes distinctive movement behaviours become mirrored by other listeners, at other times co-present listeners adopt very similar, generic ways of being in the

space. E.g. stillness, walking at a particular pace, avoidance of gaze, equal spacing in the room/ standing together (in case of couples), in ways that are subtly different from one video phase to the next. It isn't the case that all listeners come to behave in the same way, and mirroring doesn't always happen, but it is a noticeable feature of behaviour when many listeners share the installation space.

Out-of-the-ordinary behaviours may be contagious and become mirrored by others in the space. When P58 arrives in the space, she joins two other listeners, one of whom (P57) stands in one spot, gently swaying. P58 later adopts this style of movement, swaying and rocking gently on the spot. This, in turn, appears to influence P61, and for a 5-minute period, the behaviours of these two listeners appear to mirror each other, both making undulating or rocking movements on the spot.

Overall, listeners move through the space independently and collectively manage their spacing so that nobody's personal space is intruded upon. As noted earlier, listener couples often behave differently, and when they are alone in the space are more likely to stand together and communicate. There are instances in the video footage when a second couple arrives in the room, and their behaviour mirrors that of the couple already present. When P64 and P65 arrive in the space, P62 and P63 turn their backs on the new listeners and walk together to the rear of the space, where they stand very close together. P64 and P65 do the same, they stand together in the near right corner.

The final phase of annotations has a very different character from any other that was analysed in the sense that all listeners adopt stillness for long periods. This phase begins when P79 and P80 arrive in the room; after first standing together at the rear of the room and turning their back on the other listener in the space, P80 walks to the M/L position, where there is a ledge on the wall. She puts down her bag, leans her elbows on the ledge and faces the wall, very deliberately shutting others in the room out of her experience. The two other listeners also adopt standing positions around the edge of the room. When P81 arrives in the space, she walks directly to a free position at the perimeter of the room and sits down on the floor. P80 then moves from her leaning posture to the floor, where she sits with her back to the wall before lying down on the floor. At the point when P82 and P83 arrive in the space, two women are sitting/ lying down on the floor, and a male listener is standing leaning against the wall, all in total stillness. The atmosphere of the room clearly impacts the behaviour of these two new listeners, who each walk through the space slowly once before standing at the front perimeter of the room.

6.4 DISCUSSION

In study 1 (see Chapter 4), sound artists were asked the question, 'What kinds of audience behaviour have you observed?'. Their responses suggested that little was to be learned via observation because visible behaviours tend to be quite generic, revealing little about the subjective experience of listeners, with James Bulley adding that 'there isn't really a pattern to it'. Reflecting on the findings of this study, it is clear this is true to some extent. On an individual level, there are no obvious or straightforward correspondences between observed behaviour, experiences reported in the survey and demographic aspects such as age and level of expertise. Though, potentially, some correspondences might be revealed with a larger sample size. However, some behavioural patterns have been observed when co-listeners occupy the space. The following discussion will focus on relational factors identified in this study, which appear to have a bearing on behaviour and experience. In particular, the discussion will focus on the influences of social context and headphone technology used in *Being With The Waves*.

6.4.1 *Socially Mediated Listening Behavoiur*

A surprising finding of this study is the degree to which listeners appear to ignore others in the space and, at the same time, manage the shared space collectively, adopting similar behaviours (apparently) without realising. It was surprising to discover no examples of talk or gestural communication between listeners who arrived together in the space when the space was shared with strangers. Talk and gestural interaction only occurred when listeners needed to signal their intention to leave the space or, in the case of listeners who had the space to themselves and did not share the space with strangers. This suggests that the social rules of the installation space only apply when co-listeners are present; they are socially constructed.

It appears that listeners practice 'civil inattention' in group listening situations. The concept of civil attention was proposed by Goffman [Goffman, 1963] and describes the interaction of strangers in public places who pass close by to each other but respectfully act as though they have not seen each other. Civil inattention "makes possible co-presence without co-mingling, awareness without engrossment, courtesy without conversation" [Lofland, 1989] CI occurs out of respect for people's privacy, e.g. at swimming pools, where swimmers act like "disinter-

ested strangers" [Scott, 2009]. This has a functional purpose, allowing individuals to go about their business of exercising in the pool without distraction.

In the case of the sound installation, it appears as though CI is practised out of respect for the listening experiences of others in the space to allow each person in the space to focus on the act of listening. Like the swimming pool, there is a negotiated order to listener behaviours: a respect for personal space and a respect for the movements of others, i.e. 'if you want to move here, then I will respectfully move out the way'. This leads to coordinating periods of walking and standing that appear choreographed due to the minuscule delay that was observed between one person initiating movement and others following suit.

Through an analysis of video footage collected during the public exhibition of *Being With The Waves*, it has become clear that social factors impact the behaviour of listeners and, by extension, their experience of the installation. Bodily movement occurs not only as a result of individual listening intentions but as a result of between-listener interactions. This finding resonates with those of the Work, Interaction and Technology group who argue strongly for the socially mediated nature of experience around museum exhibits and artworks. Importantly, their work reveals 'how an encounter with, and experience of, museum exhibits emerges in and through the interaction of those within "perceptual range of the event" [Goffman, 1981], not just those who are in some sense "together," but also others who just happen to be within the "same" space.' [Vom Lehn et al., 2001].

This is clearly the case in *Being With The Waves*, where many patterns of behaviour were observed whereby groups of listeners move around the installation in a highly coordinated fashion, often coming to mirror or adopt the behaviours and attitudes of others in the space. In the WIT studies, the ways in which co-visitors "configure" each other's experience is often through explicit talk/ gesture between friends and family - either to shape an understanding of artwork or to reach an understanding of 'how it works'. In this study, co-listeners configure each other's experience while practising civil inattention. It is not through explicit social interaction but via subtle cues that appear to be tacitly understood or processed without conscious thought. In the context of conversational interaction, Chartrand and Bargh's influential studies have shown that actions become unconsciously mirrored - 'such that one's behaviour passively and unintentionally changes to match that of others in one's current social environment.' This phenomenon is called the 'chameleon effect' and is attributed to a mechanism known as the 'perception-behaviour link'. It is thought that 'the mere perception of another's behaviour

automatically increases the likelihood of engaging that behaviour oneself' Chartrand and Bargh [1999]. In their experiments, this is shown to be the case between interaction partners engaging in spoken dialogue. In the context of *Being With The Waves*, this appears to occur between people who just happen to be within perceptual range of one another.

6.4.2 *The Influence of Headphone Listening*

Reflecting on the results of this study, perhaps the most striking finding is the extent to which the material and social context i.e. the changing presence of co-listeners, appears to have impacted the behaviour of listeners. Given that listening in *Being With The Waves* is mediated by modified sets of headphones, it is important to consider how these devices may have shaped listener behaviours and experiences. There may be important ways in which they alter spatial perception, re-present sonic information and impact physical behaviours, which must be considered in this analysis because it affects the degree to which our findings are specific to *Being With The Waves*. To omit these factors from the analysis is a significant absence that needs to be addressed.

Unusually for an indoor sound art installation, *Being With The Waves* requires listeners to wear headphones. The collected survey responses include no references to the headphones and their technology, and in the video footage, listeners only rarely touch or interact with the headphones – most often adjusting the volume. Given the absence of relevant data, the following discussion will synthesise existing studies into the phenomenology of headphone listening, with video observations and my own impression of the effect of headphone listening on spatiality and listening experience in the context of *Being With The Waves*.

Listener-headphone relationships

Given the lack of reference to them in the collected data, it appears that the headphones as objects appended to the body receded into the background of perceptual awareness to be incorporated in the listener's broader body schema, i.e. the headphones were embodied by listeners and experienced as transparent in the sense that they did not call attention to themselves as objects but to the sound world given through them [Ihde, 1990]. This resonates with my everyday experience of listening to music with headphones. I am not continuously aware of their presence

on my body. Instead, it is the sound or music presented to me through them that is in the foreground of my experience.

In *Being With The Waves*, the modified headphone sets exist to augment the listener's hearing ability and enable them to hear the sounds that exist physically in the space but are inaudible otherwise, carried by ultrasonic sound waves. Therefore, the headphones are intended to be *listened through*, rather than *listened to* as we might ordinarily relate to headphones when listening to music. From the survey data collected during the study, it is impossible to know the disposition of participants to headphone listening, i.e. whether they *listened through* the headphones to hear the sounding world around them. It is possible that these aspects relate to the listening dispositions described in Theme 1. Where listeners engage in a spatial exploration of the installation, we might assume that they are *listening through* the headphones. However, in the case of listeners who stand in stillness and take a meditative disposition to listen, they might instead be inclined to *listen to* the headphones. A more thorough phenomenological study aimed at probing this aspect of experience would be needed to explore these nuanced relationships more fully.

The impact of headphone listening on social interaction

In the video footage, it was surprising to observe the degree to which listeners appeared to turn inward and focus on their own space of experience, leading to an almost total lack of outward social interaction among listeners who shared the space. It is possible this behaviour was influenced by the fact of headphone listening. Headphones make listening a private activity and in everyday listening situations (e.g. at work, commuting) may be used a way to transport you away from the physical world around you. In headphone listening, we may find a place of sanctuary and homeliness [Downs, 2021], an escape from a noisy world full of strangers. On reflection, this transportative quality may be problematic in the context of a sound installation that is intended to make listeners more keenly aware of their physical presence in the sounding world.

Numerous studies have likened the experience/ space of headphone listening to a 'hermetically sealed aural bubble' [Bull, 2007, Downs, 2021, Heye and Lamont, 2010, Skånland, 2011]. Considering the apparent inward focus of listeners to *Being With The Waves*, it seems likely that listeners attended to their own 'bubble' rather than a shared space of experience. In the case of Walkman listening, Schönhammer argues that lived space becomes split in two – into a presence (bodily presence in

the world) and absence (perceptually present in another sonic 'place'). This split is problematic in terms of social interaction while wearing headphones. Schönhammer finds that some people 'prefer to listen to the Walkman only when nobody is there, for they feel ashamed of creating the impression that they are unwilling to communicate' [Schönhammer, 1989]. Similarly, participants in Bull's interview study report a feeling of being 'invisible' while wearing headphones – which acts as a kind of refuge in otherwise threatening or tedious situations - 'I do not have to be intimidated by jerky men or disrupted by lost tourists' [Bull, 2007].

Scientific studies have also shown that headphone listening may lead to people keeping larger interpersonal distances [Lloyd et al., 2009, Tajadura-Jiménez et al., 2011] and that low-level lighting situations may have the same effect [Adams and Zuckerman, 1991]. It is thought this is because people exercise caution in relation to others when there are fewer environmental stimuli to rely upon. Both headphone listening and low-level lighting are features of *Being With The Waves*. While a thorough exploration of lighting's effect on behaviour will be excluded here, it is likely an influencing factor in the way that listeners feel and interact with each other.

The mysterious behaviour of co-listeners

According to Heath et al. [2002], people make sense of the behaviour of other visitors to a museum exhibit or art gallery 'by discovering, determining, connecting, its relationship, or potential relationship, to particular features of the local milieu'. The above is not wholly possible in the sound installation *Being With The Waves*. What listeners hear in their headphones depends on their own location and movement in the installation. Listeners cannot accurately make sense of other people's behaviour because they cannot know what another person is hearing or listening to. This is a scenario particular to the headphone system in *Being With The Waves* and other sound walks and installations that employ modified headphones to reveal otherwise imperceptible phenomena. Ordinarily, in art/ music contexts where multiple people wear headphones, e.g. a silent disco or video artwork, everybody hears the same recording regardless. In speaker-based sound installations, what you hear depends on where you are located in relation to the speakers but you share the acoustic space with other listeners, for this reason what they are hearing is much less mysterious. According to the surveys, this barrier to making sense of the behaviour of co-listeners was problematic for some respondents. P25 was 'disconcerted' to find the three other listeners in the space behaving differently

to themselves – 'much more "active"! – walking backwards and forwards'. The feeling of being 'disconcerted' might be attributable to the fact that P25 can't determine a relationship between the other listeners' behaviour and (what they hear as) the sounding piece. Similarly, upon noticing behaviour different to their own, P60 wonders whether the other listener has realised something that they haven't - 'I saw others move that made me wonder if they had heard something different to me.' A mechanism that we would ordinarily rely upon in everyday social situations - the ability to make sense of another person's behaviour by connecting it to features of the environment - lacks the information required to function. This clearly impacted the experience of some listeners, making them more aware or 'disconcerted' than usual by the behaviour of others.

6.4.3 *Limitations*

Undoubtedly, the findings of this study would not be replicated in a study of a different sound installation. Like any artwork, *Being With The Waves* shares a series of values and conventions with other sound installations but also has its own peculiarities and specificities. The findings of this study highlight the fact that the way a sound installation is experienced will always be contingent on both its design as an artefact and the particular affordances it embodies and on contextual aspects such as the material situation in which it is installed, the socio-cultural context and make-up of individual listeners at any one moment in time (each with their own individual dispositions and set of prior experiences).

Based on the findings of studies conducted so far, along with personal experience, it appears that listeners to sound installations (more generally) choose to respect the listening experiences of others and refrain from speaking or making loud noises so as not to disrupt the auditory scene. It is likely that aspects of social interaction observed in this study, such as civil inattention, unconscious mimicry of behaviours and the coordination of movement in order to maintain interpersonal distances, *would* extend to other installation scenarios.

Finally, the limitations of this study should be acknowledged. While appropriate to the study situation, the lightweight survey format precluded detailed descriptions of listener experiences. Responses varied wildly in this regard, with some participants providing answers of a line or two and others writing paragraphs. The survey addressed the listening experience as a whole rather than focusing on any singular moments. It cannot be known how accurately responses written

after the interaction represent the actual experiences of listeners. Due to low-level lighting in the installation (which arguably is instrumental in suggesting an orientation toward the auditory over the visual), the video footage is underexposed and becomes grainy, lacking detail, when lightened in editing software. While the analysis only includes behaviours that could be confidently identified by the researcher, it may be that details, for example, relating to interaction on a micro scale, are missing.

6.5 CONCLUSION

This chapter presented a research study conducted during the public exhibition of *Being With The Waves* at *Ramsgate Festival of Sound* in 2021. Drawing on the methods of interactive art research, listeners were surveyed after listening to the installation to obtain insights into subjective experience. The thematic analysis identified two distinct modes of listening: 1. discovering and then exploring the spatial placement of sounds with movement, and 2. meditative engagement, whereby listeners seek a deeper listening by, for example, adopting stillness and focusing on their breath.

Drawing on ethnomethodology, the installation space was also filmed, and observations were interpreted using interaction analysis. The transcription and analysis of video footage revealed patterns of behaviour that were contingent on the social context of the installation. Notably, listeners behaved more expressively when alone in the space or with one other friend. When co-listeners were present, the behaviour appeared to be strongly influenced by the visible behaviours and attitudes of others within the perceptual range. Even though listeners practice civil inattention, they adopt similar behaviours and work together to ensure that interpersonal space is maintained. A key influencing factor may be the headphone listening technology employed in *Being With The Waves*. Discussing the findings in the context of existing phenomenological research, we speculated that the 'aural bubble' of headphone listening might have contributed to inward body language and that the lack of shared sonic reference might have produced disconcerted feelings, with listeners unable to make sense of the others' behaviour.

In conclusion, the social dynamic may be characterised as *listening together-apart* in the sense that collective social factors mediate private listening experiences. Given the absence of qualitative research concerning the experience of sound art [Keylin, 2020, Semmerling, 2018], these are important insights revealing larger patterns and detailed accounts of physical behaviours that might be adopted

without conscious thought and would therefore not be captured through listener interviews or surveys. However, listening occurs in perception, and neither the third-person perspective on interaction afforded by video observations nor the post-experience survey could reveal the details of inner, sonic experience. The next chapter addresses this shortcoming directly, by exploring the use of micro-phenomenological interviews to elicit detailed descriptions of sonic interaction as lived experience.

7

STUDY 3: EXPLORING THE FELT QUALITY OF SONIC INTERACTION

This chapter is built on material first published in "Thinking with Sound: Exploring the Experience of Listening to an Ultrasonic Art Installation", by Robson, McPherson and Bryan-Kinns at CHI'24 [Robson et al., 2024].

The research study described in this study employs the micro-phenomenological interview method (see Section 3.5.3) to help listeners describe particular moments within their experience of *Being With The Waves* in fine detail. Where the previous study took place in a public context and examined the collective behaviour of listeners in groups, this study takes place in a more controlled setting. Individual participants experience the installation at a university performance space before an hour-long interview.

In Section 2.5.4, I articulated a series of challenges to the study of listening-based experiences. Employing the methods of interactive art research in Chapter 6 led to richly relational accounts of visible behaviour as mediated by social factors, but only surface-level descriptions of subjective experience and perceptual intentions. I was attracted by the micro-phenomenological interview method from early on in my PhD. Although it is a retrospective method, the interviewee is guided back to a specific moment within their experience, which they are helped to evoke and re-live, iteratively deepening descriptions with the guidance of the interviewer (see Section 3.5.3). Before using M-P in a study, I first needed to complete training in the interview method, and these training courses happen only annually; even then, hours of practice were needed before using the method in a study.

I conducted the data collection phase of this study shortly before pausing my PhD research to take 12 months of maternity leave beginning in May 2022. On my return, I began reading the data and considering the analysis approach in the context of my broader PhD project and its aims. Reflecting on the research with a fresh perspective, I considered questions such as: What does it mean to be working with sound? What kind of knowledge does the installation design itself imply? How might my epistemological choices extend from that? In response, I found Karen Barad's theory of agential realism resonated with the contingent and

situated character of listening, and perceived interactivity in the installation. It is, therefore, at the stage of data analysis in this study that I orient the research to relational ontologies, conceiving the installation in terms of sonic entanglement and considering the epistemological implications of this move. The introductory text of the CHI'24 paper from which this chapter is built is included in full here as a means to re-state the relational materiality of sound and explore the relational nature of listening.

7.1 INTRODUCTION

Reader, wherever you find yourself in this moment, I invite you to clap your hands together as emphatically as the social situation will allow. Listen attentively to the sound that is produced, and consider the questions: 'what do you hear?' and 'where?'.

I propose that this clap is not merely the sound of one hand hitting the other but the 'action of two hands clapping sounding with everything else.' The clap that we tend to demarcate as a separate nameable noise is rather the 'sound of everything vibrating in its agitation... the room, furniture, bodies, carpets, windows, doors, sounding indivisibly together' [Voegelin, 2023, para. 7]. Furthermore, it does not have an audio reality out there in the material world. You might imagine it as a burst of energy that disturbs the air around and outwards from your hands in the moment of striking, but the sound that you hear exists only in your perception. Examining the clap experience more closely, notice the directional character of your attention in this moment of listening. I imagine that it is not on the inward character of sensations - listening *to* the body - but stretches outward, *beyond* the body to meet that burst of sonic energy as it unfolds in time. And so your relationship as a listening subject to the clap is somewhat complex and interrelated.

Central to this chapter is the proposal that the relational character of sound allows us to more readily imagine ourselves as entangled with a vibrational world in flux [Cobussen, 2022, Voegelin, 2023]. I put this proposal to work by investigating the experiential character of an *entangled subjectivity* - which implies a subtle decentring of the human subjectivity - during listening encounters with *Being With The Waves*. The installation is deployed in a lab-based participant study using the micro-phenomenological interview technique [Petitmengin, 2006] to elicit the relational experience of listening.

Explicitly adopting an epistemological stance grounded in the materiality of sound, our diffractive analysis of interview data reveals temporal, ephemeral, and mobile qualities of interactive experience and emphasises the plural nature of listening. The particular approach to diffractive analysis in this chapter is to read the M-P data in relation to a curated selection of theoretical texts from the fields of sound art and sound studies that explore the relationality of sounding and listening. I argue that due to an underlying visual bias in HCI methods, the felt qualities of interactive experience that are highlighted by this process might not otherwise be articulated. The particular theories used in the analysis are introduced in the next section before details of the study itself are from Section 7.3 onwards.

7.2 THINKING WITH SOUND

In response to the underlying visuocentrism of Western thought [Horta et al., 2016], sound studies scholars promote alternative ways of knowing through sound; not to replace the visual with a 'countermonopoly of the ear' [Erlmann, 2020, p. 4] but to disrupt the status quo and promote the senses as an 'integrated network in ones relating to the world' [Erlmann, 2020, p. 4]. This is an extensive field of study, and I focus here on work that extends Barad's relational ontologies while seeking to account for sound's materiality in its specificity[1].

7.2.0.1 *Sonic Materialism*

According to Cox [2011, p. 146], sound art is profoundly under-theorised. Contemporary cultural theory and criticism entrench the notion that art experience is mediated by the symbolic field. Such an approach is suited to account for the textual and the visual but fails to capture the nature of the sonic. Sound artists and installation artists in particular (such as those described in section 2.1) explore the materiality of sound in their work, which **?**, p. 14 claims, is fundamentally nonrepresentational: How does one talk about such work, which has no fixed duration, is site-specific and sculptural, and is fundamentally concerned with sound as a physical, intensive force?. This might account for the lack of phenomenological studies focused on listening and the public's experience of sound art, a shortcoming that is lamented by Keylin [2020, p. 113] and Semmerling [2018].

1 I expect these ideas may be unfamiliar to an HCI audience, and recommend the podcast episode *Thinking (Through) The Ear* [Horta et al., 2016] as an entry-point.

Explicitly building on relational ontologies and new materialism, Cox's 'sonic materialism' [Cox, 2011, 2018] is intended as an alternative theoretical framework for the sonic arts, grounded in the materiality of sound[2]. Sound is immersive, surrounding and passing through the body, which implies rethinking the 'chasm' between subject and object and the spatial, static, and parallel existence of 'actants' imposed by a visual paradigm. Instead, Cox proposes an emphasis on 'events instead of objects, flux instead of immobility, becomings instead of beings' [Cobussen, 2022, p. 15].

7.2.0.2 *Listening as Punctuation*

The philosopher Peter Szendy describes listening as an intermediary field. Like vision, listening implies distance and critical consideration, but also implies a contact that has more to do with the sense of touch, a similarity also noted by Davis [Davis, 2010, p. 68]. It is easy to conceive of a sound hitting the listener's eardrum and penetrating inside them, but that listener also *acts*, they transform sound in their perception. For Szendy, listening is a kind of punctuation or articulation of sonic phenomena. It is 'an action, a decision in every moment' [Horta et al., 2016, Szendy, 2020].

7.2.0.3 *The In-Between Space of Listening*

The clap example that opened this paper demonstrated the relational character of sounding and listening. For Salomé Voegelin, listening is a 'knowing of the moment... that involves the listener and the sound in a reciprocal inventive production' [Voegelin, 2010, p. 5]. As an analogy, she draws on Merleau-Ponty's account of 'being-honeyed', the sensation of grasping at honey, 'which comes apart as soon as it has been given a particular shape' and simultaneously clutches the hands. Voegelin continues: 'the honey can only be felt through my stickiness. It cannot be grasped as a remote object but comes to being in my honeyed-hands as a complex phenomenon of no certain shape but a demanding nature' [Voegelin, 2010, p. 9]. The relational experience of listening, therefore, entails a shift from thinking about separate sounds and listeners to thinking in terms of 'stickiness' and orienting to an in-between space in which the connection with sound is felt.

2 It should be noted that Cox's ideas are a topic of debate [Campbell, 2020, Goh, 2017, Thompson, 2017], criticisms that have been refuted by Cox in [Cox, 2018]. The nuances of discourse are beyond the scope of this review, but are important to acknowledge.

7.2.0.4 *Plural Possibilites in Listening*

Sympathetic with materialist notions of sound, Voegelin associates listening with an openness, an inhabiting or being-with sound rather than attention to 'solid structures and being able to recognise what can be heard' [Cobussen, 2022, p. 17]. Like the ephemeral materiality of sound, listenings are fragile and uncertain. For Voegelin, sound's invisible mobility [Voegelin, 2021, p. 349] engages the listener in Merleau-Ponty's 'non-sense', his 'sensorial sense that comes from sensation rather than knowledge' [Voegelin, 2021, p. 349]. According to Merleau-Ponty, perception involves a succession of 'dis-illusions', i.e. apparitions that lead us to the real and demonstrate its fragility. Listening allows us to explore dis-illusions without resolution and instead remain within the plural experience of the heard as equal possibilities from the same world [Voegelin, 2021, pp. 350-351].

7.3 STUDY DESIGN

The following participant study was designed to explore the fourth research question:
RQ4: How is sonic entanglement *experienced* as embodied sensations and felt qualities?

The data-collection phase of the study was deliberately broad, and interview questions were content-free to allow interviews to be guided by participants. By contrast, a much narrower analytical focus was chosen to capture the relational aspects of a listener's experience.

7.3.1 *Participants*

A call for participants was made from the first author's social media accounts, and interested parties were invited to complete an online form, which included basic demographic information and simple screening questions designed to limit participation to people who visit art galleries regularly and would visit an interactive or sound art exhibition (see Appendix E.2). 24 responses were collected, and 10 of these participants (6 female, 4 male) were chosen to take part in the study. Participants were selected on a first-come, first-served basis, provided they met the criteria and their availability could be accommodated within the specified time

period. All apart from P4 had experienced a sound installation before. All participants regularly engage with the relevant practices of sound art/ experimental music (P1, P2, P7, P8), musical performance (P5, P6, P9), or audio technologies (P3, P4). The selected participants, therefore, had the relevant expertise 'to actively and knowingly speculate with us in our inquiry' in ways that I could not do alone [Wakkary et al., 2018, p. 1].

7.3.2 *Physical Set-Up*

The study took place in a flexible performance and study space at the university, which was transformed into a dark gallery space with black curtains lining the perimeter. Eight ultrasonic speakers were spread throughout the space and hidden from view, either fixed to the ceiling truss or the curtains. The space was dimly lit by coloured lights, as shown in Figure 7.1. Every effort was taken to present the room as an exhibition space, or 'hybrid' study location (see Section 3.4.2) [Höök et al., 2003, Muller et al., 2006], with minimal visual stimuli to suggest listening.

Figure 7.1: *Being With The Waves* installed at a university performance space

7.3.3 *Procedure*

7.3.3.1 *Briefing*

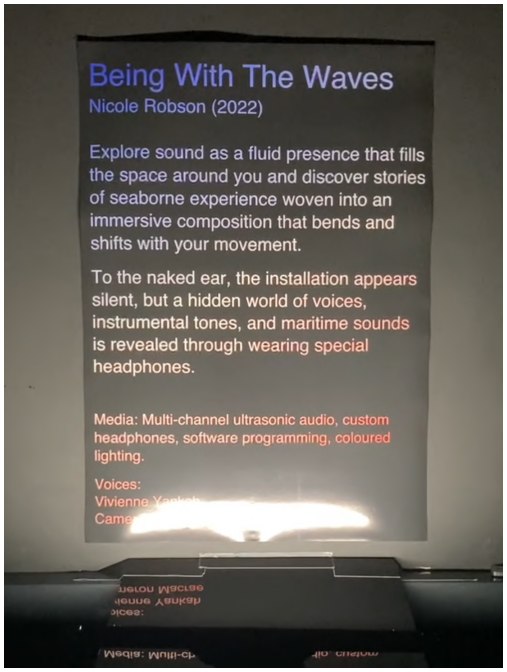
Before the study, I met with each participant for a short, 20-minute online meeting. Participants were briefed about the general procedure of the study and engaged in a short M-P practice interview that served to introduce the kinds of questions used and the sensation of coming into contact and describing pre-reflective aspects of subjective experience. During the composition of *Being With The Waves*, M-P interviews were conducted to capture descriptions of experiences in or with the sea around Ramsgate. I found that a short practice interview put people at ease and led to a more focused and reliable final interview.

Given the brevity of this pre-study meeting, participants were interviewed about a provoked experience. They were asked to perform the following simple task framed by the following instruction: *If you agree, then I propose a little task for you to perform. Close your eyes, and think of an elephant. When you have finished the task, open your eyes or give me a signal that you have finished.* Of course, this task was completely unrelated to the experience that would be under study during their interaction with the installation. However, it served to introduce the kinds of questions used in an M-P interview and familiarise participants with the sensation of coming into contact and describing pre-reflective aspects of their subjective experience.

7.3.3.2 *Listening Encounter*

Participants had individual encounters with the installation at scheduled times. Upon arrival, the participants were told quite simply that the object of the study is to listen to a sound installation artwork called *Being With The Waves*, that the installation is not audible to the naked ear, and that they need to wear special sets of headphones to listen to it. The listening apparatus was then introduced, and participants were shown how to adjust the volume. They were then invited to walk into the installation space and place the headphones over their ears when ready. I asked them to read a curatorial text (see Figure 7.2) on the wall before proceeding into the space. They were invited simply to listen to the installation and stop whenever they felt ready, removing their headphones before leaving the space. In practice, participants listened for between 5 and 20 minutes. After 20 minutes, I asked the listener to return in order to allow enough time for the interview.

(a) Entry-point to the installation space



(b) The brief curatorial text

Figure 7.2: Upon entering the performance space, listeners were guided to the main installation via arrows on the floor and instructed to stop and read the curatorial text fixed to the wall.

7.3.3.3 *Interview*

Each participant was then taken to a separate space for an interview lasting approximately one hour. The interviews were divided into two parts: a semi-structured interview (15-20 minutes) and a micro-phenomenological interview (40-45 minutes).

7.3.4 *Methodological Considerations*

A key challenge to the design of this study was how the moments to focus an M-P interview should be articulated. Finding little reference to this aspect of M-P implementation in the literature, I considered a number of approaches and sought advice from members of the M-P community and my Stage 2 progression panel. The options that I considered are summarised in Appendix E.4. Ultimately I chose to include a short semi-structured interview before the M-P interview began to learn about the experience broadly and help the interviewee to select moment(s) to focus on.

7.3.4.1 *Semi-Structured Interview*

The semi-structured interview was designed to capture meta-descriptions of the experience as a whole: the trajectory of the interaction over time, broad descriptions of what happened, listener intentions, and sensations. Each participant was asked the questions in Appendix E.5.1, diverging as necessary to probe the participant for more detail or follow a trail of thought that might lead to interesting new insights. Throughout this part of the interview, I noted experiential descriptions that were of particular interest in relation to the research questions.

7.3.4.2 *Micro-Phenomenological Interview*

I adhered to the M-P procedure as described in Section 3.5.3, following guidance provided during the training course that I completed in 2020. To articulate the moment(s) to focus the interview on, participants were asked: 'Are there any moments in your experience that stand out as particularly salient or memorable?'. When interviewees described an experience of the Doppler effect or moments of close bodily relationship to sound, I revealed an interest in those moments. I did not wish to lead participants, so for participants who did not mention these aspects (P6, P8, P9), the M-P interview focused on aspects already articulated in the semi-structured interview, such as attentive listening and/ or the relationship of the listener to the spatial placement of sounds. To probe auditory sensations and bodily feelings, I used questions suggested in the M-P training guide (Appendix E.5.2) and sought to deepen experiential descriptions by reformulating the participant's description and then framing 'how' questions. For example: 'You describe the sound as "pouring in", how does it pour in?', or 'How do you know that the sound is sensitive to your moment?'.

7.3.5 *Data Preparation*

All interview data was transcribed according to the conventions described by Poland [2011]. M-P interview data was prepared for analysis in the manner described in Valenzuela-Moguillansky and Vásquez-Rosati [2019]. Interviewer questions and reformulations were removed and interviewee descriptions were broken down into numbered utterances, then re-organised to reflect the diachronic unfolding of the experience over time. In this way, the M-P interview transcript reads as

a chronological description of the moment under study, with synchronic detail nested within. See Appendix E.6 for an example transcript.

7.3.6 *Diffractive Analysis*

The open and exploratory nature of the study led to a breadth of experiential descriptions, including auditory perceptions, intentions, bodily behaviour, mental imagery, emotional states, thought processes, and semantic interpretations. I conducted a much narrower diffractive analysis to specifically examine listener experiences of entanglement with sound in the installation. Given the material-discursive co-production of phenomena by research apparatuses (Section 2.4.2), I sought an alignment of the analysis method and the phenomena under study: sonic experience.

Materialist theories of sound (section 7.2) were 'plugged-in' to the interview data [Jackson and Mazzei, 2013] producing an emergent series of readings, which I conceive as patterns of positive interference, where theory and experiential descriptions *resonate*. This led to a clustering of phenomenological descriptions around particular theories. Rather than abstracting away from the data itself via qualitative coding, I sought to harness the fine-grained detail produced by M-P interviews. Furthermore, I explicitly sought to set the disciplines of sound studies and interaction design into conversation with one another. Throughout the analysis, I was attentive to the 'production of boundaries': how as some experiential descriptions move into the foreground, others are excluded [Barad, 2007, p. 92-93]. Thinking with sound, I became aware of emergent differences concerning other accounts of entangled experience in HCI and taken-for-granted, invisible dynamics [Lazar et al., 2021] of research methods. These wider *reverberations* inform the provocations for HCI described in Section 9.3 of Chapter 9.

7.4 FINDINGS

The diffractive analysis led to the following four clusters of experiential descriptions:

1. *Feeling Connection*: Reading the data with Voegelin/ Merleau-Ponty's notion of 'being-honeyed' surfaces data describing the felt quality of connection with sound as material.

2. *Relational Flux*: The mobile and temporal quality of sonic material leads to the identification of temporal instability of embodiment sensations.

3. *Somatic Alignment*: Szendy's proposal that listeners 'punctuate' sound with their listening surfaces descriptions of intention setting with bodily poses and movement qualities.

4. *Expecting Sensors*: Plugging the doubtfulness and ambiguity of listening (Voegelin) into the data surfaces ways in which listener expectations regarding the system design lead listeners to dwell in technological 'dis-illusions'.

7.4.1 *Feeling Connection*

As described in Chapter 5, *Being With The Waves* harnesses the acoustic entanglement of a listener with sonic phenomena as the root of interactive effects. The computer has no symbolic representation for human input and no mapping space separates behaviour from sound generation. Instead, the bodily presence and movement of the listener and sound as heard through the system are co-dependent, generated simultaneously, and as such there is no perceptible latency in the system[4]. As a result, sound is perceived as being intimately related to bodily behaviour. P7 describes the experience of sound as 'tactile in a sort of keen aesthetic sense, that the feeling in your body as you move then kind of maps experientially onto the sound.'

Plugging Merleau-Ponty's notion of 'being-honeyed' (section 7.2.0.3) into the interview data amplifies phenomenological descriptions that express felt qualities of listeners' close connection with sound as a material. One such quality is that of resistance, which ordinarily describes a physical feeling at the meeting point of a body and matter of some kind. P3 describes the feeling of a force pulling them back: it 'feels like I'm kind of walking against something, like there's a force that's pulling me back or trying to slow me down.' But, of course, there is no force physically acting on the body to resist its movement, there is just the experience of sound, a nuance that P3 is keen to express: 'it's just a feeling.. that's how I felt it's not like it is actually doing anything.' P2 describes the drone sound as 'like a cloud a few hours from raining, like it's building up with humidity inside... There's something fluid about it but it's still airy.' In moments of movement interaction,

4 Ring (de-)modulation by 20.5kHz shouldn't produce any more than a few tens of microseconds of latency, but there will be some minimal latency in the audio codec and buffering of the Teensy.

they describe this sound as having a viscosity 'because when I turned my head at other moments I felt the sound pour in at the same time as me sort of turning and opening up to it.' For P2, 'viscosity' describes a felt quality of interaction, related (I infer) to a rate of sonic change, and felt sense of materiality, as a texture with density.

Describing the sensation of interaction with the Doppler effect, P1 and P2 describe variation in the sound according to movement properties associated with physical objects that exhibit temporal variation as a result of their form and material. P2 describes the instability of sound as a jelly-like quivering, while P1 makes an analogy with toys that can't be knocked over and instead oscillate around a central position, gradually reaching a standstill. For them, the sound 'felt as if it was spinning within itself, and then when I stopped moving, it sort of went back to its original tone.' Importantly, they also describe a close connection to the movement of the sound. P1 feels it as located within the top of their head, 'as if I was dizzy, sort of being spun with the sound. It doesn't make me feel dizzy, but I think it just feels like it's there', while P2 describes feeling closely bound to the jelly sound-movement sensation, stating 'I am that jelly'.

7.4.2 *Relational Flux*

Reading the data with Cox's sonic materialism (section 7.2.0.1) foregrounds the temporal dynamics of relational experience. Technology relationships such as those describe in Ihde [1990, pp. 72-111] tend to be thought of as fixed and immobile. In the experience of interaction with *Being With The Waves*, listeners describe close bodily connections with sound that have underlying temporal fluctuation, varying in intensity and location relative to the body.

P7 describes whirling and spinning through the installation space. They also describe having a close connection with sound, in that it is experienced as both inside and outside the body, or rather 'there's not really such a big distinction.' This intimate relational quality is not fixed or static; it moves and is in flux in a way that is tied to the speed and shape of its movement. The sound is 'like a figure of eight, it kind of whips through you and then around you.' As they whirl through the installation, P7 says that 'the sound is just undulating and modulating its pitch with every whirl, and there's a kind of consistency in my body sort of creating a rhythmic intensity within that drone sound.' Probed further about the quality of this rhythm, P7 describes it as 'internal and it's like something that is

generated from within', rather than something imposed on the body from outside. Rhythm, here, appears to capture a felt quality of the interactive relationship rather than a musical quality. Unintended, it is an embodied and emergent sensation at the meeting point of the (moving) listener and external field of vibration.

The Doppler effect was felt most strongly during periods when a drone dominated the installation; at times, it was purer in sound, and at others, more textural, composed of sustained violin notes. A drone is sustained over long periods, it has a stable presence in time. However, several participants (P1, P3, P9, P10) invoke the word 'infinite' to describe a spatial presence as immense, filling the space: 'I felt like it's an infinite field of these two tones' (P3). In stillness, the drone is heard as continuous, but bodily movement leads to pitch bends and timbral distortions as a result of the Doppler Effect. In movement, the sound is no longer infinite for P1: 'It doesn't sound infinite because... when I felt as if I was triggering the spinning, I was able to stop it, so it almost felt as if it did have an end.' P1 moves from describing the sound as heavy and solid to having a spinning sound associated with the movement quality of toys (described earlier), with perceived size in the range of handheld objects. Through their movement interaction with the installation, sound comes closer to the body and is experienced as mobile and light rather than static and heavy. Sound appears to shape-shift, and the embodied relationship of the listener to sound installation is in flux.

7.4.3 *Body-Sound Alignment*

Reading the data with Szendy's notion of listening as an articulation or punctuation of the sound (section 7.2.0.2) highlights accounts by participants (P2, P5, P7, P8) that describe the adoption of particular bodily postures that are simultaneously inspired by the sound of the installation and adopted to express a particular listening intention or sense. These dispositions cannot neatly be described as either passive or active and, instead, are suggestive of an intention to align the body with sound.

Reflecting on their experience as a whole, P2 describes a journey of figuring out how they can work in harmony with sound. They describe holding their body in a controlled way: 'I really wanted to be strong and grounded so that I could make those deliberate footsteps and movements. I didn't want to flail about in there.' By calming their movements, they can give more of their body to the act of listening. This somatic disposition toward sound is echoed by P5, who describes a moment

of bodily poise in which the music was supporting their physicality, rather than the experience being about their body in relation to the music, 'so it was like a switch of emphasis or switch of relationship.' The sounds of the installation are continuous at this point, and they express a sense of 'something being sustained through it, and the pose had that potential for stillness and yet movement... It had a constant alertness and smoothness around it, like the music did.'

P8 describes sitting in a meditative pose, breathing deeply, and attempting to let go 'of being a separate entity'. They describe feeling their body as part of a wider vibrational plane: 'it felt like the space around me was also inside with the resonance... physically it's like tiny particles moving in my lung when I breathe in.' The body posture is adopted to focus on listening, but it is the sound that causes the sensation. P5 and P7 both describe the intention to become fluid with their bodily movements to match the perceived fluidity of sound. P5 notes how this bodily disposition changes their listening: 'when I was imagining my body being light or fluid whatever then you start listening in a different way.. so what I was doing with my body did affect my... listening sense.' In their attempts to make their body fluid like water - 'I turned my body into an eddy of water' - P7 notices how their body is solid, how their joints can't move fluidly: 'there's this whole feeling of resistance in my joints- that I can't be a perfect fluid- because I've got these joints and my sort of irritating physical form that's inside.'

7.4.4 *Expecting Sensors*

The speaker array in *Being With The Waves* is hidden from view, the microphones on the outside of headphones are so tiny as to go unnoticed, and the Teensy microcontroller, along with amplification circuitry are concealed inside a box. Participants have no prior knowledge of the system design with respect to the configuration of technologies that produce interactive effects. As described in section 7.3.1, participants were recruited as co-speculators and experienced listeners to sound and interactive installations, many artists and technicians themselves. Participants describe attempts to make sense of sound's organisation in the space and how the installation works, making hypotheses regarding the technologies involved. Their descriptions reveal an assumption that interactivity is configured via the mapping of sensor data to a sound engine, with changing auditory feedback output to the listener's headphones. In short, listeners assume that there is a computational process at work that has a symbolic representation of listener movement in the space.

Like many listeners, P4 describes repeatedly moving and stopping to 'test' the interaction effects: 'testing the length of pauses to check it wasn't a coincidence and feeling actually it was almost too sensitive. So almost as if I was imagining starting to go left the juddering would start. So I thought "that's too sensitive, so it can't be that" and tried it again, and it happened half a dozen times at least.' There is an expectation that interactivity effects must be coupled with some latency for computation to occur.

P2, P3, and P10 speculate that the installation involves movement sensing; either pressure sensors in the floor, an accelerometer in the box worn around the neck, infra-red distance sensors, or a camera-based motion capture system mounted on the ceiling. Reading the interview data with Merleau-Ponty's notion of dis-illusions as the root of experience and Voegelin's proposal that in listening, we might more readily dwell in these alternative possible worlds (section 7.2.0.4) highlights ways in which assumptions about technology influence listening behaviour and experience. P2 makes a cognitive connection between the rate of change to the sound and the movement quality of their footsteps. This leads them to believe there are pressure sensors in the floor. They describe listening carefully with this connection in mind and 'trying to put that sound that was in my ears in my foot... I was trying to imagine them... not like that's my foot and that's my ear, that's coming through here and that's doing that, it's more like, okay this is one unit and how does this whole thing work together'. Similarly, P10 believes there to be a matrix of sensors above them detecting their position and movement in the space. This leads them to associate their body movement and the bending sound of the Doppler effect with the position of imaginary sensors. These associations of movement and sound with particular spatial locations surely transform the listening experience. Both are phenomenological dis-illusions and demonstrate the possibility for plural interpretations of the installation.

7.5 METHODOLOGICAL REFLECTIONS

The experience of listening is ephemeral and elusive, while the human experience is complex, layered, and diffuse. This sonic framework helps to ground the analysis of phenomenological descriptions in dimensions of experience that are most salient to the materiality of sound: temporality, spatiality, mobility, and plurality. In the next sections, I reflect on the methodological aspects of this study. The interview findings are discussed in relation to other study outcomes in Section 9.1.

7.5.1 *Micro-Phenomenology and Sonic Experience*

Research is often generative, new aspects and ideas come to light as a result of renewed engagement with the subject at hand. In my case, the participant study was designed and carried out long before the analysis approach and central ideas in this paper came to be. Careful consideration was given to the method for articulating listening experiences, and I stand by my selection of micro-phenomenology (M-P) as the optimal fit. When applied rigorously, the method is unparalleled in its capacity to reveal rich experiential descriptions, the significance of which is yet to be fully explored within the field of HCI. However, via my diffractive engagement with theory, I noted some friction between M-P and my orientation to the sonic, a slight epistemological mismatch. As such, the temporality of sonic experience does not flow out of the data.

O'Callaghan draws attention to a more or less implicit assumption in the history of philosophical work on perception, 'that what we learn about perception by studying vision generalizes to the other sense modalities' [O'Callaghan, 2007, p. 3]. M-P tends to treat sensations as objects rather than events, which, in the case of sound, is problematic. To probe the synchronic details of an experience, the M-P interviewer works to stabilise the interviewee's evocation of a past moment, thereby freezing time. While visual sensations and mental images are readily stabilised in this way, sounds, which are inherently temporal, are not. It may be possible to repeatedly iterate through a short period but not to freeze a sound in time. The M-P interview questions suggested in training material (see Appendix E.5.2) elicit the details of a sonic sensation by asking participants to describe its object qualities, such as direction, location, size, loudness, tone, and persistence. I found these questions productive in that they provided a shared language within which to talk about sound in phenomenological terms without the need to use technical or musical jargon. However, these questions do tend to treat sonic sensations as objects, not events. Therefore, descriptions do not readily account for the temporal fluctuation of sounds, or indeed any other sensations, on a micro-gestural level. Detail, which in the case of this study, would be beneficial to capture more readily.

Of the M-P questions to probe sonic sensation, I found the question 'does this sound come from somewhere?' productive as it situated the sonic sensation in relation to the body and revealed, quite organically, the perceived closeness of sound, along with descriptions of size and other felt qualities, including the temporal fluctuation of sonic sensation. As a result, I could approach the question of

what it *feels like* to be entangled with a level of descriptive detail that would not have been obtained by using traditional qualitative interview methods. The identification of possible frictions is a constructive finding as it allows me to consider how I might tailor the M-P framework to account for more fluid rather than discrete events and improve interview questions to most effectively study a variety of phenomena, including an experience of sound.

How I might capture temporal fluctuation with the M-P framework requires close consideration because the stabilisation of attention on a singular moment of past experience is foundational to the method. In future, I plan to seek advice from expert practitioners to examine this issue and also introduce sound art practitioners to the M-P technique, engaging them in ongoing discussion and experimentation with the method to frame questions that target the sonic, such as 'How tightly bound do you feel to that sound?', 'Does that sensation fluctuate?', 'How stable is it?'.

7.5.2 *Comments on the Research Apparatus*

In the installation, study design, and analysis method, I chose to make particular agential cuts, which determine the scope and content of our findings. For example, paratextual elements of the installation, such as its title, curatorial text and musical symbolism, inevitably shape the experience of listeners in some manner. It is possible that when describing sensations of resistance or viscosity - qualities ordinarily associated with liquids - listeners are influenced by aquatic references in the work. By making this point, I am not suggesting that the data is distorted or its validity undermined, but rather that these verbal descriptions are inseparable from the singular installation assemblage. I do not expect these findings to describe the experience of sound installation art in general, but I am interested in how design elements come to shape experience. Therefore, the question arises: where broadly similar interactivity is encountered without those aquatic cues, is the feel of interaction articulated by listeners with similar language and metaphor use? The next study, described in Chapter 8, will remove explicit references to water and examine the extent to which they inform experiential descriptions.

7.6 CONCLUSION

Contributing to the fields of posthuman and more-than-human design [Coskun et al., 2022], this chapter offers a practical implementation of entanglement theories and the agential realism of Karen Barad, in particular, [Barad, 2007], seeking consistency between epistemological commitments, design intentions, and qualitative research methods. I decentred human agency in the articulation of listening experiences by focusing the analysis on aspects of an entangled subjectivity, i.e. the relational qualities of listening, and did this by reading M-P data in relation to relational theories of sounding and listening. The outcome is a partial view of the data set that highlights relational, temporal, and mobile qualities of interactive experience. I am excited by the depth of insight obtained through this study and believe that M-P could more fruitfully elicit sonic experience with practice and careful consideration of the questions posed.

This chapter has highlighted the active influence of research methodologies on knowledge production. As a research probe, the artwork *Being With The Waves* plays an important role in shaping possible experiences. Many aspects of the artwork led to ambiguity in this study: the underlying technologies could not be seen, the prominence of watery symbolism may have influenced experiential understanding and description, some listeners were unaware of Doppler-based interactivity, and others could not be certain that audible changes resulted from bodily movement. Each of these issues is due to the design of the artwork: the sound design and its mediation by the technology as well as the curation of the work. The next chapter describes the creation of a second artwork, *Sonographies*, with which I aim to hone the installation's potency as a research probe, distil key qualities of the ultrasonic technology as the locus of meaning-making and explore the role of curation for shaping listening experiences.

8

STUDY 4: EXAMINING THE SITUATED DESIGN AND GALLERY CURATION OF SONOGRAPHIES

This chapter includes material published in "Negotiating Entanglements in the Composition and Curation of an Ultrasonic Art Installation", by Robson, McPherson and Bryan-Kinns at NIME 2025 [Robson et al., 2025b].

This chapter describes the final study of this thesis, which examines the practice of creating a sound installation called *Sonographies* during a month-long creative residency at *no format Gallery* in South London. *Sonographies* is a new and separate artwork from *Being With The Waves*. It employs largely the same ultrasonic technology as that described in Chapter 5, but establishes new conceptual framing, sound design and visual curation.

Throughout this PhD, the foci of participant studies shift between matters of practice (Chapter 4) and matters of experience (Chapters 6 and 7). This chapter focuses primarily on practice, taking a *research through practice* approach (Section 3.3 to examine the process of creating *Sonographies* while deliberately attending to the gallery's materiality (site) as a nonhuman influence on creative ideation and decision-making. This chapter addresses RQ5 and findings are reported as a design journey in Section 8.4.

RQ5: How do nonhuman, material influences shape *my* artistic practice and process with the ultrasonic installation?

This chapter also examines the relationship of design practice to listener experience as a secondary focus. During the installation's public exhibition over two weekends in February 2024, visitors were invited to complete a short survey after listening to the installation. A diffractive analysis of survey data considers the (dis)connections of artistic intentions with listener experiences and perspectives, as well as the relationship of data to the survey's design, materiality and the temporal frame of its completion. The findings of this diffractive analysis are presented in Section 8.5, before a discussion of study outcomes in Section 8.6 addresses the doubtful experience of 'designing-with' [Wakkary, 2021], connections between

artistic activity to listener reception and nuances of the relationship of *Sonographies* to site and notions of bodily presence. The findings of this study indicate aspects of the installation that produce desired aesthetic and experiential qualities.

8.0.1 *Motivation*

Studies 2 (Chapter 6) and 3 (Chapter 7) both employed the artwork *Being With The Waves* as a research probe. In my final remarks of the last chapter, I pointed to ambiguities in the design of that artwork that may have hindered the research studies to date, including whether the prominence of watery symbolism in the piece may have influenced experiential descriptions. In Chapter 2, I defined sound art installations as inherently site-specific, but the relationship of the ultrasonic installation to material agencies of the site has, so far, not been fully explored. These aspects, together with the wish to hone my craft with the installation technology, are key motivators for this chapter.

This chapter builds directly on the interview study described in Chapter 4, which found many ways in which sound artists work to harness the site of an artwork, its social and material character as an active force that guides their artistic activity. Artists described a design process in which sound, space, technologies and materials are, to use their terminology, 'brought together' or 'assembled' following a close listening engagement with a site to understand its materiality and potential. I see parallels between the site-oriented practices of sound installation artists and design strategies articulated in recent more-than-human design literature. For example, the theme of 'working-with' articulated in Section 4.2.1.2 echoes the posthumanist practice of 'designing-with', a perspective that acknowledges the agency of non-human factors and recognises that outcomes of design arise from the relationships between humans and broader ecosystems rather than from isolated human intentions [Wakkary, 2021]. Study 4 is motivated by a desire to gain further insight into relational artistic practice and capture a level of detail that can only be accessed through first-hand experience. This chapter, therefore, examines my own practice as I work in situ at a London gallery, re-assembling the installation for its new context and attending to the influence of the site in the design process.

In the discussion of Chapter 4, it was posited that the artists' own listening experiences become mediated in the artwork and are (to some extent) transferred to the listener. This motivates the decision to survey public visitors about their un-

derstanding and experience of *Sonographies* and choice of diffractive analysis as a method: examining the interference of artistic intentions and listener experiences.

8.1 STUDY DESIGN

8.1.1 *Research Through Practice*

In Chapter 3, the practical work of this thesis was described as research through practice, acknowledging that the nature of practice is artistic while also involving technology design and adjacent to research through design (RtD) methodologies (see Section 3.3). This study adopts RtD methods to examine the process of creating *Sonographies* while attending to the influence of nonhuman, material agencies (gallery context, acoustics, environment, technologies).

Within HCI, there is ongoing debate as to how the knowledge gained through design research can be articulated and validated [Höök et al., 2015]. A notable trend over 20 years of RtD projects has been the presentation of design research focused heavily on final artefacts paired with an (often chronological) account of the design activities that led to it via methods such as annotated portfolios [Bowers, 2012] that tend to privilege outcomes over process, success stories over failure. The RtD described in this chapter aligns with recent shifts to focus on the emergence Gaver et al. [2022] and 'messy "through" parts of the design process' [Oogjes and Desjardins, 2024, p. 2] rather than the final artefact.

The process of making *Sonographies* is presented in 8.4 as a design journey. The design journey is an RtD method for documenting the process and reflecting on the 'direction and decisions taken to elicit insights' by 'highlight[ing] details... and bring[ing] them together analytically' [Wakkary et al., 2023, p. 793]. In this study, a reflective first-person account of the design process is constructed from contemporaneous notes and recorded conversations with my collaborator Eva Martinez. This account is selective in the sense that each of the four 'design events' presented relates to research foci: the negotiation of material agency and design for embodied experience. Oogjes and Desjardins [2024, p. 2] define design events quite broadly as 'occasions in which some difference can be observed'. Looking back on the residency, it is the moments of surprise, tension and dead ends that stand out against a background of more expected activity and creative experience. This work contributes to a growing body of literature examining the twists and turns of design practice, which has been described, for example, in terms of nonlinear

paths [Desjardins and Key, 2020], failures [Howell et al., 2021], and loose ends [Goveia da Rocha et al., 2022].

8.1.2 *Co-Curation*

Chapter 4 highlighted the importance of curatorial or 'staging' devices such as lighting, props, materials, texts, etc, to suggest intended ways of listening to or experiencing a sound installation artwork. Chapters 6 and 7 also revealed the sensitivity of listeners to visible qualities of the venue and the ascription of meaning to curatorial gestures: lighting, curatorial texts etc, which until now have been a late addition to the installation space rather than central design consideration. In this study, the curation and visual presentation of *Sonographies* is thoroughly considered in collaboration with Eva Martinez. Eva is an experienced curator, creative coach, producer and dramaturge working across the visual and performing arts, with a particular specialism in contemporary dance curation. She held the role of artistic Programmer at Sadler's Wells, dance and Performance programmer at Southbank Centre and at Dance4.

I met Eva while working with the dancer Akshay Sharma[1] on his solo dance performance *Can This Place Be A Temple?* in 2023. I was the composer for that project, and Eva was the dramaturge. Her dance-related experience suited this project given the movement-based interaction produced in *Sonographies* and the decision to foreground embodied experience. Eva was enlisted as a professional study participant and compensated for her time on the basis of £20/ hour for 15 hours. This time was allocated across 4 online meetings and 4 in-person meetings, which began in advance of the residency, continued throughout the residency and included a debrief after the public exhibition dates to reflect and share learnings. Eva was a supportive presence throughout the study, offering advice, sharing experience and assisting in the curation of *Sonographies*. Our conversations helped to make explicit aspects of my practice and thought processes that might otherwise have remained mute or tacit. Her different disciplinary background was also key, drawing awareness to my own assumptions, values and working practices. While enlisted as a study participant, this was a professional working relationship, working toward artistic and aesthetic outcomes rather than in the service of research aims.

1 https://akshaydances.com/

All online meetings were audio recorded and later transcribed automatically with manual correction. After each in-person meeting, key points were noted and reflected on in the design journal. This documentation informs the design journey reported in section 8.4.

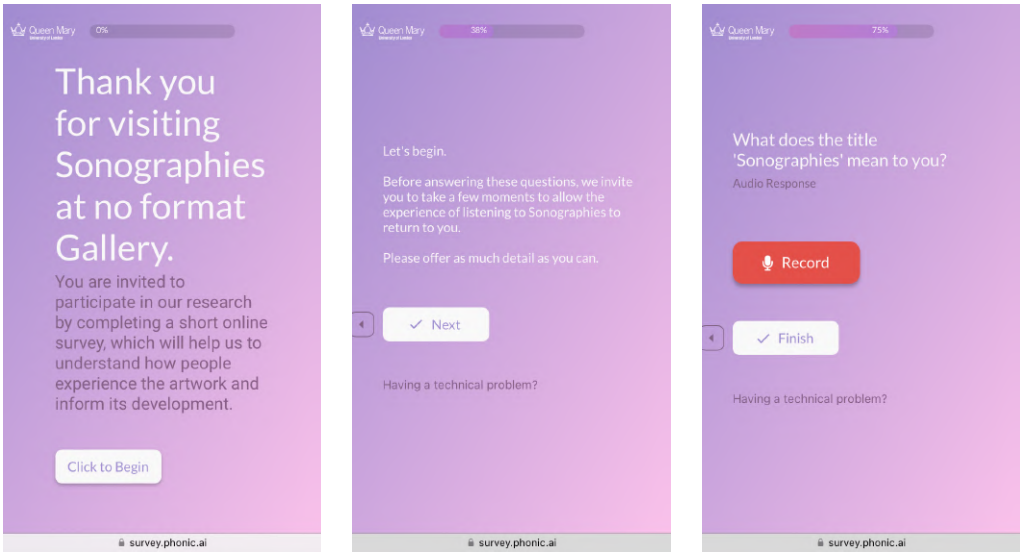
8.1.3 *Creative Residency and Public Exhibition*

Sonographies was presented at *no format Gallery* in Deptford, South London, over two long weekends in February 2024. Since listener engagement was not a key focus of this study and without additional invigilators, I chose not to track the dwell time of individual visitors. Instead, I kept a simple tally of visitor numbers, and across the two weekends, *Sonographies* received 58 visitors.

8.1.4 *Post-Experience Survey*

Following their experience of *Sonographies*, listeners were surveyed to gain insights into the experience of *Sonographies* and the effect of curatorial decisions. Immediately after leaving the installation space, visitors were introduced to the research verbally and invited to complete a short online survey on their smartphone created using the phonic.ai platform. Like the survey employed in Study 2, it was designed to take a short amount of time (around 5 minutes), to have low interference with the visitor's experience and allow for 'quick, on-the-spot completion' [Bengler, 2015]. The presentation of Sonographies sought to foreground the sonic sense over the visual wherever possible. In this vein, the survey consisted of just 3 questions and collected only voice responses. It was hoped that this format might capture instantaneous, instinctive and detailed reactions to the questions, rather than the short, measured and considered text response that participants tended toward in Chapter 6.

Participants accessed the survey via a printed QR code, pointing to a phonic.ai URL where the survey was hosted. The entire survey wording may be found in Appendix F.2. A landing page offered an introduction to the study, participant information, consent statements and instructions before voice responses were sought in relation to three questions. The first, "how did you feel when listening to the installation?" was lifted from the Chapter 6 survey to encourage experiential descriptions. The second question, "How would you describe the experience of listening to *Sonographies* to a friend?" is related to the question posed in Chapter 7:



(a) Landing page (b) Brief instruction (c) Final question

Figure 8.1: Screenshots of the digital survey

"How would you describe the sensation of listening to the installation to somebody unfamiliar with it?" which was found to reveal unexpected perspectives. The final question, "What does the title *Sonographies* mean to you?" was suggested by Eva to examine what the title *does* in relation to meaning-making.

Participation in the survey was limited to visitors who experienced *Sonographies* during its exhibition at *no format*. Participants were effectively recruited via the gallery's event listings and my own social media posts and email invitations. Given the competing pressures on my time, I chose to target my existing networks (friends, family, affiliated student groups) rather than a general audience. The phonic.ai platform provided an automatic transcription of vocal responses, which were checked and adjusted manually.

8.1.5 *Diffractive Survey Analysis*

Sonographies is the outcome of artistic and research intentions. As the artist and researcher, I am utterly entangled with *Sonographies*. The installation has developed over four years of PhD research. It is closely related to my wider artistic practice, which forms and is formed by my identity. Reflecting on my subject position relative to the survey data, I believe that it would be impossible to adopt a reflective analytical stance, implying a separation and distance, observing phenomena from

the outside. Instead, a diffractive approach (see Section 3.6.2) was taken to the collected survey data that would a) harness rather than mitigate my entangled position in the midst of knowledge production and b) capture the entanglement of human agency with other agencies [Bozalek and Zembylas, 2017] i.e. foreground connections between the data, the design of Sonographies and survey as a research method.

In practice, the analysis was conducted through repeated readings of the survey transcriptions. At first, impressions and points of interest were noted that could guide further analysis. Afterwards, a more formal process of analytical work began: highlighting and colour coding parts of selected passages according to their correspondence with my intentions for the piece and existing understanding of its effect and affordances. Additionally, memos were added to each highlight describing my felt response to the data, querying the meaning of the data and commenting on aspects that suggested closer consideration. The use of memo-writing in post-qualitative analysis has been proposed by [Augustine, 2014, p. 749]. The findings reported in Section 8.5 are an aggregation of descriptions and insights that I judge to be most pertinent in relation to the research questions that extend my understanding of the installation and its relationship with human experience and means of research.

Arguably, there is a thematic coherence to the perspectives that are brought together, but this is not a thematic analysis [Braun and Clarke, 2012]. Fundamentally, the survey data was not coded in a way that fragments and abstracts away from the whole, situated account. I also sought a (new) materialist perspective on the analysis by considering the data in relation to that which produced it: the installation and the survey as a research method, specifically the digital survey as a situated intervention that invited listeners to respond to particular questions via a particular format, by speaking into their mobile devices in a way that is quite intimate.

8.2 ARTWORK 2: SONOGRAPHIES

For video documentation of *Sonographies*, please refer to `https://nicolerobson.com/sonographies-documentation`. Headphone listening is recommended to hear the same audio that was fed to the listener during their interaction.

8.2.1 *Design Choices and Motivations*

Sonographies stems from my desire to create a new artwork using the same technology by completely changing the sound design. I sought a pared-back aesthetic that would distil qualities of the installation, get to the essence of what it does in terms of feeling the body and being present in the space. Essentially, where *Being With The Waves* foregrounded a representational mode of understanding - apprehending the meaning of texts and sounds as signifiers of maritime themes, *Sonographies* is intended to emphasise an embodied mode of understanding, using abstract or ambiguous sound design that suggests (rather than overtly signifies) themes of intimacy, the personal and the body. *Sonographies* is also informed by past design experiences, study findings, informal listener comments and the momentum of artistic practice, which contribute to the following three design choices, all of which were articulated before the creative residency at *no format Gallery*:

1. **The decision to harness the gallery's materiality as an active influence on the design process**
   Inspired by the site-specific practices of sound installation artists, a close relationship was sought between the installation's design and the gallery where it would be presented. *Being With The Waves* was always tailored to the space once sound materials had been determined; the composition was spatially diffused, tweaked and mixed in situ in response to the room's layout and acoustic at the end of a design phase. With *Sonographies*, a close engagement with the site was sought from the outset, allowing the creative process to be influenced by the gallery's existing appeal to the senses and material qualities (i.e., its volumetric form and appearance, construction materials, acoustics, the environment beyond its walls).

2. **The decision to foreground embodied and relational awareness.**
   Extending the work of study 3, *Sonographies* should encourage embodied and relational awareness. A secondary concern in *Being With The Waves*, these experiential aspects move to the foreground in *Sonographies*. Through its design, I hope to foster an intimate awareness of the body, how it is situated in relation to spatial sound and involved in the co-production of listening experiences. To support this move, the decision was made to shift from representational to embodied meaning, from the literal maritime symbolism of *Being With The Waves*, toward a more abstract and minimal aesthetic, avoiding di-

rect meaning and exploring curatorial devices that support bodily awareness. The title *Sonographies* points to the use of ultrasound to scan the body but is deliberately open, avoiding overt symbolic meaning.

3. **The decision to reduce technological ambiguity.**
   The ultrasonic technology produces an interactive experience without sensors. Study 3 highlighted an assumption among study participants that interactivity must be configured via sensors and mappings. This 'technological disillusion' had an undesirable impact on listening experiences, occupying the thoughts of inquisitive listeners and diminishing the awareness of sensory experience. In an effort to reduce this ambiguity in *Sonographies*, the technologies will be visible. Where speakers have previously been hidden in darkness and computational components concealed within a housing, they will now be shown. Therefore, technology is intended to be a facilitating presence rather than the locus of attention and meaning.

While much remains unchanged, each of these decisions implies a movement away from the design of *Being With The Waves* and a shifted set of priorities. Anything that does not directly serve to foreground embodied modes of listening is sidelined. The above design choices represent priorities that motivate and inform the design journey described in section 8.4.

8.2.2 *Speaker Arrangement*

Sonographies is an eight-channel sound installation. Four speakers face into the space, each mounted in the centre of one of the four walls. Another four speakers are housed on the ceiling, facing downwards, one in each corner of the room. The arrangement of speakers can be seen in Figure 8.2. Note that this arrangement is far from arbitrary. It is strongly influenced by the gallery layout and acoustics, see Section 8.4.0.1.

8.2.3 *Technical Changes*

Earlier in this PhD, when describing *Being With The Waves*, I noted that self-noise produced by the Adafruit Powerboost board - which powered the Teensy microcontroller and recharged the Lipo - became demodulated into audibility, leading

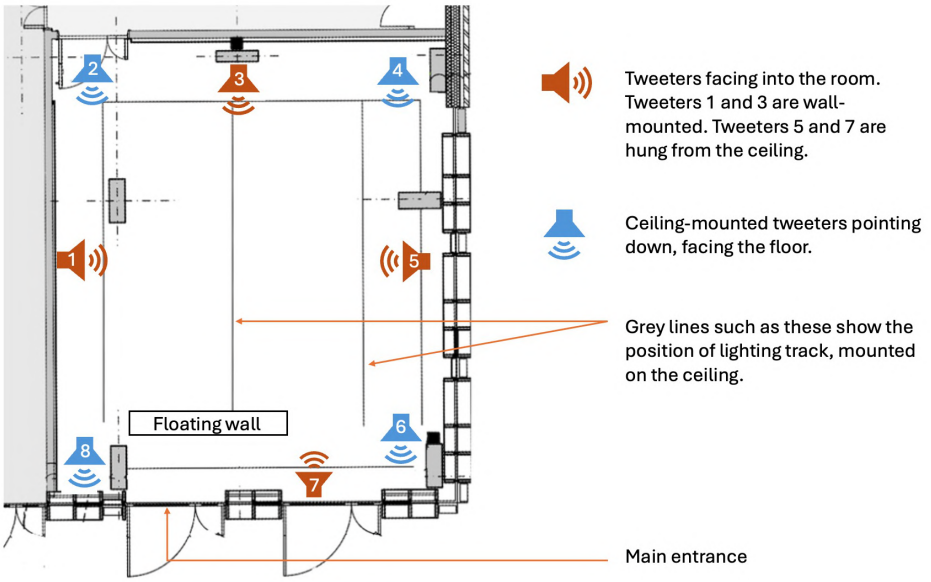


Figure 8.2: Floor plan of no format Gallery annotated with the positions of eight tweeters.

to noticeable whine and noise on the audio output (see Section 5.6.1.1). I was keen to resolve this issue before the public exhibition of *Sonographies*. Hypothesising that the whine accorded with the operating frequency of the chip used in the Powerboost, I sourced a different LiPo charger using a different chip component, the Seeed Lipo Rider Plus[2], which resolved the issue. With a cleaner output signal, I also tweaked resistor and capacitor values in the amplification circuit to boost the gain of the audio signals output to listener headphones. In sum, these changes enabled louder and more transparent mediation of ultrasonic phenomena in the installation space. A schematic showing the design of the amplification circuit is shown in Figure 8.3.

8.2.4 *Sound Design and Conceptual Framing*

> The man with the magnifying glass - quite simply - bars the every-day world. He is a fresh eye before a new object. The botanist's magnifying glass is youth recaptured. It gives him back the enlarging gaze of a child. With this glass in his hand, he returns to the garden... Thus the minuscule, a narrow gate, opens up an entire world.
> *The Poetics of Space* [Bachelard, 2014, p. 155]

2 https://www.seeedstudio.com/Lipo-Rider-Plus-p-4204.html

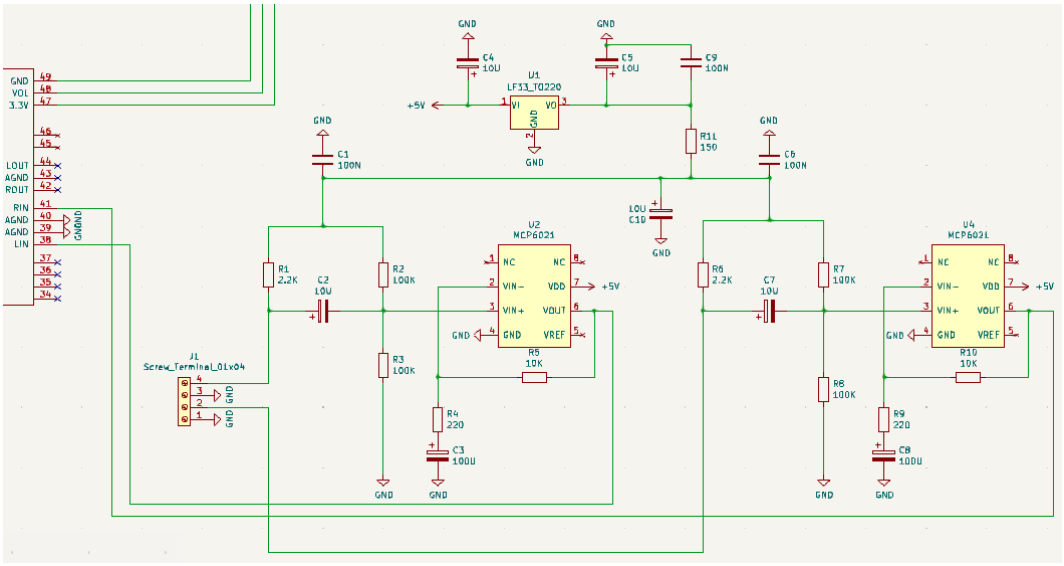


Figure 8.3: Schematic of the amplification circuit used to boost microphone outputs prior to processing and output by the Teensy microcontroller. It is the Teensy symbol that is cropped out on the left to enable a close view of the circuit itself.

In *Sonographies*, an alignment was sought between representational and symbolic qualities of sound design and the intimate quality of embodied experience that the installation technology produces. In other words, a distillation of meaning into an underlying conceptual frame that would support rather than distract or detract from the felt quality of interactive experience. This approach was adopted as a design strategy in relation to the research question: *How can the installation be reworked and curated to emphasise embodied experience?*. In response to this intent, the sound design for *Sonographies* draws on themes of the domestic, intimate and personal space.

Sonographies is entirely composed of sound materials collected at my home. Inspired by the above Bachelard quotation and mirroring the way that the installation appears to magnify phenomena, sounds were recorded with a sensitive microphone in close proximity to reveal intricate detail that would otherwise be barely audible. The motoric whirr of a small clock mechanism, the background hum of household appliances, rustle of duvet covers and breath of my sleeping son were recorded in this way. Resonant frequencies of the gallery space were translated to musical pitches and recorded as sustained chords on the piano in the living room. Again, the microphones were placed in close proximity to the strings and captured the sound of piano hammers, the beating and dancing of harmonics.

As has been described elsewhere in this thesis (especially in chapter 5, ref section), the extent to which the installation is perceived to be interactive depends on the sound materials from which it is composed and their mediation by the installation's ultrasonic technologies. The presence and audibility of the Doppler Effect depend entirely on sound design choices. Through Study 3, I learned that interactive effects were not always noticed by listeners and at times, it was unclear to listeners whether new sonic events in the composition of *Being With The Waves* were being triggered in response to their behaviour. Through the M-P interviews conducted in that study, I developed a sensitivity to the different modes of attention to the body in relation to sound, concluding in the section 'Relational Flux' (ref) that 'sound appears to shape-shift and the embodied relationship of listener to sound installation is in flux.'

With the sound design of *Sonographies*, I wished to frame interactive effects more prominently in the artwork and organise the composition around different *flavours* of body-sound relationship. The result is a 20-minute composition arranged across eight tracks in Ableton, each corresponding to a tweeter in the gallery space. It plays on a continuous loop and falls broadly into three sections each marked by a particular body-sound relationship and set of sonic materials:

1. **A sparse interior scene**

   Body-sound relationship: close, intimate and directional. The Doppler Effect is prominent drawing the body into close relationship with individual sounds that have a perceptible spatial location. Encouraging an 'entangled subjectivity' (described in Section 9.3.1): a hybrid attentional disposition, attending to the co-production of sound by and with the body.

   Sonic composition: The continuous whirr of a clock mechanism (speaker 4) and electric hum of fridge (speaker 6, see Figure 8.2) are the backdrop to a collagic arrangement of more prominent sound events that is intended to evoke a sense of place. For a period of time, the rise and fall of human breath is uncannily present. Later the space is punctuated by a series of solo cello bow strokes. These sounds are emitted from tweeters 5 and 3 respectively, which face into the space and have timbral qualities that make them highly sensitive to the Doppler Effect. The intention is for the listener to discern this relationship and duet with the sounds, experiencing closeness and wild warping effects.

2. **Transition.**
   Body-sound relationship: No Doppler Effect. A break from intimate interactive effects. The intention here is to choreograph listening, shift toward spatial listening, i.e. an extrospective mode of attention listening to sound as positioned in the gallery space.
   Sound materials: Vinyl crackle is emitted from the corner speakers. Emitted down into the space, the overrall effect is of pointillistic sonic articulations. The frequency of the carrier frequency for amplitude modulation on the transmitter side ramps up through this section from 20.5kHz to 40kHz, which in turn modulates the pitch and timbre of the crackle - which shifts slowly from rock-like rubble to bright sparks.

3. **A richly harmonic drone**
   Body-sound relationship: Like section 1, close and intimate but here with focus on directionality. Promoting the feeling of being within a continuous field of sound, immersed or submerged in the installation.
   Sound materials: Drone composed of time-stretched piano recordings and sine tones, creating a dense field of sustained sound. The drone is spatially distributed, with different selections of pitches are emitted from each tweeter and continuously sensitive to movement.

8.3 VISUAL, MATERIAL AND TEXTUAL CURATION

Sonographies was curated in collaboration with Eva Martinez. The scope of this work included 1) aspects that prime the experience i.e. the writing of marketing and curatorial texts and production of imagery that the listener encounters in advance of listening to the installation, and 2) the staging of the installation, including the visibility and placement of installation materials in the gallery and interventions that alter its appearance, such as the introduction of materials and lighting into the space. The main marketing text that was shared online can be found in Appendix F.3, and the public exhibition poster is shown in Figure 8.4.

8.3.0.1 *Curated Trajectory*

This section describes curatorial interventions in terms of the intended trajectory of a listener through the installation.

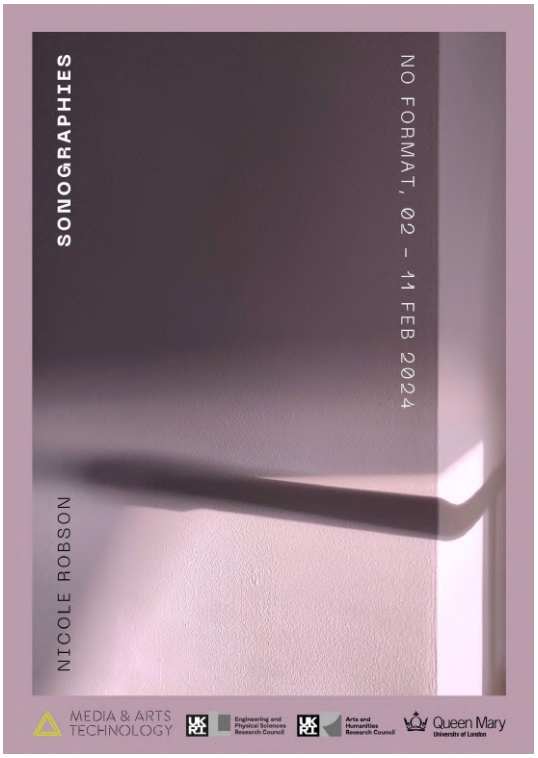


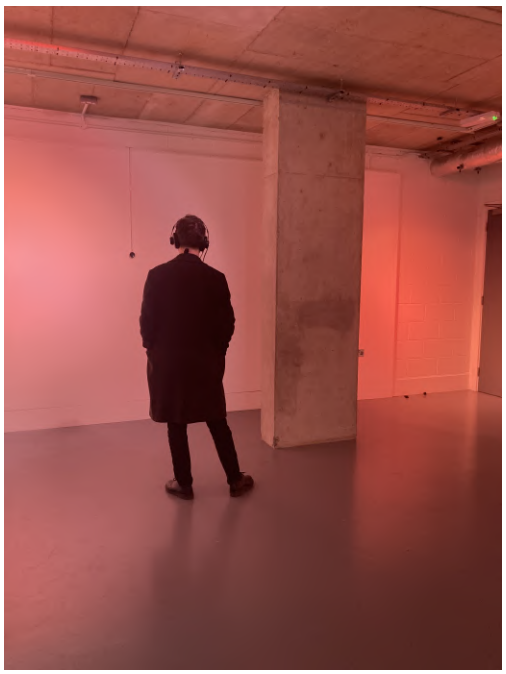
Figure 8.4: Sonographies poster, seen by most visitors online in advance of the exhibition and also displayed outside the gallery.

Upon arrival at the gallery, the visitor enters through the glass doors (image (a), Figure 8.5). The installation is almost inaudible to the naked ear, so at first the listener encounters only a white gallery divider concealing the installation space behind, with text displaying the the title of the work, name of the artist and a short provocation to: *listen with headphones, listen with your body, listen with the space*. Wherever possible, I sought to foreground the sonic modality over the visual. Therefore, in place of the curatorial text that would conventionally be visible in a gallery space, a small white speaker with built in motion detector plays a short audio welcome and instructional text:

> Welcome to *Sonographies*, a sound installation exploring hidden and intimate spaces of experience. Concealed in near silence, a spatial composition is sounding in the gallery but above the range of human hearing. Unstable and sensitive to movements of the body, the installation is revealed through bespoke headphones created for the work. Please, take a pair of headphones, wear the strap around your neck, and notice that there is a knob for you to adjust the volume if you wish. *Sonographies*

(a) Arriving at the gallery doors

(b) First impressions



(c) A listener inside the installation space

(d) A suspended tweeter, in front of one of many light curtains covering the windows

Figure 8.5: Images describing the visual curation of Sonographies at no format Gallery

> is an invitation to dwell in sound, to listen with your body and listen with the space.

Though this was intended to replace the need for a human introduction however I often sat inside the gallery doors to monitor the space and introduce the survey to listeners upon their exit. I would therefore introduce the work in-person, providing the same information as the above text before assisting the visitor to wear one of five available headphone sets. These were placed on a low shelf at the bottom on the divider (image (b), Figure 8.5).

As soon as the headphones are over the ears, the sound installation is revealed to the listener. They walk into the installation space, which is an apparently empty gallery space lit in soft pink (image (c), Figure 8.5). The windows running along two sides of the space are covered with paper and then full-length white muslin curtains in front of that (image (d), Figure 8.5). Some natural light enters the space, but the outside world cannot be seen. The listener stays and listens for as long as they wish. When they have finished listening they leave the space, removing their headphones and replacing them on the shelf at the entrance before exiting the gallery.

8.4 DESIGN JOURNEY: A FIRST-PERSON ACCOUNT OF THE CREATIVE RESIDENCY

This section presents the findings of RtD activity as a design journey: a reflective and descriptive account of design activities during the creative residency at *no format Gallery*. Each of the four subsections corresponds to a key event within the design process. Each event offers an insight into the interplay of (human) artistic intention and (nonhuman) material forces. The events are presented in chronological order, with their temporal frame in relation to the overall timeline of activity noted clearly. The design journey is constructed from contemporaneous notes and recorded conversations with Eva. Unless otherwise stated, all quotations are my own, lifted from the design journal kept during the residency. The following text is in the first-person present tense, allowing that period to be re-experienced through the act of writing, which was found to aid the process of reconstruction and reflection. I acknowledge that the quality of the writing is reminiscent of micro-phenomenology self-interviews [Sparby, 2023], also known as 'auto-explicitation' [Vermersch, 2014]. This is not a method that was applied here, but having practised it in my M-P studies, may inform the written tone.

8.4.0.1 *Event 1: Working in situ at the gallery, January 2nd and 4th 2024*

I spend the first residency day at *no format Gallery* looking, listening, singing, making sketches and writing notes. I consider creative possibilities - what the material form and acoustic character of the gallery offers and suggests in relation to the installation's design and curation, alongside practical considerations such as how the tweeters will be fixed to the walls and audio cable run through the gallery out of sight. The gallery has a 5m x 7m footprint, a ceiling height of 2.9m and a light, contemporary and industrial feel. The two external walls are almost entirely glazed with floor-to-ceiling windows, and the two internal walls are painted white. The concrete floor is painted grey, and a number of bare, rectangular concrete columns punctuate the perimeter of an otherwise empty space. The columns partially create pockets of enclosed space in the far corners of the space and this feels important - suggesting certain speaker positions and their orientation to listeners. I sketch a number of possible speaker configurations, speculating on the effects of different placements. Placing tweeters on the columns, sound might be projected not just into the centre of the gallery space, but toward and alongside walls. I wonder about the effect of placing tweeters on opposite sides of the same column, how the listener might experience a transition between different sound materials through their movement around the column, how tweeters might be pointed at walls and windows, and sound reflected back into the gallery space.

Listening to the gallery, I am struck by just how different *no format Gallery* is to the previous locations where the artwork has been installed. Ramsgate Music Hall and the university Performance Lab are both black box venues with relatively dry acoustic and heavy doors that isolate the spaces from the outside world. By contrast, *no format* is prominently and pleasingly reverberant. I enjoy singing into the space and find the reverb comforting, noting that 'it sticks to me and extends my voice quite naturally'. The acoustic response of the gallery feels intimate and produces a strong sense of being present in a physical place that I hope to bring somehow into the installation headphones. I also note how no format Gallery feels 'porous' in the sense that the external environment spills into the space and demands my attention, creating a relationship with the outside world that hasn't existed in previous iterations. I hear cars passing, people talking as they pass by, the sounds of 'sirens, airplanes, the clatter of construction'. Additionally, I feel overlooked and experience a loss of privacy due to the large windows. When Eva visits the gallery and listens to installation materials in situ for the first time, she notes how her listening experience is altered in relation to the ex-

ternal environment: the installation becomes a soundtrack to the observed. This experiential effect is at odds with the intended focus on embodied experience and relational awareness of sound in the physical space of the gallery. It is clear that windows must be covered and that curatorial interventions will be needed to alter the gallery space in the service of design intentions.

Figure 8.6: Working in situ at no format Gallery

The following day, I bring the installation and its associated technologies into the gallery. I move a table into the centre of the gallery and set up the laptop, audio interface, amplifier boards and reams of audio cable that spider across the gallery floor connecting to tweeters fixed on columns and walls (see 8.6. Wearing the installation headphones, I listen to different sound materials; simple arrangements of sine tones and string drones that were previously used in *Being With The Waves* and new recordings made at home and intended to capture a sense of domestic intimacy; the rhythmic mechanism of a clock, the breathing of my sleeping son, the rustling of a duvet, the motoric clicking of a wind-up toy. Again, I am thrown by the influence of the gallery. Many of the sounds I have collected feel underwhelming - lacking impact, lost in the space - now mediated by the installation technologies in situ. The close and warm reverberance of the gallery does

not translate to headphone listening; it is audible only as hissy, high-frequency transience: 'tss, tss'. I am aware of how reflective *no format* is compared with previous venues, 'sounds really stretch out into the space' and I discern a weaker sense of sounds existing local to their source. As a result, the speaker configurations I had sketched do not produce any strikingly new or engaging effect. In my journal, I note 'a sense of being de-centred by the new context - it throws up different challenges, raises more questions, offers certain (and uncertain) possibilities'.

The more that I try to listen to the installation and understand how sound materials are transformed by the gallery acoustic, the more I find the external sounds of construction and traffic intrusive, oppressive almost, and I increase the output volume of the audio interface to compensate (thereby increasing the volume of ultrasound in the gallery space). The mic inputs on the Teensy do not clip, yet my ears begin to ache, and I become acutely aware that I don't know how loud the ultrasound is in the space: 'Do my ears hurt from the ultrasound? or are these headphones just really uncomfortable?'. I feel quite keenly that - inaudible to the naked ear - ultrasonic phenomena are not for the human listener and that I am reliant on an imperfect (far from transparent) listening technology. Logically, I know that sound levels couldn't cause me any pain, but unable to directly perceive ultrasonic phenomena in the space, I experience a loss of confidence and doubt my own ability to judge.

Insight: Attending to the gallery context and its materiality as an active influence on the creative process leads to feelings of discomfort and doubt. I am unsure how to negotiate external influences and proceed artistically.

8.4.0.2 *Event 2: Remote thought and preparation, site-specific experiments at the gallery, January 27th*

Given the prominence of outside sounds in the installation, a key question appears to be whether I include or refer to them in the installation or mitigate and possibly exclude them from the work. I make a note in my journal recalling the installation practices of John Wynne (one of the sound artists interviewed in study 1), who created a fluid relationship with external space by bringing the sounds of train wheels on the tracks outside of the gallery into the installation. Despite the isolating quality of headphone listening in *Sonographies*, I am keen to create a sonic relationship between the gallery and the installation. Seeking to advance the task of sound design and dispel feelings of discomfort and uncertainty, I adopt

compositional strategies that I have used in past site-specific musical work (albeit in the acoustic space, not using the ultrasonic technology): acoustic analysis and modelling.

I input the gallery's dimensions into the amroc room mode calculator[3] to generate a list of resonant frequencies (primarily axial modes) and also record an impulse response using the sine sweep method[4]. Resonant frequencies are translated from Hz to musical pitches, which then inform the choice of tonal centres and collections of notes to constrain the musical composition. I play these out into the installation as sine tones, which I find 'reassuring' but also somewhat 'arbitrary as not actually triggering room acoustics' as they would if played out acoustically and audibly. I also create audio effects using native Ableton plugins that are intended to model or capture the character of the gallery acoustic so that, via the sound design, the gallery is brought into the headphones. Using Ableton's multiband EQ plugin ('EQ8'), I program resonant peaks at each frequency corresponding to an axial room mode and then duplicate the plugin to multiply the resonant feedback, thereby creating a crude physical model of the gallery space to be excited by input audio sources. In one experiment, a recording of my unborn son's galloping heartbeat is used to excite this resonator effect.

Ableton's convolution reverb plugin is used to convolve incoming signals with the recorded impulse response, and in my journal, I note how the reverb is recognisably 'of' the space, that it brings a feeling of warmth, and of being situated in an acoustic place, which is useful for the artwork. However, as with the resonant effect just described, I encounter a problem of how to deploy these acoustic effects in the installation. Each audio track in Ableton relates to a tweeter in the installation and, therefore, has a defined spatial location. If I add reverb to a track (as a direct insert) should the reverb only be heard from the related tweeter, or exist in the installation globally i.e. with the effected signal routed to each tweeter? Should I even be using the convolution to produce a spatial effect, an impression of room acoustics, or should it be used more creatively? In my journal, I note how these are decisions that 'wouldn't ordinarily be a consideration were I working in

3 https://amcoustics.com/tools/amroc

4 In this context, an impulse response (IR) is a sonic measurement capturing the resonant response of a room by exciting it with some audio stimulus. Commonly, an impulse response is made using either short broadband sound such as a clap or starter pistol gunshot, or a sine sweep. In this method, a stereo pair of microphones is set up to record the space while, simultaneously, a sine tone sweeps through the entire audible frequency range. The digital audio workstation Ableton includes an IR Measurement Tool as part of the Convolution Reverb package, and this was used to capture the sine sweep at *no Format Gallery* (https://www.ableton.com/en/packs/convolution-reverb/)

the audio realm - I wouldn't need to think about faking acoustics. This headphone bubble world is so strangely connected but also detached from the "real", the "natural"'. Additionally, would these effects and their connection to the gallery even be discernible to a listener who has just arrived in the gallery for the first time?

I persevere for some time along this path, creating a series of sonic experiments that utilise the effects in relation to different sound materials and spatial configurations, but remain dissatisfied - they don't seem to advance the project, suggest solutions or relate the sound design to the gallery context in a meaningful or perceptible way. Ultimately, none of these effects are used in *Sonographies*.

Insight: Compositional techniques that have been utilised in past site-specific work in the acoustic domain do not translate effectively to the headphone listening space of *Sonographies*. Experiments in this vein do little to advance the sound design and tensions are noted in relation to the ultrasonic modulation and listening technologies employed in *Sonographies*.

8.4.0.3 *Event 3: Remote development of listening technology, experimentation at the gallery 30th January*

I live outside of London, and it isn't feasible for me to work at the gallery 5 days/ week. Roughly alternate days are spent at home, where I prepare sound materials and attend to the multitude of other tasks involved in staging *Sonographies*. I work to complete upgrades to the audio amplification circuit that boosts the volume of incoming signals from the microphones before they are routed to the Teensy. In (ref: section, implementation details), I describe a continuous whine sound produced by the Adafruit Powerboost board and demodulated into audibility. In *Being With The Waves*, notch filtering had been used to quieten the whine but at the expense of audio fidelity in general. I am keen to remove the noise and related filtering for *Sonographies*. A new lipo power supply board is sourced[5], which - running on a different chip and operating at a different frequency does not add any noise to the system. Additionally, alternative voltage regulators are tested and compared, and improvements to audio fidelity are achieved by replacing this component and tweaking component values to boost the gain of output signals.

A new PCB with these changes embedded was completed in the midst of the creative residency at no format allowing for a cleaner, louder and more transparent mediation of the ultrasonic space via the technology (see Figure 8.7). This has

5 Seeed Studio Lipo Rider Plus, https://wiki.seeedstudio.com/Lipo-Rider-Plus/

Figure 8.7: Updated PCB, with new components and layout

a profound impact on the experience of listening and direction of my creative process. The sounding space of the installation audio is now more vivid and fills perceptual space in listening, overriding external sounds. Additionally, the sounds of my footsteps and of my clothes rustling as I move are more audible as though part of the installation, which in combination with Doppler effects, creates a visceral awareness of being situated in my body and in the installation - desirable effects in the context of *Sonographies*. Additionally, I find that the relationship of the installation to the sounding environment is resolved: the installation appears as an alternate acoustic reality, detached from that of the site in which it is placed. The technology and its mediation of sound demand the attention of the listener,

producing effects that are more prominent and perceptible compared with the acoustic experiments described earlier.

While I am not consciously aware of this at the time, my compositional practice shifts from attending to the gallery and its sonic characteristics toward sound design that supports and emphasises the effects of mediation in the installation. For example, I place an intimate recording of my son's breathing as he sleeps at a high volume in the centre of the space. Effectively rhythmic bursts of noise, an intense juddering, are heard as I move in relation to the tweeter from which it is emitted. Similarly, the pitch of a sparse and punctuated cello line warps wildly with my movement. The effect is uncanny and can't be ignored. These sounds have a visceral effect - both symbolically and interactionally - and work in the context of my design choices for *Sonographies*.

A subtle shift also occurs in the way that I conceive of and imagine the installation as the designer. At the outset of the residency, I tend to imagine the installation from outside (a disembodied view from nowhere, perhaps) as a spatial mass of varying density/ viscosity that could move, expand and contract in the space. With the new audio fidelity and heightened sense of presence, my own body is back in the installation, with its partial and situated perspective and I conceive the installation as on the skin as much as it is in the room.

Insight: Minor material changes to the amplification circuit result in major improvements to the fidelity and transparency of sonic modulation. The installation becomes more vivid and visceral, unexpectedly resolving a series of design problems and implying a shift in my compositional attention and techniques - from the gallery and its sonic characteristics toward sound design that supports and emphasises the heightened effects of mediation in the installation.

8.4.0.4 *Event 4: Moving between curatorial discussions at the start (intention setting) and end of the creative residency (debrief and reflection, late February 2024)*

Through my collaboration with Eva Martinez, the curatorial is elevated as a design priority, and we work together to explore the effect of extra-sonic design elements on the experience of listening to Sonographies. She invites me to consider the whole experience: how visual, tactile and linguistic stimuli might suggest or coax a listener toward an embodied mode of perception, and also how liminal spaces - the entry and exit - can be 'held' and actively contribute to the artwork. In our early discussions, we speculate about the effect of carpet or different textures underfoot,

how the weight and design of the listening apparatus on the body might work to encourage bodily awareness, how and to what extent themes of the domestic are signified in the space, how lighting should be used, where headphones should be positioned, etc.

She also grounds me - this is a development phase, hopefully one of many future iterations - I cannot do everything, emphasising the need to prioritise, and this becomes clear as time appears to accelerate in the run-up to public exhibition dates. I feel the time pressure and expectations due to the gallery context keenly - suddenly, the presentation of the artwork is a key concern, and there are a multitude of decisions to be made and materials to be purchased. I act largely on instinct, prioritising the interventions that I believe will have the most impact on the experience, to be achievable given time and budget constraints. I also act instinctively - adopting a clean, minimal aesthetic - i.e. to my taste and aligned with the minimal aesthetics of sound installation traditions.

I count our de-briefing meeting as the final stage of my design journey. I had hoped that the residency would be an opportunity to really develop and explore the parameters of sound design in the installation. To some extent this activity was sidelined, relegated in importance due to the gallery setting and associated pressure to present a complete, curated experience. On reflection, however, our curatorial interventions (e.g. covering the windows, bringing softness into the space with long, semi-sheer white drapes, lighting the space in soft pink) were transformational, more impactful on the listening experience than I had initially imagined. Eva describes the interventions as creating an 'intentional space'. I interpret this to mean that the gallery is no longer the background, a canvas upon which to hang artworks, but contributes meaningfully to the art experience, and this is discerned by the listener because while the interventions are subtle, they are clearly intentional and therefore brought into relation with the sonic. Equally, re-housing the electronic circuitry in an organic form brings the object into the aesthetic sphere of the artwork, part of the experience, specific to the act of listening to *Sonographies*, rather than a generic tool that might be transferred to other settings.

Insight: Curatorial interventions bring the visible materiality of the gallery into the artwork. The gallery becomes an intentional space and is perceived in relation to the sonic, thereby impacting the listening experience. Where I had previously positioned this design activity as primarily sonic, I come to realise that it is truly multi-modal and attend to the whole of the experience.

8.5 SURVEY FINDINGS

8.5.1 *Hyper-Awareness of the Body*

The decision to foreground bodily sensation over representational meaning was a key decision taken in this iteration of the installation. This move is borne out in survey responses. Only three participants describe the occurrence and content of mental imagery (P6, P22, P23). Descriptions of bodily sensation are prevalent in the data set and largely resonate with my own intentions for the piece, suggesting that the design decisions taken were justified and worked to communicate my intentions in the installation. Within the responses that I have highlighted as resonant with my intentions, there are nonetheless descriptions of the installation that augment my understanding of the work and set *Sonographies* apart as different from *Being With The Waves*. Notably, participants report heightened (P33), acute (32), intimate (P21) and hyper (P21) awareness of bodily presence and movements.

For some, this sensitivity is produced by the audibility of clothing and footsteps. P16 states that 'as soon as I put the headphones on me, I could hear my footsteps and I started to pay attention a lot to my body', while P21 describes a 'hyper-awareness of my bodily movements... my shoes on the ground, I could hear my hands more, more clearly in a different way. And so that evoked... a hyper-awareness of those, those parts of my body. For P17, hearing the sound of their shoes and their coat had a big effect on the piece, producing a close and intimate sensation, a hypersensitivity not only to what they are doing and how their body 'is', but also drawing them into the work. 'I would describe it as a hyper immersive experience um purely because um there's, there's, there's this just complete intrinsic link to you and what you're doing and how you interact with the piece.' This suggests an awareness of the sound installation itself/ as a whole, as as hyper-sensitive to the body. The mirror image of earlier responses, P33 describes a hyper-awareness of the room (rather than the body), they say:

> 'I could feel sort of where I was physically rather than just seeing where I was. I would describe it as experiencing or being within a room that has a presence to it. Like feeling the room in a different way and having a heightened state of awareness as to where you are physically and what the room means to you physically.'

8.5.2 *Collective Sound-Making*

My intention and expectation is for listeners to experience *Sonographies* individually, rarely interacting with other listeners in the space. However, 5 participants (3, 4, 7, 25, 26), all visiting as part of a group, discover that sounds produced in the installation space are transformed, appearing very different through the headphones. P4 notes that 'it felt like the acoustics of the space were completely changed and were reacting differently to different things... it sounded unlike anything I've heard before. Very, very peculiar.'

For these listeners, making sounds and collectively discovering how the installation mediates sound dominates their responses to questions 1 and 2 of the survey. Social sound-making becomes the primary mode of interaction and is perceived to be the central intent and meaning of the piece. These perspectives clash with my own intention for listeners to adopt introspective and embodied modes of listening. This alternate understanding of *Sonographies* is encapsulated by P25's response to the question, 'How would you describe the experience of listening to Sonographies to a friend?':

'[it's] like listening to a secret sound world that you were part of and, interacting with it, finding out how you can manipulate the sound, and it's fun. Especially if you go with friends because then you each find out different things and share it with your friends to see how the sounds change and it's quite delightful in that way.'

The listeners P7 and P8 describe jingling different sets of keys and discovering that each has different sonic characteristics, heard via the installation. P7 states that their 'keys sounded like if you move cutlery inside a plastic bowl', but P8's sound like 'the bell that cows have around their neck. And also like when you have like a set of saucepans in the wind'. For P7, sounds become more appealing and calming in the installation, 'when I shook my chewing gum box, it sounded like rain falling and usually it's just a very annoying sound'. P26 also visits the installation as part of a group of friends, who likewise discover that sounds appear differently in the installation space and describe clicking with their fingers in their mouth - which is much louder, with 'something extra added to it' and rubbing their hands to produce 'a really big shushing sound'.

8.5.3 *On the Meaning of 'Sonographies'*

The third and final survey question asked, 'What does the title Sonographies mean to you?'. It was included on Eva's recommendation to learn how listeners interpret the title and make sense of it in the context of the installation - in short, to learn what it does, whether it works, whether it supports or detracts from the intended meaning in Sonographies. With *Sonographies*, I had deliberately sought a title that - compared with *Being With The Waves* - was free of extra-musical association, more open, abstract, functional even. This proved a difficult task, and I settled on *Sonographies* as a plural of 'sonography', the medical practice of scanning the body using ultrasound. This nod to the use of ultrasound, the body, and internal space resonated with the intention to foreground embodied experience in this iteration and draw on themes of the domestic and maternal as the impetus for the sound design. Additionally, I imagine the listening apparatus as a kind of ultrasonic probe or transducer, revealing hidden sonic details of the installation space. By making *Sonographies* plural, the word becomes less familiar and is untethered from the literal meaning of sonography. To me, *Sonographies* implies multiplicity and connects with the word 'biographies' to foreground personal experience and the intimate life stories of individuals.

The survey data shows *Sonographies* to be interpreted in many different ways. Only 4 participants relate *Sonographies* with ultrasound (P12, 18, 32, 33), and 3 (P19, 21, 22) associate it with stories and biographies, such as 'multiple sound biographies' (P19). For 8 participants (P1, 3, 7, 8, 14, 16, 28, 33), *Sonographies* implies the visualisation of sound in some manner - 'sound pictures' (P7), graphical representation (8) and visualisation of sound (3, 14, 28, 33). Another prominent interpretation is of *Sonographies* relating to mapping (16, 32) and topography (17) i.e. the landscape of the sound (17, 29, 31) or mapping of space with sound (32). Prior to reading the survey responses, I had not discerned sonic visualisation or connections with landscape and mapping as possible interpretations of the title.

Furthermore, it is noticeable how participants connect the perceived meaning of *Sonographies* with their experience, making sense of the work post-hoc.

Only three participants actively state that they didn't think very much about the title while listening (P3, P14) and are only considering it now (P14), but it seems that participants did not consider (at least in a linguistic, intentional way) the meaning of *Sonographies* in advance this question being asked. Now prompted to do so, the title is brought in relation to their experience and consideration of the

title leads to an extended interpretation of their interaction in relation to perceived linguistic meaning. Consider the following examples:

For P3, sounds are 'visualised' through interaction:

> I haven't really thought about it, but a sonograph is usually like some way of visualizing... it felt a little bit like the visualisation bit was the interactivity. So instead of like visualising the sounds through hearing and seeing, it felt like we could visualise them by being in the space and through the interaction, get a deeper, better understanding of what was actually going on. So maybe visualisation through embodiment, something like that.

P16's response follows a similar trajectory, finding a correspondence between perceived semantics and their experience:

> When I read that word, my brain just cuts it in half. So I first read 'graphies', which makes me think of drawing and mapping. And sono to sound. So, I guess it responds completely to the experience I had, which was that I was mapping the sound with my movements. And I can see the drawing I made.

P17 attempts but struggles to resolve the connection of *Sonographies* as topography with their experience of the piece.

> *Sonographies* very much makes me feel like the landscape. How you could imagine a topological map and then think about a piece of music like that, which is quite strange, to be honest, because a piece of music is very momentary, and I can only be in one place at a time. But obviously, the point of the piece is to move around and explore the composition as it's unfolding. So, topography and sound are what I think the two words stem from.

For P31, the resolution from title reference to experience is more definitive:

> The title *Sonographies* suggested to me a kind of scanning of the body through, through ultrasound with geography in a way. So it was kind of the landscape of the body or the landscape of the sound. And how that sound was how the sound waves were reacting to the body. Yeah, that's how I felt.

For P19, the connection exists but is much looser:

> I suppose I probably relate it to biography. So, something about someone, through sound, and I guess, would be plural in the word, multiple sound biographies. I guess in the experience of the work I'm sort of taking that in a kind of a loose way.

Examining these responses, it is palpable how question 3 plays an active role in co-producing knowledge about the installation and listener experiences. The wording of the question 'what *does* the title Sonographies mean to you?' invites a response in the present tense, i.e. what does it mean at this moment, after the experience of listening? All participants (apart from P31) respond in the present tense, beginning with phrases such as 'it implies...' or 'I would associate it with/ translate/ read it as...'. Reading the responses, I sense that they do not reveal how listeners were primed by the title in advance or drew meaning from it during their interaction with the work. Instead, the question prompts consideration of the title at this moment after experiencing the work, having already answered two questions that invited consideration of experience, what the installation is and does. It is in that context that listeners arrive at this question. Additionally, the survey invites participants to respond orally, recording their responses on their mobile devices. These responses are indicative of a thinking-through in the moment of answering that is perhaps more instantaneous and spontaneous due to the survey format rather than a written format that encourages consideration in advance of putting pen to paper.

While all responses are situated and constructed in relation to the question, to past experience of the installation and to the survey format. Here, the influences or 'flows of affect' [Fox and Alldred, 2015] between the research apparatus and audience-led data are discernible.

8.6 DISCUSSION OF KEY FINDINGS

The following discussion synthesises the insights gained from the design and exhibition of *Sonographies*. I reflect on the interplay of material agencies, creative intent and listener experience and contextualise key findings in relation to more-than-human design practice and discourse on immersion and presence in extended realities.

8.6.1 *The Doubtful Experience of Designing-With*

The design journey described in Section 8.4 captures a series of design events salient to the question of how material agencies were negotiated during the creative residency at *no format Gallery*. While researchers and designers in the field of more-than-human and posthuman design deliberately work to de-centre their own perspective or agency, via techniques such as noticing [Nicenboim et al., 2023] this was - I found - to be an upshot or consequence of my attunement to site. By seeking the inclusion of material agencies, I felt my own creative will or agency to be displaced or 'decentred' and experienced feelings of discomfort, frustration and doubt (Sections 8.4.0.1 and 8.4.0.2). Similar emotions have been associated with acts of decentring by Biggs et al. [2021] and Nicenboim et al. [2023]. Drawing on autoethnographic accounts of birdwatching as an act of noticing other species, Biggs et al. [2021, p. 7] describes the unexpected feelings of discomfort and 'abjection' - a kind of nauseous sense of being overwhelmed by the 'inescapability of birds'. Nicenboim et al. [2023, p. 196] too acknowledge feelings of discomfort, suggesting that decentering entails exposing and embracing the frictions in encounters with nonhumans, moving to new domains, staying uncomfortable and remaining a beginner.

Since I characterised my experience of doubt and discomfort as a byproduct of the design stance, I sought to dispel those feelings and move forward by attempting to problem-solve and find more harmonious compositional methods. Had the residency been longer, more open-ended and without a close deadline for public exhibition, I might have willingly remained with the sensation of unease and unknowing for longer to examine whether it could be generative for design. In practice, there was a pressing need to move the design of *Sonographies* forward and therefore seek resolution. The dissipation of doubt occurred with a shift in more-than-human agencies: from working in relation to the materiality of the gallery to the materiality of the technology. Potentially, the feelings of doubt I experienced were due to an inherent friction between the installation's listening technology and site-specific practices. This will be discussed in the following section.

8.6.2 *Aligning Aesthetic Values with Material Agencies*

> "The process of making the more-than-human elements 'cohere' entails 'feeling' among those heterogeneous ingredients such that they produce a 'cogent' event." [Wilkie and Michael, 2023, p. 105]

> **Cogent** adjective
>
> 1. a: appealing forcibly to the mind or reason : convincing
> | *cogent* evidence
>   b: pertinent, relevant
> | a *cogent* analysis
> 2. having power to compel or constrain
> | *cogent* forces
>
> [Merriam-Webster]

The practice of creating *Sonographies* was guided by clear aesthetic direction. While the sound design and its interrelation with the gallery was unclear, I had a fixed idea of how the work should be experienced and felt. Design decisions were made in relation to the aesthetic register, i.e. always asking: does this serve or detract from the intended experiential mode? The above quotation by Wilkie and Michael [2023] resonates with my orientation to the more-than-human elements. The intention to create coherence, or to produce an alignment, in the way that sonic and material qualities of site and visible curatorial interventions relate to the sound design of the installation. The disparate parts act together to produce a 'cogent' event that compels the listener to appreciate certain aesthetic qualities, appealing forcibly to the body, etc.

Throughout design event 2, I persevered with the intention to forge sonic connections between the installation sound design and the sounding environment of the gallery to no avail - the sonic devices did not cohere with the installation, did not work productively to produce a cogent event [Wilkie and Michael, 2023]. The resolution that occurs through design event 3, on the introduction of tweaks to the listening apparatus is due to a re-orientation. Rather than primarily designing-with and orienting to nonhuman influences associated with the gallery as a site, I shift to designing-with the listening technology and particular mediation of sound. In other words, seeking a certain aesthetic and experiential effect (this is always in

relation with the sound design) I perceive that of all 'heterogeneous [more-than-human] ingredients' [Wilkie and Michael, 2023, p. 105], it is the technology of the installation - producing an alternate audio reality to the one in which the listener's body is situated - that coheres with desired aesthetic experience and works to produce a 'cogent' event. The relationship of sound design to site moves out of frame, and relationship of sound design to the technology moves into the centre. Doubtfulness is dispelled, I experience a weaker sense of my agency being de-centred because my intentions are more harmonious with the technology agency.

By articulating this re-orientation to the technology, I do not wish to make a dualistic distinction between the technology of the installation and the materiality and sonic environment of the gallery. Improvements to the listening technology entailed a more transparent and audible mediation of ultrasonic phenomena in the gallery space and interactive effects due to the entanglement of human listeners. The technology now brings the installation effects/ affordances to the forefront of listener perception rather than the whine and hum of electronic circuitry. It is, therefore, the body-sound interaction that is centred rather than the material presence of the listening technology.

8.6.3 *Hyper-Presence, Being Here and Elsewhere*

This study has examined the relationship of the ultrasonic installation technology to matters of site and found that relationship to be layered and complex. While weakly suited to site-specific compositional approaches, the installation is nonetheless entangled with the gallery. It produces a kind of audio augmented reality (AAR) that has the contradictory effect of transporting the listener to an alternate audio space while at the same time emphasising one's bodily presence in the physical space of the gallery. Hence, while listening to *Sonographies* we are simultaneously here and elsewhere.

This PhD research is inspired the close and nuanced listening-based interaction afforded by installation artworks in the sound art tradition. The entanglement of sound installation with the acoustic features of its site has been a key consideration for sound artists. This study explored possibilities for creating a tight relationship between the ultrasonic installation technology and site of *no format Gallery*, attempting to create sound design that would perceptibly link the sounding world of the installation (in headphones) to the acoustic character and sounding environment of the gallery. A key finding, is that the installation is poorly suited to site-specific

composition, which - given the closed-off nature of headphone listening - a 'hermetically sealed aural bubble' [Bull, 2007] - is hardly a revelation. Yet, artworks such as Christina Kubisch's *Electrical Walks* and Edwin van de Heide's *Radioscape* equip listeners with headphone-based listening technologies that reveal usually imperceptible details of the sounding environment. These artworks are richly site-specific, drawing the listener's awareness to sonic characteristics of the external environment, within which the body is situated.

In the case of *Sonographies*, the interaction of emitted ultrasonic phenomena with the environment produces a minimally interesting effect. The reverberant acoustic of *no Format* diffused emitted ultrasound, diminishing the effects of narrow directivity. The aesthetic appeal of the gallery reverberation was heard only as high-frequency transience when mediated by the installation and modelled reverb was barely perceptible as relating to the gallery. Acoustic analyses to find room modes proved fruitful as a compositional constraint, 'creating a territory for creative exploration' [Boden, 2004], but when played out in the installation following ultrasonic modulation, do not audibly resonate in the room.

The sounding space that is revealed by the installation technologies is a constructed one, an audio augmented reality (AAR). Potentially, it is this displacement, this productive ambiguity [Gaver et al., 2003] between the visible space and the audible space that defines the relationship of *Sonographies* to site. The AAR accompanies the visual space of the gallery, which is curated to foreground a particular aesthetic, in support and alignment with the installation but also drawing the gallery into the intentional sphere of the artwork, the presence of the gallery *is* brought into a meaningful relationship with the sonic (see Section 8.4.0.4 and 'intentional space'). Additionally, the composition is necessarily arranged and mixed in relation to the gallery's acoustic profile, and I would choose to work in situ for future iterations of the installation because the site of installation is such a strong mediating factor.

Running contrary to AAR paradigms such as audio walks where the sound accompanies and directs attention to the external environment, the AAR of *Sonographies* foregrounds internal sensations of being bodily, of having bodily presence and being entangled with the installation. Listeners described a heightened or 'hyper' sense of bodily awareness and presence (described in Section 8.5.1) that is afforded by the amplification of body sounds (footsteps, clothes rustling) and exaggerated Doppler Effects. In the context of immersive environments and extended reality experiences, the term 'presence' is used to describe the illusion of being

more in the virtual environment than the physical environment in which your body is situated. The notion of presence in *Sonographies* is complicated, a kind of hybrid experience of hearing one's bodily entanglement with acoustic phenomena, immersed by and in relation to an apparently 'other' sonic space to the one that may be inhabited with human hearing.

The body acts as a bridge between the two spaces. It is heard as being in both places at once. I noticed when analysing the survey responses in relation to hyper-embodied awareness that was almost interchangeably expressed as a heightened state of bodily awareness and a heightened sensitivity to the room. For example, P33 describes the room as having presence: 'like feeling the room in a different way and like having and like a heightened state of awareness as to where you are physically and what the room means to you physically'. Without wishing to dwell on semantics, I do find this interesting - as though what we're trying to express is a heightened state of relational awareness, and that becomes expressed as either being more aware of the body and one's bodily presence or more aware of the room and it's having a kind of presence.

8.6.4 *Relating Listener Experiences to Artistic Intentions*

> In Art as Enaction, the philosopher Alva Noe (2002) describes the artist as an 'experience engineer' because the act of making a picture, for example, involves careful observation of the world, and 'an activity of reflection on what you see and what you have to do to see. The painter literally enacts the content of a possible experience' [Noë, 2002, p. 5]. The artists that we interviewed described carefully listening to particular spaces and environments over long periods. We suggest that, to some extent, the artists' own listening experiences are mediated in the artwork to shape those of their audience.

The above quotation, taken from the discussion of Chapter 4, proposes the mediation or transfer of a sound artist's own listening experiences to the audience, via the material and sonic arrangement of the artwork. In the context of *Sonographies*, compositional decisions were made based on my listenings from within the installation, seeking to foreground aesthetic values and based on my own sense of the installation producing a cogent effect (as described in Section 8.6.2). The question that arises, then, is to what extent are my own listening experiences mediated in

the artwork to shape those of the audience? The survey data, along with informal observations and discussions with listeners, provide some insight.

In Section 8.5.1, I described how intimate or hyper bodily awareness was a defining feature of *Sonographies* for many listeners. It was my intention that the installation should forcibly appeal to bodily sensation in this way. Survey results suggest that the installation design coherently foregrounded this as a key aesthetic value of the artwork. By contrast, sonic references to themes of the home and the domestic were not perceived by listeners, or at least not captured by the survey results. These concepts guided the creative process, informing sound selection and arrangement, but are not mediated by the artwork. The abstraction attempted by *Sonographies* does appear to have sidelined cognitive interpretation in favour of embodied apprehension.

The tweak to the listening technology that removed unwanted noise, allowing for louder and more transparent mediation of the installation, also mediated audible sounds in the same way. Hence, the sounds of clothing, breath and footsteps become woven into the experience of the installation. This was not 'designed' but an unintended consequence that, happily, worked to foreground bodily behaviour in the sounding world of the piece.

The social sound-making described in Section 8.5.2 was unexpected behaviour, an appropriation [Dix, 2007], using the installation technology in a way that was not envisaged in the design. Notably, two groups of friends engage with *Sonographies* in this way, and no visitors to *Being With The Waves* did this. Acknowledging that I have limited data to draw on and that there are many differences between the two installations, I would speculate that the audio tweak contributed to the occurrence of these activities because it is a kind of linking device. Through sound-making, the listener can make sense of the installation's mediatory effects by producing sounds that they know in the audible realm and listening to their transformation via the installation. Making sounds becomes a way to share the strangeness - otherwise experienced individually - with friends. In this case, it is not my own listening experience that is mediated in the installation, but an affordance of the technology producing unexpected behaviour in social, group-listening situations.

8.7 REFLECTIONS ON ARTISTIC PRACTICE

The development of *Sonographies* and its particular emphasis on bodily affect and experience has challenged my artistic practice and prior ways of working. Outside of the PhD, my compositional practice tends to occur in relation to something representational. I compose music and sound design for film, dance performance and public installation artworks and in each of these cases there are concepts and subject matter to draw on as inspiration that - crucially - ought to be communicated or reinforced by the music. Composition in these instances is concept-driven. The sound design for *Being With The Waves* was undertaken in this vein; it included spoken word and narrative content and was rich with sonic imagery emphasising watery and nautical symbolism. *Sonographies*, by contrast, sought to address the body directly and engage an embodied state of self-consciousness, something akin to thinking with the body [Sheets-Johnstone, 1981b] or embodied reflection [Buttingsrud, 2021]. In service of this aim, the sound design sought to capture a similar felt sense to that of the installation (closeness, intimacy, the organic) without being directly representational. I did not have this musical language already, and it was a challenge to my practice to attempt this direct address to the body. With the sonic material for *Sonographies* I have begun to shift my practice in this direction, and there is rich scope to develop further.

I began the process of composing for *Sonographies* with a thematic framing in mind: the domestic. A key learning has been that concepts and subject matter may be key drivers of the process without directly impacting experience or appealing strongly to signification processes in listening. Similarly, the extent to which the work is framed by the title is a choice. In the debriefing meeting with Eva, we discussed how the title *Sonographies* has an openness in the sense that:

> '...it doesn't create an extra frame of meaning on top of the experience, so in that way, you're getting again this directness of people forgetting about the title and then engaging and then maybe at some point making a connection. That's one function of a title it doesn't always have to frame things so tightly unless you want to.' (Eva)

Through this study, I have learned that the sonic composition is far from the main object of installation design. Equal attention was paid to the engineering of ultrasonic modulation, the design of the listening apparatus and the textual, material and visual curation of the artwork. This challenged my conception of what

the creative residency would entail and limited my ability to develop the interactional potential of the installation through sound design. At the time, I found this frustrating. It felt as though the myriad design foci were a distraction from the activity of sonic composition. However, I now appreciate and value the holistic and multimodal nature of installation design and understand that the coherence of visual and material design elements with the sonic interaction is of primary importance. All work together to produce experiences of the installation in which listeners feel themselves to be centred and their own experiences to be the material of the installation. This point is discussed in my debriefing session with Eva, who notes that 'I felt like *I* was the main material': my intention precisely.

8.7.1 *Design Sensitivities*

Through the practice of making, exhibiting, discussing and analysing listener responses to *Sonographies*, a series of design sensitivities have been identified:

1. **Practice mediated listening in situ**
   Rather than listening to an installation space and its response to sonic materials (sounding audibly in the space) with the naked ear, listen through the installation technology. Listen to and experiment with audible materials that have caught the interest of listeners to *Sonographies* i.e metallic sounds, the close sounds of the body, clothing, footsteps.

2. **Consider carefully the social implications of hearing other bodies as well as your own**
   Given that the creative process occurs largely in isolation it is easy to forget that visitors will often be listening in the company of others. Listeners to *Sonographies* enjoyed sharing their listening experiences with others. This sociality could be embraced by including tactile objects and soundmaking devices into the piece or, alternatively, it could de-emphasised by curating the piece in near darkness or dividing the installation space to create areas for private listening.

3. **Develop sound design as means of engineering interactive effects**
   The extent to which the Doppler Effect is present depends on the type of sounds used in the composition, their directional orientation and prominence in the installation space. Listeners commented on the transition section

of the piece, where pitched sounds recede and crackling, percussive textures emerge in their place. During this section, the Doppler Effect is barely perceptible, and that break from interactive effects was welcome. There is scope for further exploration to explore how sonic composition might choreograph the listener by showing and hiding interactive effects.

4. **Develop a wider range of sonic materials and approaches, including means of software manipulation prior to working on the installation in situ**
   A limitation that proved quite frustrating during the creative residency at *no format Gallery* was that I could not implement a compositional idea or sketch quickly. While I occasionally work with software-based sound design tools, I prefer to work with acoustic musical instruments and recorded sound. I did not have the tools to do this at the gallery, and so the process of implementing a compositional idea entailed ideation and planning in the space, then composing and making sonic materials at home, and then bringing them back into the space to listen through the technology, arrange and mix them spatially. This proved time-consuming and limited the flow of composition in situ.

5. **Embrace the visibility of the speakers**
   In *Being With The Waves*, the tweeters were deliberately hidden from sight to encourage listeners to explore the space by ear. If they were visible - I hypothesised - listeners would defer to the visual location of speakers, listening to each in turn rather than exploring the in-between space of the installation. In *Sonographies*, the speakers were visible, but listeners weren't completely guided by their visual location. Due to modulation effects and perhaps the reflective character of *no Format Gallery*'s acoustic, sound seems not to stick to its location in the way you would expect. Eva notes that 'for me it was like I could see where things were, but it really didn't feel like I was just navigating the space because of where I saw the technology'.

6. **Continue to 'hold' the entry and exit**
   Eva encouraged a thorough consideration of liminal spaces in the experience of the installation, i.e. what listeners first encounter and how the transition into the installation is managed. The entrance point was given a lot of thought. I sought to - in Eva's words - 'hold' the entry. That is, include and curate the transition as part of the work itself. My initial intention was for this to be managed without invigilation: the audio text would direct listeners

to don the headphones and provide a very brief introduction to the work. In practice, I was present and took on this role, which Eva felt was important:

> 'there is something about the relational quality that encountering a human being feels like at the beginning... would it have been really cold if I just arrived, heard a voice and encountered a machine?... I felt that there was value in the human interaction. It sets up a relationship. I think it also relaxes me when I'm in relation to people. I think generally you feel a bit more held if there's an explanation from somebody.'

In our debriefing, Eva also encouraged me to be curious about the exit point: How should listeners leave the space? Does anything else happen?

7. **Develop curatorial relationships with materials and light**
   With *Sonographies*, I worked with textiles and light for the first time. Eva and I both felt that the softness of the curtains and pink lighting impacted the experience of the work, emphasising embodiment. I am also curious to experiment with projection mapping as a means to layer light and imagery on the architecture of installation. A curatorial aspect that fell outside of the scope of this study was how materials underfoot might draw awareness to the body and also intersect with sonic interaction. This could be a subtle intervention adding a soft texture like a carpet underfoot, or more dramatic: imagine walking over a floor covered with metallic objects such as spoons!

8.8 CONCLUSION

This chapter described the final research study of this PhD, which centred on the practice of creating a second sound installation artwork called *Sonographies* during a creative residency at *no format Gallery* in South London. Inspired by the site-specific approaches of sound artists, I worked to create links between the sonic composition and acoustic features of the gallery, attempting a more-than-human disposition whereby nonhuman material influences are invited into the process and allowed to shape artistic practice. This attunement to the site led to feelings of discomfort and doubt, potentially due to an underlying tension between the installation's listening technology and site-specific practices. Upgrades to the technology emphasised the strong mediatory effects of the technology on the listening experience, and only when my orientation shifted to working with these effects

did my aesthetic intentions begin to cohere with and become amplified by the ultrasonic technology.

This chapter has highlighted the importance of curation in shaping the experience of listeners. Brief post-experience surveys suggest that the intention to foreground embodied modes of experience was successful, with many listeners referring to sensations of closeness, intimacy and hyper-awareness of the body. Adopting a relational stance in the analysis of survey responses highlighted unexpected social sound-making, multiple interpretations of the installation and the contingent, situated character of responses.

9

DISCUSSION

This chapter synthesises the findings of this research, addressing the overarching questions that have guided the exploration of relational factors in the design and experience of sound installation art. Section 9.1 compares and discusses the findings of Chapters 6, 7 and 8 in relation to the first overarching thesis question, speculating on connections between the installation's design and the experience of listening. Each of these studies has particular foci and takes place in different settings. Therefore, direct comparison is not possible. Rather than suggest causal links between design features and qualities of experience, I embrace the situated character of my findings: contingent on the specific research-assemblage [Fox and Alldred, 2015] of which the artwork is a key part. Section 9.2 addresses the second overarching thesis question by reflecting on the research methodologies employed throughout the PhD and offering a critical appraisal of their effectiveness in articulating listening-based experiences.

Entanglement and the sonic are theoretical concepts that challenge established paradigms. In Section 9.3, I offer a series of provocations for HCI that have been developed in response to these ideas from my position between disciplines. I then summarise the main findings of each research study in Section 9.4.

9.1 THE RELATIONSHIP OF DESIGN AND EXPERIENCE

In this section, I discuss my findings in relation to the main research question introduced in Section 1.4:

MQ1: How does the design of a sound installation artwork, its material situation and social context relate to lived experience?

Each of the research studies in this PhD was conducted using different methodologies in different contexts and in relation to different installation artworks. Descriptions of lived experience are contingent on the particular research-assemblage [Fox and Alldred, 2015] through which they were produced. In addressing the above question, it should be emphasised that material and social influences are not mu-

tually exclusive [Barad, 2003, Introna, 2019]. The design of the installation is entangled with the materiality of the site; social behaviours are equally enmeshed with and influenced by the material dimension. Lived experience is produced by the specific situation and listening in a particular temporal frame. Experience is singular and emergent.

Throughout this thesis, I have sought to understand the relationship of design choices to the experience of listeners and the felt quality of interaction. Hence, while I recognise that the artworks have a cumulative aesthetic and experiential effect, I will speculate on individual aspects of the installation that appear connected to certain experiential and behavioural qualities. In doing so, I draw on both the findings of research studies *and* my understanding of the installations accrued through practice, over years of thought and learning how to work *with* the ultrasonic technology, how it feels to listen and interact. I characterise these insights as *informed speculations* rather than definitively causal relationships. I believe that informed speculation allows space for difference, acknowledges the situated and contingent character of lived experience, and the impossibility of truly knowing (in a provable sense) how lived experience is shaped by design decisions. These ideas connect with epistemological discourses in HCI [Gunkel, 2018], particularly in relation to uncertainty [Akama et al., 2015, Reed et al., 2024, Soden et al., 2020] and inform the final provocation in Section 9.3.

To begin, I consider the extent to which the underlying system design of the ultrasonic installation technology described in Chapter 5 alters the felt quality of interactive experience.

9.1.1 *The Felt Quality of Sonic Interaction*

Inspired by the multi-speaker and site-related paradigm of installations in the sound art tradition [Seiffarth, 2012], I have sought to design interactive experiences whereby listeners experience close and direct interaction with sound and become intimately aware of their bodily presence and changing spatial relationship. With the artworks *Being With The Waves* and *Sonographies*, I believe that this intention has been met by creating sonic compositions that work with and enhance the affordances of the ultrasonic installation.

The ultrasonic installation technology (Chapter 5) affords close interactive effects due to the Doppler effect becoming exaggerated as a result of amplitude modulation processes: listeners hear their movement directly, and the composi-

tion warps and shudders in response to even tiny changes in posture. Theoretically, the same movement-based interaction might be achieved via alternative technical means [Françoise et al., 2017, Jensenius, 2015]. High-resolution camera tracking might produce data relating to the spatial position of the listener's ears, and this could be mapped to sonic parameters defining the headphone's output. Assuming that the system was to have imperceptible degrees of latency, it feels pertinent to consider whether interaction would *feel* different.

My conviction is that the system design employed throughout this PhD fundamentally determines the felt quality of interaction [Erkut et al., 2015] due to the physical entanglement of sound and space [LaBelle, 2012]. The installations *Being With The Waves* and *Sonographies* sound physically in the space and are shaped by their acoustic properties. While weakly suited to site-specific compositional practices (see Section 8.6.2), they nevertheless need to be arranged and mixed in situ. The technology involves no symbolic representation of human behaviour. Emitter and receiver side modulation occur separately and concurrently, i.e. one does not depend on the other in the way that inputs and outputs are dependent in the event-loop paradigm. The microphones operate as sensors, but rather than observing listener movements from an outside perspective as a motion capture system might, they encapsulate the meeting point of a listener's ears with the sounding space in its entire material configuration. Therefore, the electrical output of the microphone - its 'data' - is a rich encoding of physical, spatial and sonic relationships. There are no bandwidth limitations and no 'non-grammatical' actions [Sha et al., 2013, p. 2011] - any movement affects all scales, from micro to macro.

In the camera-tracking version, no sound phenomena would be present in the space itself. The data would be an abstraction from the interaction, a stream of numbers representing Cartesian coordinates that could be framed within a computational system as describing listener position and movement. Arguably, this would be an instance of what Agre [2014, p. 1] describes as a 'representational artefact' in the sense that the computer models a version of the activity it seeks to be used for. Due to these underlying differences, my hypothesis is that a reconstruction of the installation using movement sensing and mappings in the event-loop paradigm would lack the degree of detail and depth that the ultrasonic installation affords. These differences might be subtle, minute even in sonic terms, but *felt* on a pre-reflective, experiential level.

9.1.2 *Listening Through*

Continuing the above thought experiment, how might the focus and directional quality of a listener's attention differ in the case of the ultrasonic installation technology compared with a camera-tracking version? It is heard via custom sets of headphones with tiny omnidirectional microphones housed on the outside of earcups. I noted in Section 6.4.2 that the headphones are intended to be *listened through* such that the multi-channel distribution of sounds in the space might be appreciated, rather than *listened to* as we might ordinarily relate to headphones when listening to music.

With the speakers hidden in *Being With The Waves*, it wasn't clear that the headphones should be listened through. Across both studies, listeners perceive interactive effects associated with their movement, and some try to discover how the installation works. They look for cameras and sensors and, if they can't be found, nevertheless assume their presence and dwell in technological disillusions (see Section 7.4.4). Anecdotal evidence in the data suggests that where listeners perceive the presence of sensors, audible variations to the sonic composition are perceived in relation to parts of the body. For example, P2 in Chapter 7 describes 'trying to put that sound that was in my ears in my foot... I was trying to imagine them as one unit... how does this whole thing work together? Here, the direction of attention is on or within the body, as well as noticing how a movement alters the sonic feedback in the headphones. It has an inward, bodily character.

Where listeners become aware of sound in the space and listen *through* the headphones, I would argue that the direction of attention is more outward, positioning one's behaviour and perception of the work in relation to the sonic field that surrounds the body. The quality of closeness that the installation affords (see Section 9.1.4) continues to ground the work in the body or even on the skin of the listener, but it is paired with a more outward appreciation of the installation. These distinctions are subtle but important and shape my conception of an *entangled subjectivity* (described in more detail in Section 9.3.1, an attentional disposition that is neither introspective nor extrospective but a hybrid, marked by an attentional disposition that is directed outward to meet the nonhuman world and an ongoing awareness of relationality. An entangled subjectivity is encouraged within design research exploring the more-than-human body [Kilic Afsar et al., 2023, Ryding et al., 2023, Tsaknaki et al., 2021].

From my perspective, *Being With The Waves* felt more muted and closed (than *Sonographies*), which, in combination with not seeing the space or the technologies and the layered composition of different sound types, drew auditory attention to the musical content of the work. By contrast, I believe that the design of *Sonographies* worked to foreground an entangled subjectivity, suggesting that the listening devices should be listened through. With higher microphone gain and the (near) elimination of self-noise originating from the electrical components in the listening device, a more transparent mediation is achieved, allowing listeners to hear the space more presently. Additionally, the speakers were visible in the space. Listeners could approach them and appreciate particular sounds becoming louder with that movement. The examples of group sound-making described in Section 8.5.2 and awareness of incidental sounds in the space, such as footsteps or the rustling of clothes in Section 8.5.1, provide evidence that listeners' attention was drawn to the sonic space outside and surrounding the body, not merely to the contents of the headphones.

9.1.3 *Metaphor Use*

Through a comparison of studies employing *Being With The Waves* with *Sonographies*, it appears that maritime and liquid metaphors used in descriptions of experience result from comparable representational qualities in the artwork.

In Section 6.2.1.1 of Chapter 6, I reported that 8 listeners compared the listening experience to the feeling of being immersed or submersed, as in water. In Section 7.4.1, sensations of resistance or viscosity are described, qualities ordinarily associated with liquids. In Section 7.5.2, I pointed out that it is unclear to what extent that terminology and language is being used to describe felt qualities of interaction because the artwork itself references watery imagery. Therefore, it was a deliberate choice in *Sonographies* to remove that symbolism to make a comparison, though not a direct one, because the survey only provides snapshots of listener experience and perspective. Nevertheless, to see whether listeners continue to describe the felt quality of interaction in those terms. Though inspired by themes of the domestic, the sound design for *Sonographies* tended toward the abstract; there is no speech or vivid musical imagery. I found no maritime imagery or metaphors in the Chapter 8 survey data, apart from one comment by P14 who described the feeling of *Sonographies* as 'really immersive, like being in a sea of sound'. This participant is also a friend, and I know that they had previously experienced *Being With The Waves*. Al-

though stated somewhat casually, this lone watery utterance strongly implies that the linguistic articulation of experience is mediated by themes and symbolism in the sound installation.

9.1.4 *Closeness, Connection and Intimacy*

Across all of the studies, listeners characterise the felt quality of the ultrasonic installation as being close or intimate. My understanding is that audible Doppler effects contribute to sensations of interactivity. I hear my movement. This draws awareness to my body, and the direct coupling of movement with sound contributes to sensations of closeness and intimate connection with sound. Also, as described in Section C.1.4, microphone-mediated listening appears to pull sounds toward the ears, such that they may be perceived as closer to the body than they might be to the naked ear.

Although not captured in the analysis of interview data in Chapter 7, P4 described the installation as 'an all-over hug, or maybe like when we're underwater... where there's contact everywhere, some pressure.' This, of course, relates to the above discussion of metaphor and articulation. P4 describes the feeling of being submerged but specifically implies the sensation of contact all over the body. This feeling of contact has come through quite strongly across the studies. As has the sensation of being located, experiencing a strong sense of presence. For example, in Study 3 (see section 7.4.1), listeners describe the close pairing of movement with sound phenomenologically, in terms of a felt connection that is perceived as having qualities that are movement-like or physical.

In Chapter 6, L58 describes an awareness of their '360 multidimensional body' and 'sensors all over the body informing me of where I am and how I am in the space.' While the presence of sensors was, of course, an illusion, I would speculate on a connection between feeling one's presence and notions of closeness and connection. This aspect comes through more strongly in the Chapter 8 survey data. Here, several listeners characterise their experience in terms of hyper-awareness or sensitivity to either the body ('Everything felt like hypersensitive to what I was doing and how my body was' - P17) or to the room ('I would describe it as... having a heightened state of awareness to where you are physically and what the room means to you physically' - P33). In Section 8.6.3, I suggested that these descriptions might be more alike than they are different: two sides of the same coin. Both express a heightened state of relational awareness that becomes expressed as

either being more aware of the body and one's bodily presence or more aware of the room and its presence.

Speculatively, I see a connection with closeness. The room is felt on the body, and feeling the room on the body heightens awareness of one's body in the space. Potentially, this aspect of the installation, so difficult to express succinctly in the English language, contributes to descriptions of submersion or contact with water. In study 4, without musical symbolism or metaphorical language close at hand, similar sensations are instead expressed in terms of sensitivity, awareness and intimacy.

9.1.5 *Physical Behaviour*

I perceive notable differences in the visible outward behaviour of listeners across the three studies. Through Chapter 6, I characterised the behaviour of listeners to *Being With The Waves* as introspective. Listeners appeared to turn inward, and many stayed for long periods, adopting a meditative disposition, some sitting and lying down on the floor. Listeners were observed to practice civil inattention [Goffman, 1963, Lofland, 1989] to others in the space and very few examples of outward social interaction were noted. By contrast, no listeners to *Sonographies* (Chapter 8) were observed to sit or lie down on the floor. As described in Section 8.5.2, groups of listeners enjoyed sharing the strange mediation of sound in the installation, shaking sets of keys, and making sounds with their bodies.

The *look and feel* of the installation spaces was markedly different across the two artworks. *Being With The Waves* was experienced in near darkness with coloured lights punctuating the space, whereas the gallery for *Sonographies* was filled with natural light and bathed in soft pink. For *Being With The Waves*, I deliberately sought black-box venues and darkened spaces to suppress the visual sense and hide the technologies from view. In *Sonographies*, I reversed this decision, instead seeking a minimal visual aesthetic that would not detract from the sonic and covering windows to ensure the listener's attention remained within the bounds of the space and ideally focused inward on the act of listening. I suspect that the dark environment emphasised introspective modes and that the lighter space led to a stronger awareness of other listeners in the space, and a more outward disposition.

It is also worth noting that across the two public installations and Chapter 7 where only individual experiences were captured, solo listeners behaved more expressively - free to behave impulsively, try wilder, faster movement - than those

who listen in the presence of others. Here, behaviour follows conventional patterns and is co-regulated by the group according to civil inattention [Goffman, 1963] and mirroring [Chartrand and Bargh, 1999].

9.2 METHODOLOGICAL OUTCOMES

In this section, I discuss my findings concerning the second main research question:
MQ2: How can qualitative research methods be employed to effectively articulate the experiential detail of listening-based interactions?

Section 2.5.4 described the challenges of articulating the lived experience of sound and, perhaps due to this, noted the lack of prior research examining the felt quality and experience of sonic interaction. With no clear direction emerging through a review of existing literature, I chose to work with a number of different qualitative research methodologies throughout this PhD, continually reflecting on their effectiveness for eliciting experiential detail and honing my approach in response. To address the above research question, I will begin by evaluating each of the methodologies before discussing epistemic and methodological shifts that occur in this thesis.

9.2.1 *Evaluation of Methods*

Over the following subsections, I evaluate methods employed in research studies to elicit descriptions of interactive and listening-based experiences. Note that for this reason, reflection on the interviews employed in Chapter 4 and first-person design methods 8 are excluded from this discussion.

9.2.1.1 *Post-Experience Surveys (Chapter 6 and 8)*

Chapters 6 and 8 both describe the collection of survey data during public exhibition of the ultrasonic art installation. Informed by HCI and IAR literature, the need to research the experience of sound art in an appropriate public exhibition context was prioritised [Benford et al., 2013, Bengler and Bryan-Kinns, 2014, Hollan et al., 2000]. In each case, I chose to maximise participation by designing a short survey that could be completed in circa 5 minutes immediately after exiting the installation [Bengler, 2015]. This choice of data collection method was medi-

ated by the constraints of public exhibition on a small, DIY scale. At both *Ramsgate Festival of Sound* and *no format Gallery*, I needed to invigilate the exhibition and be on hand to deal with technical problems or visitor questions. It was not possible to, for example, run interviews with listeners while the installation was also open to the public, a strategy often adopted in interactive art and museum-based studies where there is a larger research team and budget to draw on, for example, in [Costello et al., 2005, Trunfio et al., 2022]. Therefore, the surveys were a pragmatic choice. In both research studies, they produced useful insights and snapshots of subjective experience but lacked detailed descriptions and depth of insight.

Due to the brief format and pre-defined set of questions, the surveys address the experience of the artwork as a whole. The post-experience survey is well suited to eliciting general impressions of the art experience, i.e. that which is defined by Dewey as a pattern of intensified experience that stands out as against the general stream of our experience [Dewey, 1934, p. 326]. The survey format, as I discovered through Chapter 6, tends to produce general or surface-level descriptions and is not suited to the elicitation of phenomenological insights and certainly not singular moments within a long stream of similar experience. This is a problem in the case of sound installations, which are experienced over (sometimes) lengthy periods and often have a sustained, homogeneous character.

The Chapter 8 survey encouraged listeners to not merely describe their experience but to interpret and reflect on its meaning, and those insights have proved valuable as they highlight different ways in which the same artwork can come to produce meaning for individual listeners. In this sense, I have found the post-experience surveys most useful when they encourage visitors to co-speculate [Wakkary et al., 2018, p. 1] on the experiential nature and meaning of an artwork.

The Chapter 8 survey included just 3 questions compared with the six included in the Chapter 6 survey. Fewer questions produced richer insight. Quickfire surveys such as this can only ever produce partial perspectives, and I would choose to lean into that in future. Open questions proved fruitful. 'How would you describe the experience of listening to *Sonographies* to a friend?' encouraged listeners to consider their own experience but then also distil the most pertinent characteristics and interpret the purpose or intention of the installation. The third question that was targeted to learn about the perceived meaning of *Sonographies* as a title also revealed how little that word had informed meaning-making practices while listening and brought it into contact with the experience after the fact, leading

participants to interpret their experiences in light of its perceived semantics (see Section 8.5.3).

Potentially, the reflective quality of responses to the survey in Chapter 8 was emphasised by the mode of response. The act of sitting with a clipboard and filling in written responses (Chapter 6) is very different from walking around outside and recording responses into your smartphone. The spoken response of the Chapter 8 survey seemed to inspire spontaneous responses, with participants working things out in the moment of speaking. Arguably, talking into your smartphone, the survey becomes an intimate discussion with yourself, and it becomes possible to capture uncertain experiential aspects on the cusp of understanding that might not become committed to paper through writing. In future, I would continue to adopt spoken surveys as the next best alternative to interviews.

9.2.1.2 *Video Analysis of Observations (Chapter 6)*

Chapter 6 includes an analysis of video observations recorded during the public exhibition of *Being With The Waves* at Ramsgate Festival of Sound. As with the survey, the choice of this method was dictated by limitations; I needed to invigilate from outside the installation space and could not observe behaviours directly. Choosing the method of observation due to its prominence in the fields of interactive art research (Section 2.5.2) and ethnomethodology (Section 2.5.3), I (somewhat uncritically) took a third-person perspective, watching interactions from the outside and largely without reference to audio stimuli because the installation is inaudible. The camera viewpoint: static and encompassing the whole of the installation space allows appreciation of collective behaviours but provides little insight into individual experience.

A key benefit of interaction analysis (based on [Jordan and Henderson, 1995]) was that the temporal unfolding of interaction and the potential influence of contextual factors could be maintained through the analysis. In the case of sound installation, listeners mostly adopt quite generic physical behaviours: walking and standing. The analysis entailed a search for meaning beyond the obvious, looking for behavioural patterns and underlying intentions. Patterns and differences across the data set as a whole appeared to be contingent on the presence and behaviour of co-listeners. As a means to investigate the relationship of interactive behaviour with social factors, observation and interaction analysis were ideal, and it's worth noting that no similar ethnomethodological studies of art listening be-

haviours have been found in the literature. However, as a means to elicit insights into sonic experience at an individual level, observation is poorly suited.

9.2.1.3 *Micro-Phenomenological Interviews (Chapter 7)*

Seeking to capture detailed accounts of subjective experience and inspired by the method's adoption in HCI [Prpa et al., 2020], I employed micro-phenomenology (M-P) in Chapter 7. This would be challenging to implement during a public exhibition. Therefore the location of this study shifted to a hybrid university performance space, where it would be possible to conduct hour-long interviews with individual participants.

As has already been noted in Section 7.5, I believe that M-P is very well suited to the elicitation of sonic experience but that M-P questions tend to treat sound as an object rather than an event. Participants found it difficult to articulate a singular moment within the experience on which to focus the interview with confidence, and I found that doubtfulness on their part made the evocation state hard to reach. Sound installation experiences are long and may have a homogenous quality, but participants need to anchor within a singular moment that can be recalled from within the tapestry of past experiences. Further work is needed to overcome this problem. Potentially, descriptive experience sampling [Hurlburt and Akhter, 2006] might be used. Listeners would interact freely with the installation, but a random buzzer or haptic stimulus would prompt them to note down the contents of their experience immediately prior. These notes could then be used as an anchor, determining the moment(s) to be returned to in an M-P interview exploring pre-reflective dimensions of experience.

9.2.2 *Epistemic Shifts*

An epistemological shift occurred during this PhD. In the early stages and undoubtedly influenced by the positivist tendencies of HCI, a field to which I was new, I (somewhat uncritically and unknowingly) adopted a third-perspective on interaction - watching listener behaviour from the outside and largely without reference to audio stimuli (Chapter 6). In Chapter 7, employing the M-P interview method, data were produced from a second-person perspective. As the interviewer, I had an active role in helping the interviewee to describe their experience, which arguably balances first and third-person perspectives [Reed et al., 2022]. In Chapter 8, I conducted research through practice from a first-person perspective. There is a

notable shift across the PhD from observing interactive behaviour from a detached distance to becoming utterly entangled in both data collection and analysis.

To describe this shift in terms of a move from third to first-person perspectives implies a neat transition and distinct viewpoints that are held separately. Arguably, research methods provide a frame through which we attempt to define a stable perspective on the data. In reality, perspective is somewhat messier; indeed, any attempts at objectivity and neutral distance are always and inevitably rendered through the first-person lens. It is a choice whether that first-person perspective is acknowledged and attended to in the analysis or mitigated as bias. It should also be noted that while first and second-person insights are well-suited to the articulation of experiential and embodied insights because they centre the self, they risk a disconnection from wider political, social and cultural forces.

These perspectival shifts are indicative of a wider epistemological movement in the thesis toward more-than-human theories, thereby emphasising the co-production of knowledge by the research apparatus. The move to embrace agential realism occurred in response to my becoming more attuned to the specific qualities of sound - as spatial, temporal, immersive, ephemeral, and co-produced by the space in which it is heard and the listener who hears it. Sound is an *interstitial* material [Döbereiner, 2020, p. 604] and is utterly different to the tactile materiality of physical objects. It can't be moved from one place to another unaffected, and this implies the situatedness of knowledge [Haraway, 1988]. To know sound is to be involved in its perceptual production, which implies the entanglement of knowledge with the methods [Barad, 2007, Fox and Alldred, 2015] and researchers involved [Barla, 2023].

9.2.2.1 *Methodological Critique of Study 2*

The following three subsections include material published in "Listening Together-Apart: The Social Mediation of Sound Installation Listening", by Robson, McPherson and Bryan-Kinns at Audio Mostly 2025 [Robson et al., 2025a].

Each philosophical standpoint impacts the way that research is conducted and written about. Using Study 2 'The Experience of *Being With The Waves* at a Public Art Festival' (Chapter 6) as a case study, I will now consider how the research would have changed had a feminist new materialist perspective been adopted from the start.

Study 2 was conducted within a social constructivist framework, utilising the third-person methods of survey, video observation and interaction analysis. Since then, my work has shifted toward feminist and relational perspectives, and I have engaged in first and second-person methods that actively entangle my subjectivity as a researcher with the knowledge produced. These later research experiences alter my perspective and understanding of Study 2, enabling me to appreciate social effects in terms of entanglement and to apprehend how the methods shape what is possible to know. This critique might be viewed as a diffraction of the 2021 study and my research understanding at that point, with my 2025 perspective, not simply mapping where differences appear, but where the *effects of difference* appear [Haraway, 1991, p. 300].

Ethnomethodology foregrounds the social mediation of human behaviour and technology use by design. However, usually it is applied to situations that have a more overtly social character, where there are obvious visible signs of social interaction, such as conversation and hand gestures. The listening behaviours that I observed in Study 2 were mostly subtle and generic: walking and standing, while ignoring other people in the room. However, through the research methods - processes of transcription and analysis, attending very closely to what was happening - enabled me to apprehend the organisation of behaviour around social dynamics. I now recognise how the method in that study utterly co-produces the data. This is a lens on the research that I did not have at the time and that results from an engagement with new materialist [Fox and Alldred, 2015] and 'post qualitative' [St. Pierre, 2019] moves in the social sciences.

In the following critique, I consider methodological aspects of the research that, were I to conduct the study today, either would be done differently or be given greater emphasis due to the adoption of feminist and new materialist epistemology [Barad, 2007, Haraway, 1988, Kissmann and Van Loon, 2019]. Specifically, I propose 1.) an equal attunement to material (sonic and physical) and human (i.e. social) agencies in the analysis and 2.) a commitment to situated knowledge [Haraway, 1988] that foregrounds the contingent quality of findings and acknowledges the active entanglement of the artist-researcher with knowledge production.

9.2.2.2 *Towards a Sociomaterial Analysis*

Interaction analysis, as a methodological approach used to study social interactions in various settings, makes ontological assumptions based on social constructivism, i.e., that reality is continually produced through human interactions.

Naturally, the analysis method foregrounds and captures social interaction. An attunement to relationality and new materialism allows an appreciation of how behaviour is shaped not only by social forces but how they are entangled with material agencies. Were I to conduct this study today, I would seek to include material agencies in the analysis of video observations and interrogate not only how listening behaviours are shaped by the social context but equally by the physicality of the exhibition space and, of course, by the sonic material heard via the installation headphones. The influence of the headphones was considered in the discussion of this study (Section 6.4.2), but these aspects could have been drawn into the interaction analysis. This proposed wider focus enables a more holistic consideration of the installation and its listeners as an assemblage and might have allowed us to understand how the installation *works*, what it *does*, and how behaviours connect with its particular design. To quote the writing of Fox and Alldred [2015, pp. 406-407], an epistemological orientation to new materialism might 'reveal relations, affects and affect economies in assemblages', with an orientation towards 'what things do, rather than what they "are"'.

The work of Hillevi Lens Taguchi[1] in the field of childhood and education studies includes practical examples of analyses that centre on material agency. Their analysis of an interview with a six-year-old boy at school explores how meaning is co-constituted by the 'matter' of the interview environment [Taguchi, 2012]. The 'space of interviewing' is enacted by the arrangement and physicality of the table and chair: 'the table actively separates and distances the adult from the child. The table can be felt to agentially enact distance, formality and seriousness together with the adults' material-discursively performed talking' (p. 275). Considering the study in Chapter 6, I believe there are important ways in which the physical space and arrangement of the installation, entangled with the social dimension, inform the behaviour of listeners. Some of these are mentioned in the discussion of findings: the darkly lit room, the installation of headphones, and some not, such as the wall-mounted ledge that suggested to many listeners that they should lean on it and listen in stillness (see Section 6.2.3). Surely, many more influencing aspects of the work's materialities could have been identified had I been attuned to the potential relationship of visible behaviour with the stuff of the installation at the time of reviewing and analysing the video footage.

The most notable absence in the analysis, however, is the sounding installation. The sonic composition for *Being With The Waves* consists of a 25-minute piece

1 https://www.su.se/english/profiles/hillen-1.192935

of looped audio. Individual experience of the installation is determined by a listener's spatial position and movement. It wasn't practical to capture each participant's output feed from the microcontroller during the study; however, it *would* have been possible to correlate video footage with the correct loop position to conduct the interaction analysis in relation to a stereo mix of the composition. In hindsight, this was a missed opportunity, and the study outcomes express almost entirely a visual expression of listening and social interaction. Had the analysis been conducted with the sonic composition, it might have produced insights into, for example, whether groups of listeners pause or begin coordinated periods of movement in relation to sonic events and the extent to which stillness or expressive movements correlate with periods in which the Doppler effect is prominent. An understanding of how the installation choreographed group listening behaviours might have produced further actionable design insights. In defence of this misstep, I wish to point out that conventions of transcription in qualitative research methods all too often replace sonic data (e.g. an interview recording) with a mute textual representation (a transcription) for analysis. This convention, arguably, perpetuates an assumption that sonic qualities do not contribute to knowledge production. In my case, they certainly do, and if this study were to be re-run, observed behaviours would always be interpreted in relation to the sonic.

9.2.2.3 *Committing to Situated Knowledge*

Section 6.4.3 pointed to the situated quality of the findings as limitations, and was written to acknowledge how the ability to generalise the results to wider sound installation experiences is constrained by the study. In hindsight, this was an attempt to adhere to positivist conventions in HCI and frame the singular, ungeneralisable quality of findings as negating the quality and potential contribution of the research. For Haraway [1988], rational knowledge claims are those that are located in relation to contexts, social positions and nonhuman agencies; 'feminist objectivity means quite simply situated knowledges' (p. 581). Reading the study from this viewpoint re-frames its specificity as a strength.

Ethnomethodology is compatible with feminist epistemology in the sense that it foregrounds situated knowledge and contingent qualities of human interaction, examining how social meaning is actively constructed. I believe that a strength of this study is its demonstration that physical behaviour is co-produced by specific groups of people listening together. Were I to conduct the analysis again, I would

commit to Haraway's epistemic position and seek to foreground singular qualities of the findings.

Returning to this work after engaging with first and second-person [Robson et al., 2024] methods in more recent studies, I have become aware of the detachment that is enacted by video observation as a method. The method was chosen due to its prominence in the fields of interactive art research and ethnomethodology, and a third-person perspective was adopted somewhat uncritically, watching interactions from the outside, from a single fixed position. This detachment is echoed in the analysis, which is interpretative, the researcher making sense of patterned behaviours based on their social understanding, but - largely following HCI convention - their involvement is treated neutrally by the write-up. Feminist scholarship challenges traditional notions of objectivity, arguing that knowledge is always influenced by the researcher's positionality (social identities and experiences). This leads to 'strong objectivity', which acknowledges and incorporates these biases, rather than striving for a false neutrality [Gani and Khan, 2024, Haraway, 1988].

Writing from a Baradian perspective, Barla [2023] suggests that the researcher ought to be treated not only as part of the research apparatus that observes phenomena but also as an apparatus that 'diffracts the forces she intra-acts with, producing difference-as-it-emerges rather than mirroring sameness'. I am an artist and a researcher. I created the ultrasonic installation and conducted the research. I am utterly entangled in the research, and my understanding of the installation and its affordances, accrued through sustained periods of making and composing, could have been leveraged and made active in the analysis of video observations. This would have situated the research more precisely and might have produced deeper and more nuanced insights into what is visible.

9.2.2.4 *On Diffraction as a Method*

In Chapters 7 and 8, I chose to conduct diffractive analyses of interview and survey data. In both cases, the analysis makes explicit the production of findings in relation to other agencies. In Chapter 7, findings are produced through the interference of M-P interview data with a curated set of sonic theories. In Chapter 8, survey findings are presented in relation to my subjective understandings of *Sonographies* and the material situation in which participants responded to the survey. Diffractive analyses foreground a partial reading of the data. The method suited the later studies of this PhD but is perhaps not so well suited to exploratory studies

such as those presented in Chapters 4 and 6, where research directions and theoretical allegiances are not yet established and where a deductive thematic analysis might allow for a more complete representation of the data.

The diffractive analysis of Chapter 7 interfered relational theories of sound and listening with the discipline of HCI. Thinking with sound, I became aware of taken-for-granted, invisible dynamics [Lazar et al., 2021] of research methods in HCI. These wider *reverberations* inform the provocations for HCI described in the next section.

9.3 PROVOCATIONS FOR HCI

This section is built on material first published in "Thinking with Sound: Exploring the Experience of Listening to an Ultrasonic Art Installation", by Robson, McPherson and Bryan-Kinns at CHI'24 [Robson et al., 2024].

> The case of sounds and audition demonstrates that attention to modalities other than vision enriches our understanding of perception and its role in situating oneself, forming beliefs, and acting upon the environment.
> O'Callaghan [2007, p. 3]

Throughout this thesis, I have been promoting sound art installations as an alternative paradigm of interactive design and the sonic as an alternative orientation to the visual, one that might reveal different kinds of knowledge about our experiences with technologies. By considering an alternative approach, the (often tacit and unchallenged) ontological assumptions and methodological infrastructures that govern practices in HCI-related fields begin to surface and become perceptible. I champion the sonic here as a provocation to open up new ways of thinking about the experience of interaction and offer a series of provocations for HCI.

9.3.1 *Design for an Entangled Subjectivity*

Being With The Waves and *Sonographies* are designed to encourage close, attentive listening together with a keen awareness of bodily entanglement with the installation. I describe this disposition as an entangled subjectivity. It is marked by an attentional disposition that is directed outward to meet the nonhuman world and an ongoing awareness of relationality. Derived from theories of listening (Section

7.2), this subjectivity subtly decentres the human in the sense that it is neither an introspective mode (examining one's own thoughts, feelings, bodily sensations) nor an extrospective mode (examining what is outside oneself). Instead, it is a hybrid perspective. Still rooted in lived experience, an entangled subjectivity examines *how* the ongoing phenomena of experience are co-constituted by our bodily engagement with a material assemblage. For example, participants in our study attended to feelings of close connection with sound, such as viscosity, which relies equally on qualities of the material and the character of human behaviour (section 7.4.1).

In HCI and design, many different approaches to decentring human subjectivity have been described, such as conducting ethnography with nonhumans [Giaccardi et al., 2016], noticing differently [Liu et al., 2018] and designing for nonhuman users [Ghajargar and Bardzell, 2022]. Nicenboim et al. [2023, p. 2] raise the important question of 'How do we cope with the impossibility of accessing nonhuman perspectives really, given our inherent human assumptions and ways of knowing?' My approach is still interested in designing for humans while also sharing the stage with other things. I propose the concept of entangled subjectivity as a slight deviation from modes of bodily knowing [Núñez-Pacheco and Loke, 2022] and useful design sensitivity in the context of somatic [Höök et al., 2017] and experience-centred design [Wright and McCarthy, 2022, Wright et al., 2008] and their intersection with entanglement theory [Kilic Afsar et al., 2023, Tsaknaki et al., 2021].

9.3.2 *Sense Less, Know Less, Quantify Less*

As the art material in *Being With The Waves* and *Sonographies*, i.e. that which is experienced by listeners via the headphones, sound cannot be reduced to qualities of the musical composition nor its physical sounding in the installation space above the range of human hearing. Instead, the material of sound is intra-acted: co-produced in the entanglement of a listener with the installation's technologies [Barad, 2007]. It is due to this co-constitution of sound that listeners perceive interactive qualities and sensations of intimacy and connection. The installation, therefore, foregrounds a relational notion of sound as a kind of 'interstitial matter', that which is in-between different media and bodies involved in its production [Döbereiner, 2020, p. 604].

My findings in Chapter 7 regarding the expectation of sensors, dialogic relationships, and computational latency (Section 7.4.4) highlight the assumption that an interactive device or artwork has a symbolic representation of human behaviour. The prevalence of mappings-based interactivity (Section 2.2.2.1) may be constraining both the design and experience of new technologies. The expectation of sensors foregrounds a cognitive mode of engagement whereby a user works to make sense of a system through their interaction with it. By harnessing the materiality of sound as an active determinant in the configuring of interaction, the ultrasonic installation technology described in this PhD demonstrates an alternative design ideology that Sha termed 'human-matter interaction' in 2013 [Sha et al., 2013], the full potential of which is far from being realised. The installation's technologies co-construct sound in a nonrepresentational way: without inspecting and processing data about human behaviour. It is my conviction that this approach promotes interactive experience that is richly multi-dimensional, nuanced, and visceral, addressing ongoing embodied thought [Sheets-Johnstone, 1981a] and reflection [Buttingsrud, 2021]. Therefore, moving against the tide of computational complexity and advancement, I offer the provocation to sense less, understand less, quantify less, and move away from the notion that the machine needs to encode a neat symbolic representation that humans understand on similar terms.

9.3.3 *Assume Dynamism*

For Cobussen [2022, p. 16], sonic materialism entails 'a true paradigm shift in how Western philosophy and thinking in general should consider the world: not as stable, filled with independently perceivable objects, separated from the perceiving subject, but as a world in flux, an eternal becoming in which subjects (also eternally becoming) are immersed'. Interactions with technology are rarely static and yet temporality is often overlooked in the articulation of user experience. I encourage HCI researchers to assume dynamism and flux rather than fixed properties and to consider the temporality of interaction on all scales from the macro trajectory or narrative arc of an interaction [Benford et al., 2009, Tennent et al., 2021] to micro details. As I found in the micro-phenomenological descriptions grouped under Relational Flux (Section 7.4.2), felt sensations might have rhythm or local micro fluctuation, shape-shift, drift in and out of awareness, and vary in intensity or stability. A key challenge lies in the articulation and development of research methods that allow these aspects to surface.

9.3.4 *Attend to Sensory Difference*

Study participants encountered the same assemblage of sound and technological mediations but enacted wildly diverse listenings (section 7.4.4). Perceptions of the installation do not neatly mirror the stimulus but diffract it, leading to marked differences in the felt experience of listeners. Spiel has highlighted the prevalence of normative body conceptions in design research [Spiel, 2021] and the need for embodied computing to account for diverse bodyminds, differences in 'felt experience' [Spiel, 2021, p. 9] and neural difference [Spiel et al., 2022]. These ideas are echoed by Drever in their writing on auraldiversity [Drever, 2019, Drever and Hugill, 2022] and are calls that I wish to amplify here, along with a provocation to consider sensory impairment in design practices. By sensory impairment, I mean a continuum of difference, from the fluctuation to sensory acuity that we experience on a day-to-day basis to sensory loss and more debilitating conditions.

During early public presentations of *Being With The Waves*, I witnessed anxiety around noise levels in the case of listeners with hyperacusis (which involves a reduced tolerance to sound) and the tentative wearing of headphones by hearing aid users. My observations drew attention to the fact that I hadn't placed diverse listening needs front and centre in the design process. They highlighted the need for accessible control of volume and muting, and the careful mixing of audio elements in the composition to inspire confidence in diverse listeners.

9.3.5 *Develop Sonic Sensitivities*

I believe that the embodied, experiential qualities that I learned from designing beyond the mapping paradigm could inform researchers in interactive sonification. My design process was driven by a sensitivity to specific sound art practices, deep and active modes of listening and the nuanced, microinteractions that can be afforded through spatial sonic artworks. I could only design for a close, embodied sonic experience by already possessing a bodily understanding of it. Undoubtedly, this sensitivity to sound has developed over time through my lived experience as a musician, and cello practice (Section 3.2), which demands close attention to sonic details and somatic qualities.

In HCI, and experience-centred design specifically, much has already been done to attune to materials [Giaccardi and Karana, 2015, Ofer and Alistar, 2023], multisensory experiences [Obrist et al., 2016] and design with the body through somatic

practice [Hook, 2018, Loke and Schiphorst, 2018]. However, workshops and design practices rarely attune to sonic experience. Activities could be designed to sensitise designers to the relational and embodied dimensions of listening, developing a sonic connoisseurship to inspire interaction design.

At the NIME conference in 2025, I collaborated on the design of an Entangled Listening workshop[2]. Through guided mediations, hands-on exercises, and discussion, the workshop worked to guide listeners to notice their role in co-creating sound with their perception (promoting what Oliveros terms 'quantum listening'[3]) and to tune listening toward more entangled design practices. For example, in one activity, participants listened to the ultrasonic installation described in this chapter and explored how their listening changed when prompted by a series of text scores. Other activities explored non-cochlear listening through touch and mediated listening through ultra-sensitive microphones. Our use of text scores and prompts to inspire different relational awarenesses echoes the approach of the composer and researcher Alex De Little, whose *Spatial Listening* practice (2017-) uses sounding and listening in architectural spaces to 'instil sonic ways of knowing, being, and socially relating in space' [De Little, 2018].

9.3.6 *Speculative and Multi-Modal Epistemology*

Earlier in this chapter, I characterised my understanding of design-experience relations as *informed speculation* (Section 9.1). Speculation implies uncertainty and recognises that knowledge has limits [Gaver et al., 2004, p. 53]. It relates to ambiguity, which, in alignment with Reed et al. [2024], I understand as an inherently human property: it is possible for individuals to interpret the same phenomenon differently and for the same individual to interpret the same phenomenon in multiple ways. Rather than view uncertainty and ambiguity as something to be overcome - as is traditionally the case in Western science and HCI - Soden et al. [2020, pp. 2-3] argues that HCI ought to develop 'practices and conceptual framings that help us embrace uncertainty and further develop it as a site of inquiry, rather than seek its resolution'.

Similarly, Gunkel [2018, pp. 21-22] argues that HCI needs to become a 'speculative science'. 'Speculative' is understood here etymologically, as derived from

2 https://nime2025.org/proceedings/339.html

3 Extending the practice of deep listening, 'quantum listening' emphasises the role of the listener in producing the heard: 'Quantum listening simultaneously creates and changes what is perceived. The perceiver and the perceived co-create through the listening effect' [Oliveros, 2022, p. 52].

the Latin 'speculum' meaning mirror or reflector. 'Speculative' implies a kind of self-reflective and, according to Žižek [2008, p. 3], designates an epistemology that 'recognises the way that what comes to be known is always and already conditioned by the situation or condition of knowing' [Gunkel, 2018, p. 21]. In qualitative inquiry, diffractive methodologies tend to be pitted in opposition to self-reflective modes [Barla, 2023, Bozalek and Zembylas, 2017], somewhat undermining the more-than-human critique of dualisms and rigid separations that oversimplify the complexity of phenomena. As described in Section 2.4.3, an embodied objectivity might interface between human subjectivity and the material world [Calvert-Minor, 2014, p. 136]. Given HCI's orientation to human factors in computing, it is well-placed to embrace and explore the seams of human-centred and more-than-human inquiry.

Interactive technologies rarely address the modality of vision alone and more often address multimodal perception. I am not suggesting that a sonic orientation would be appropriate for examining interaction broadly. Rather, those methods produce data [Gitelman, 2013] and should not be uncritically adopted. In fields such as Soma Design, whereby the data of experience explicitly shapes design practice [Höök et al., 2017], this issue is perhaps even more acute. In this thesis, I have demonstrated that epistemologies derived from other sensory modalities may reveal alternative characteristics of interactive experience. Besides the sonic, it may be productive for HCI researchers to explore epistemologies grounded in haptic touch [Fulkerson, 2020] or the kinetic intelligence of movement [Sheets-Johnstone, 2002]. Ultimately, however, working towards an integration of all sensory knowledge.

9.4 REVIEW OF FINDINGS

Having addressed the main research questions of this PhD in the first two sections of this chapter, I now summarise my findings in relation to the chapter-specific research questions that were introduced in Section 1.5.

9.4.1 *Learnings from Situated Sound Artists*

RQ1: What can be learned from experienced sound artists about the relationship of practice to the site of an installation and subsequent reception of the work by a listening audience?

As noted in Section 2.1.5, research that addresses the practical question of what artists *do* is largely absent from sonic arts discourse. Chapter 4 provides a rich description of attitudes, methods and processes associated with situated sound art practice. The findings presented in this chapter directly influence the design of the ultrasonic installation technology described in Chapter 5 and the two artworks created with it, working to ground the practical work of this PhD in a particular vein of artistic practice.

The artists working in a site-specific manner expressed an ethos that may be characterised as mediatory, or *working-with*. That is, rather than imposing a pre-conceived compositional idea, their practice is influenced by a site's material and sonic characteristics. Artists seek to understand the potential of a site through sustained engagement to understand the sounds that exist already within the space and its acoustic response. They describe listening closely for long periods to understand the sounds that exist already, probing a space with bursts of sound or using acoustic analysis tools to examine its acoustic response.

Chapter 4 also identified a series of experiential modes that sound artists work to foster. Artists seek to engage the ears of their listeners and foreground the sensory modality of sound over all others. Listeners should have an active relationship to the artwork, feel the need to *do something* and understand that they are implicated in making sense of the piece according to their spatial relationship to it. Artists, therefore, work to draw listeners' attention to perceptual processes and foster states of consciousness that are often associated with the meditative practice: turning inward to the self, being present at the moment, and experiencing a heightened awareness of bodily and spatial presence. Artists work to foster these experiential modes through sonic devices and by harnessing the multimodal nature of an installation (i.e. through curation) to enhance or direct the listening experience.

9.4.2 *Interactive Experience Without Sensors*

RQ2: How might the entanglement of a listener with the physical phenomena of sound be harnessed in the design of an interactive sound installation to promote a rich sensory experience?

The installation technology described in Chapter 5 is grounded in the multi-speaker paradigm of sound installation art. A sonic composition is arranged spatially, and the experience of the installation is determined by the listener's spatial orientation and physical and perceptual activity. However, by choosing to work in the ultrasonic domain and introduce modulation processes, the entanglement of a listener with acoustic sound is harnessed by design. Essentially, the 'unavoidably interactive' relationship of the listener, space and sound sources [Matthews, 2019, p. 297] is *amplified*.

To summarise the system design: the multi-channel sonic composition is shifted into the ultrasonic realm and out of human audibility via amplitude modulation and emitted via an array of tweeters placed throughout the installation space. Ultrasonic phenomena are captured by tiny microphones on the outside of headphone earcups to approximate a binaural arrangement, then routed to a microcontroller where amplitude modulation is applied again. This shifts the sound back into audibility before being output to headphones. Due to these processes of ultrasonic modulation, the spatial appearance of sound is altered, and the Doppler effect, which is usually only perceptible in the case of fast-moving sounds such as emergency vehicles, becomes exaggerated in relation to a listener. The sound installation appears to warp and shudder with even very small head movements in relation to the fixed tweeter positions. With no sensors or mappings, the experience of listening may nonetheless be perceived as interactive due to the spatial arrangement of sound sources and the close entanglement of the listener with sound phenomena physically present in the air.

The extent to which interactive effects are perceptible in the installation is, unusually perhaps, a matter of sound design. Therefore, to actually *harness* and make artworks with the technology entails equal attention to the aesthetic domain and to interaction design; the two become enmeshed in this installation technology. The challenges and practice of creating artworks with the technology are described and reflected upon both in Section 5.5 and later in the thesis, through Chapter 8.

9.4.3 *The Socially Mediated Character of Listening Behaviours*

RQ3: How do listeners experience a sound installation in the context of a public art festival?

(a) What do listeners do? In terms of:

  (i) Physical behaviour (e.g. movement, bodily dispositions)

  (ii) Perceptual activity (e.g. directing attention, intention setting)

(b) How do the material and social context mediate behaviour?

Synthesising the results of a lightweight, post-experience survey with video observations, Chapter 6 reports a breadth of physical behaviours. Typically, listeners both describe and are observed to behave quite generically: slowly walking, standing, rocking gently on the spot and closing their eyes to focus on the activity of listening. However, some listeners are more expressive, adopting performative dance-like movements covering the entire floor space. An interaction analysis of video observations suggests that the physical behaviour of listeners (i.e. that which it is possible to see) is strongly influenced by the presence (or not) of other listeners. For example, solo listeners tend to be less inhibited and experiment with broader ranges of movement than those in the company of others. Also, listeners appear to coordinate their behaviour, practising civil inattention and co-managing the shared social space to ensure that personal space is maintained.

While these findings might generalise to other, similar sound installations, the specific design of *Being With The Waves* surely mediates behaviour in very specific ways. For example, the impact of headphone listening on the inward character of behaviour is discussed in Section 6.4.2 and the impact of maritime imagery in *Being With The Waves* on the articulation of experience is discussed in Section 9.1.3.

9.4.4 *The Experience of Sonic Entanglement*

RQ5: How is sonic entanglement *experienced* as embodied sensations and felt qualities?

Chapter 7 reports on a second listener-focused study, whereby individual listeners experience *Being With The Waves* installed at a university performance space before a micro-phenomenologically inspired interview aiming to articulate the felt

quality of interactive experience. Following a diffractive analysis, setting the data into a relationship with theoretical perspectives on *the sonic*, a series of descriptions coalesce and are brought to the fore. While each shares a relationship with the theory, the individual descriptions differ in content and are rich in specific detail. The diffractive analysis produces a highly partial view of the data but one that captures new, plural and productive insights for the research that might not otherwise have emerged.

Reading the data with Voegelin/ Merleau-Ponty's notion of 'being-honeyed' [Voegelin, 2010, p. 5] surfaces data describing the felt quality of connection with sound in the installation in terms that ordinarily refer to physical materials. In Section 7.4.1, listeners describe interaction as having felt qualities associated with force, density or viscosity and underlying movement qualities such as spinning and quivering. Considering the data in relation to Cox [2018] and O'Callaghan [2007], who describe the sound as an inherently mobile and temporal kind of material, points to the temporal instability of embodiment sensations. In Section 7.4.2, listeners describe the close and intimate quality of interactive experience as being in flux, varying in intensity and in direction, and the appearance of sound and physical qualities as unfixed, shifting from heavy, solid and infinite to light and mobile with the listener's movement and interaction with the installation.

In relation to Szendy's notion that listeners 'punctuate' sound with their listening [Szendy, 2020] surfaces descriptions of intention setting with bodily poses and movement qualities that cannot neatly be described as either passive or active and instead, are suggestive of an intention to *align* the body with sound. Plugging Voegelin's writing on the doubtfulness and ambiguity of listening [Voegelin, 2021] into the data surfaces ways in which expectations regarding the system design lead listeners to dwell in technological 'dis-illusions'. Unable to see the speakers and given the ambiguous nature of the box connected to the headphones, many listeners assume the presence of pressure or movement sensors and experience the work in relation to these 'illusions'.

9.4.5 *Negotiating Material Agencies*

RQ7: How do nonhuman, material influences shape *my* artistic practice and process with the ultrasonic installation?

Where Chapter 4 surveys the practices of other artists in relation to site, Chapter 8 examines my own practice as I work on the installation *Sonographies* in situ at a contemporary art gallery in London. Up to this point, I had not explicitly sought to relate sonic compositions made for and with ultrasonic technology to the places in which they were to be heard. Directly informed by the mediatory practices of sound artists described in Chapter 4, I sought to understand the potential of the gallery and compose with the space. Working in this way led to feelings of discomfort and of my creative agency being decentred, feeling unsure how to proceed.

In Section 8.6.2, I speculate that site-specific compositional practices are misaligned with the technology's affordances, my own aesthetic ideas, and interactional intentions to emphasise embodied experience. Upgrades to the listening technology entail a more powerful mediation of sound - the installation becomes louder, and its strange articulation becomes clearer. This sways the direction of creative practice, and I drop my orientation to the site's materiality in favour of designing with the listening technology and its particular mediation of sound.

Again, picking up on the insights garnered through Chapter 4 into the staging devices that artists use to direct the attention of listeners and shape their listening disposition, Chapter 8 includes collaboration with Eva Martinez, an experienced curator and dramaturg. The materiality of the gallery is altered by window coverings, fabric, lighting and text to emphasise an embodied mode of experience. Reviewing listener surveys, it appears as though the design of *Sonographies* meets this intention, with listeners describing a hyper-immersive and intimate experience, in which they are keenly aware of bodily presence and activity. Through this chapter, I reflect on a newfound appreciation for designing the whole of the experience because curation has a strong mediating influence on the experience of listeners and their perception of the work.

9.5 FINAL THOUGHTS AND FUTURE DIRECTIONS

At the outset of this PhD, I naively imagined that it would be possible to apply qualitative methods from other domains to the study of sound installation experience with little friction. This, of course, turned out to be a far more complex and layered problem than I had first supposed. Sound can't be seen in relation to what a listener does. Listenings are so transient and fragile, situated in the body and its place in the world. Each chapter of this thesis has explored relational qualities of sonic experience, either through technology-centred design and its intersection with sound art practice or through qualitative research studies to explicate audience perspectives. Considerable effort has been channelled into selecting, honing and testing different methodologies, each of which makes particular *cuts* and produces partial insights into complex and contingent phenomena.

Many aspects of this research deserve further study. I sense that the micro-phenomenological interviews conducted in Chapter 7 barely scratched the surface of what might be possible to learn about spatial sonic experience using the technique. I strongly believe that the design of an M-P study could be engineered to target the multi-modal sensation, or *texture* of interactional moments more efficiently and that the precise study design could be tweaked to help the listener return to specific past events. Developing M-P techniques for eliciting listening experiences in detail will require ongoing practice. It may be fruitful to instigate a regular study group with other M-P practitioners or sound artists with an interest in the experiential dimensions of their work.

I did not set out with the intention to investigate more-than-human theories and epistemological matters. That movement in the PhD occurred quite organically in response to frictions between qualitative methods and the relational materiality of sound. As it turns out, the metaphor of diffraction is apt for describing the interaction or interference of sound art and HCI in this PhD. Resonances, dissonances, and the *effects* of disciplinary difference led me in unexpected directions, which arguably have become a defining feature of this research. These twists and turns of research are a contribution not only to my learning but might inform research practices positioned at the interstices of artistic and scientific disciplines.

As a researcher, I did not exist prior to this PhD inquiry. The interdisciplinary stance of this work will have a lasting impact on my wider values and artistic practice. It has been fascinating to engage with listeners, and I will continue to seek insights into audience experience as a means to enrich my practice. Additionally,

through a philosophical orientation to entanglement, I have developed a sensitivity to the fragile, contingent and uncertain nature of human understanding that I will carry forward into future work.

Concerning the ultrasonic installation, questions such as 'how does the inaudible decentre human subjectivity? and 'who or what can listen to the installation?' fall outside the scope of this thesis but point to the wider implication that sound as a material can lead to new ways of thinking about interaction design and the more-than-human body [Cecchetto, 2013, Cimini, 2015]. I am interested in exploring the nature of entangled subjectivity through a practice-based engagement with field recording. Additionally, deep listening, which involves 'expanding to the whole field of sound while finding focus' [Oliveros, 2022, p. 30] might be used as a way to connect and attune with the environment [Loveless and Zinovieff, 2023], and field recording through electromagnetic, seismic, or underwater microphones, a means of enacting more-than-human engagements in art and design [Barclay, 2019].

In conclusion, this research has explored the subtle entanglements of listener(s), sound, technology and place, showing that interactive experience can emerge not only through computational systems, but art assemblages that harness the materiality of sound and the relationality of listening. By bringing sound art into dialogue with human–computer interaction, and by centring the experiences of listening audiences, I have proposed ways of designing and researching that recognise the agency of people, materials, and environments alike. The installations and studies presented in this thesis are offered as both technical and methodological implementations, and as provocations for HCI researchers to *think with sound* and listen closely to the phenomena under study. Listening is never passive, but an active participation in the making of the world; a search, not for fixed answers, but for shifting and contingent patterns of understanding. Such contingency, I contend, is a vital orientation for design, one that acknowledges the specificities of context, sharpens sensitivity to difference, and embraces our entanglement in the material and social worlds we inhabit.

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APPENDIX

A

APPENDICES FOR CHAPTER 4

A.1 ART EXPERIENCES AT ARS ELECTRONICA FESTIVAL 2019

In September 2019, immediately prior to beginning my PhD research proper, with supervisors in place but no precise direction of travel, I travelled as part of a cohort of MAT students to exhibit interactive artworks at Ars Electronica festival. My experience in relation to a series of artworks there has been influential on ideas motivating this research. Browsing the other student work exhibited as part of the 'Campus Program', I encountered a small and unassuming piece called *Silent Songs* by Katja Volk [1]. Here a coloured beam of light is diffracted by an intricately designed 3D printed shape that could be rotated manually by the visitor, the light producing complex patterns of abstract shapes on the wall behind. What struck both me and my PhD supervisor, Andrew McPherson - was the visual detail and nuance that could be explored via just tiny adjustments to the position of the object in relation to the light. This complexity and its utter relationship to the materials and character of manipulation was so engaging and, I felt, really quite *beautiful*.

In the vaulted attic spaces of the Ursulinenkirche at the OÖ Kulturquartier in Linz, I encountered two installations submitted to the Prix Ars Electronica in the 'Digital Musics and Sound Art' category. The first of these was *Stay* (2005-) by Sine Wave Orchestra [Jo et al., 2005], a participatory sound installation in which visitors were invited to take a small sine tone generator, set its frequency, and clip it to one of many metal rods suspended throughout the gallery space. Over the course of the exhibition, the gallery space became filled with what, from a distance, sounded like a cloud of white noise hanging in the air. Stepping among the wires, I became aware of shifting harmonic clusters and an even closer listening afforded the perception of individual tones, micro-compositions and the interplay of different pitches as they combined in the air. The soundscape was so complex and fixed in the exhibition space that as I moved, I could perceive my changing spatial relationship to the installation via the shifting balance and orientation of tones. The rich nuances of the installation were discovered through my movement.

1 https://ars.electronica.art/outofthebox/en/silentsongs/

Immediately afterwards, I experienced the renowned Spanish sound artist Francisco Lopez's installation *MANTRAcks*[2], a 10-channel installation 'adapted' for the site in which I was listening. The impression that the piece gave was one of a dense and immense field of sound: alarm-like and lively with bell-like impulses that resonated the room itself. Again, minute sonic fluctuations could be discerned as I moved my head just a small amount, leaning into the spaces between the rafters or crouching lower to the floor.

Though employing entirely different sensory modalities, I discerned an experiential connection between the tiny interactive light sculpture and the spatial sound installations just described. In each case, my movement - even making very subtle adjustments to my hand or bodily position - produced a palpable change to the look or sound of the artwork, allowing me to discern complex phenomena and explore intricate and spatial details directly and physically. I recall my attentive disposition as a kind of listening and feeling in movement, discerning in every moment the cumulative effect of the installation as a microcosm of local detail specific to my bodily engagement and changing with my (physical and perceptual) behaviour.

Importantly, I perceived these art experiences as interactive and as richly *meaningful*, though producing understanding and depth of experience that addresses the body more than conscious thought patterns, a kind of body-sound meaning that I struggle to articulate in words. Attempting to recall and reflect on the sound installations, I found it relatively easy to describe visual detail: the look of the speakers, the shape of the room, and the colour and texture of building materials. It is much more difficult to recall and also articulate the sonic qualities of the composition; the timbral and temporal qualities that engaged my sensory perception and physicality all at once and all as one. Even harder to articulate the sensory character of embodied experience in a particular moment or even as a trajectory over time. The rich, interactive quality of the sound installation experience and the extent to which I feel lost for words when I attempt to articulate it inspire and motivate this PhD research.

2 https://ars.electronica.art/outofthebox/en/mantracks/

B

APPENDICES FOR CHAPTER 4

B.1 RESEARCH ETHICS DOCUMENTS

Research Study: Site-Specific Sound Art
Information for Participants

You are invited you to take part in this research project. Please read the following information carefully as this will tell you why the research is being done and what you will be asked to do if you take part. Please ask if there is anything that is not clear or if you would like more information.

This study is part of a PhD project, within the Media and Arts Technology department at Queen Mary, University of London. The purpose is to learn about site-specific approaches to working with sound, and the effects that an artist's design choices might have upon audience behaviour. The invited participants are all sound artists or composers who describe their work as site-specific and produce installations or performances in which the audience is free to move through the space.

All participants are invited to take part in a one-to-one interview lasting approximately one hour, which is semi-structured around a set of key questions. The interviews will be audio recorded and later transcribed. Recordings will only be used by the researcher in relation to this study and stored securely. Direct quotations may be used in reports and publications and you are free to choose whether you would prefer to be anonymised or named.

It is up to you to decide whether or not to take part in the study. If you do take part you will be given this information sheet to keep and be asked to sign a consent form. You are free to withdraw at any time and without giving a reason.

~

Please read Queen Mary's privacy notice for research participants[1] for important information about your personal data and your rights in this respect.

If you have any questions or concerns about the manner in which the study was conducted please, in the first instance, contact the researcher responsible for the study. If this is unsuccessful, or not appropriate, please contact the Queen Mary Ethics of Research Committee, Room W104, Queens' Building, Mile End Campus, Mile End Road, London, E1 4NS or research-ethics@qmul.ac.uk. If you have any questions relating to data protection, please contact Data Protection Officer, Queens' Building, Mile End Road, London, E1 4NS or data-protection@qmul.ac.uk.

[1] This is found at: http://www.arcs.qmul.ac.uk/media/arcs/policyzone/Privacy-Notice-for-Research-Participants.pdf

MEDIA & ARTS TECHNOLOGY

Consent Form

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Study: Site-Specific Sound Art: design approaches & audience interaction
Queen Mary Ethics of Research Committee Ref: QMREC2334

Thank you for considering taking part in this research. The person organizing the research must explain the project to you before you agree to take part.

If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time. If you are willing to participate in this study, please circle the appropriate responses and sign and date the declaration underneath.

Statement	**Circle a response**
I agree that the research project named above has been explained to me to my satisfaction in verbal and/or written form	YES / NO
I understand that if I decide at any other time during the research that I no longer wish to participate in this project, I can notify the researchers involved and be withdrawn from it immediately	YES / NO
I have read both the notes written above and the Information Sheet about the project, and understand what the research study involves	YES / NO
I agree to take part in the study, which will include use of my personal data	YES / NO

Participant's Signature:_____ Date: _____

Investigator's Statement:

I _____ confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the volunteer and provided a copy of this form.

B.2 INTERVIEW QUESTIONS

1. Please introduce yourself and describe your practice.
2. Describe the last piece that you made or something that you are working on at the moment.
3. Describe your process of making an installation/performance.
4. Who is your audience, and do they require any specialist knowledge or training?
5. What kinds of behaviour have you observed?
6. Have you asked audience members about their experience of the work? If yes, what did they say?
7. Does audience feedback inform future changes to your work? If yes, what changes have you made?
8. I have been using the word *audience* to describe those who experience your work. Would you use an alternative term?
9. What verb would you use to describe the act of creating your works? For example, I might say you are *designing* – would you use an alternative?
10. Describe your experience as an audience member to a site-specific sound installation or performance that you have experienced and admire.
11. What does the term 'site-specific', mean to you?
12. Do you use digital technologies in your work/process? If not, why not?

C

APPENDICES FOR CHAPTER 5

C.1 SOUND DESIGN EXPERIMENTS: NOTES

C.1.1 *Simple, Sustained Sounds*

Examples: Sine tones, sustained harmonic instrumental notes such as a long, single note played on bassoon.
Spatial appearance: These kinds of sound appear to fill the space as an ambient presence. They are not easily localisable to an individual tweeter and promote a greater sense of being immersed in sound. The Doppler effect is very prominent here; tiny sonic fluctuations may be appreciated via micro-movements (small adjustments to head position, shifting weight) and more prominent distortions to the sound are heard as a result of quicker movements over a larger area, e.g. walking through the space, fast head movements, lunges. The way that sounds change with my movement has a fluidity - it feels naturally and organically paired with my movement. These sounds also have a closeness - I perceive them up close, touching my ears, rather than as sound objects 'out there'. As I walk through the space, I have the feeling of moving my body through a fluid that fills the room. In an attempt to describe this sensation, imagine submerging your hand(s) into a large body of water and then moving them, palms open, through that water. The ripples and disturbances to the water are a direct physical result of both your actions and the properties of water as a material. Interacting with simple sustained sounds in the installation somehow has a comparable 'feel'.
Encouraged behaviours: Close listening via micro-movements, e.g. turning the head or standing still and shifting the weight of the body. Playfully moving through the whole space with variation in speed and direction, or experimenting with more performative movement gestures in the range of the body e.g. lunging, swinging arms and play - exploring the novel effect.

C.1.2 *Inharmonic, Articulated Sounds*

Examples: Speech or percussive, noise-rich impulses.
Spatial appearance: These kinds of sounds do not have an ambient appearance and instead are more easily localisable to a tweeter location. They have a well-defined spatial profile and appear to 'stick' to the tweeter. As I turn on the spot, I am very aware of my changing orientation to their stationary spatial location. Although highly directional, the system distorts my sense of distance in relation to the sound. Speech, for example, does not fill the space around me as in real life but instead sounds broadcast on the radio, but with that radio signal coming from a very particular location with narrow directivity.
Encouraged behaviours: Stillness, listening to the words, turning on the spot to appreciate the 'fixed' spatial location of sounds, walking in and out of the range of audibility.

C.1.3 *Field Recordings*

Examples: Stereo recordings capturing environmental ambiences and incidental sounds.
Spatial appearance: These have a similar appearance to speech, i.e. are strongly directional, and the Doppler Effect is barely perceptible, particularly when the sounds have a temporal articulation. By layering field recordings (emitted via tweeters in different spatial positions), it is possible to create the feeling of being in an environment when listening with the headphones because the same spatial, binaural cues are (mostly) present. It was found that the focus of the recording is important here. Environmental ambiences (captured at a distance, focusing not on one sound but on the soundscape as a whole) work to create this effect, whereas closely mic'ed sounds (whereby the microphone is positioned to capture a particular sound in the environment rather than the environment as a whole) do not.
Encouraged behaviours: Spatial interaction, macro exploration of the entire space to seek out or get closer to particular sounds. Also slower body twisting to appreciate the changing orientation of sounds placed in the space. Stillness, enjoying the sensation of being in an environment.

C.1.4 *Microphone Listening*

In the ultrasonic installation, sounds are not apprehended directly by the naked ear but mediated by microphones housed on the outside of the headphone earcups. An important feature of listening (as opposed to simply hearing) is the ability to focus auditory attention on different sound sources in the environment around us e.g. the cocktail party effect. In my experience, listening through the microphones entails some flattening of the spatial dimension. Sounds appear closer, with a lack of depth. It is as though the microphone takes over the role of bringing sounds to the foreground, and the exploration of a spatial scene via one's auditory attention seems less natural somehow. This alteration of spatial perception due to the microphone mediation of sound means that movement of the body, i.e. changing the orientation of the microphones to the environment, becomes the primary way of interacting with sounds in the space. This is not to say that the perceptual activity of shifting auditory attention is not possible, just that somehow one's ability to perceive depth and isolate sound sources via perceptual means is muted.

D

APPENDICES FOR CHAPTER 6

D.1 VISITOR SURVEY AND CONSENT FORM

Your age:
Your gender:

Indicate how the following statements apply to you:

1. I am a musical person
   Not at all – slightly – moderately – fairly – very much

2. I am an experienced visitor to sound art and/ or interactive art installations
   Not at all – slightly – moderately – fairly – very much

The following questions will help us to understand how you listened to the installation and how it felt in your experience. Please fill the available space will as much detail as you can.

3. What did you do to listen to the installation?
   For example, you could describe your physical actions, listening strategies, changes that happened over time.

4. How did you feel while listening to the installation?
   For example, you could describe any emotions, bodily sensations or mental images that arose.

5. While listening, did you notice the passing of time or the behaviour of other listeners in the space?

6. Is there a moment that stands out as significant in your memory of the experience?
   Please describe that moment

Queen Mary
University of London

Dear visitor,

We would like you to be part of our research project. You should read the following information and only agree to take part if you want to, it is entirely your choice.

Being With The Waves is a sound installation that is part of a PhD research project that explores the experience of listening to spatial sound art installations. At the Ramsgate Festival, we are collecting feedback via surveys and at times will be filming the installation space to collect observations of visitor behaviour. Your participation will help us to understand how people listen to the installation, guide the artwork's development and our future research directions.

For more information about this research and how the data that we collect will be used and stored, please see the information sheet provided. If there is anything that is not clear or if you have any questions, please ask us.

Consent statement:

I confirm that I have read the above information, that the research project has been explained to my satisfaction and I agree to take part in this study.

I agree to being filmed and to images or video footage being published as part of this research in anonymised (face blurred) / identifiable form (please delete as appropriate).

I consent to the processing of my personal information for the purposes of this research study.

I understand that such information will be treated strictly confidentially and handled in accordance with the provisions of the Data Protection Act 2018 and comply with data processing policies of Queen Mary University of London.

Signed:

Date:

Title of Research Study:
Exploring the experience of listening to a spatial sound art installation in the context of a public art festival

Principal Investigator:
Nicole Robson, supervised by Prof Nick Bryan-Kinns and Dr Andrew McPherson

Queen Mary Research Ethics reference number: QMERC20.483

E

APPENDICES FOR CHAPTER 7

E.1 RESEARCH ETHICS DOCUMENTS

Queen Mary University of London

Participant Information Sheet

Study title
Exploring the experience of listening to a spatial sound art installation

Version number and date
Version 2.0: 28.05.2021

Researcher's name
Nicole Robson, supervised by Prof Nick Bryan-Kinns and Dr Andrew McPherson

Queen Mary Ethics of Research Committee reference number:
QMERC20.016

Invitation paragraph

You are being invited to participate in a research study. Before you decide whether or not you wish to participate in this study, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us questions if there is anything that is not clear or if you would like more information.

What is the purpose of the study and what would taking part involve?

The purpose of this study is to explore the experience of listening to a spatial sound art installation. The installation consists of a number of speakers positioned around the installation space that emit a spatial sonic composition. To the naked ear, the installation is silent and only by wearing a set of modified headphones are listeners able to hear it.

The study falls into two parts. In the first part, you would be invited to freely listen to the installation. Your interaction would be filmed by a camera set up in the space and the sounds that reach your ears would be recorded using tiny microphones embedded on the outside of the headphones.

In the second part of the study, you would be interviewed by the researcher in order to learn about your experience. As part of this interview, you would be invited to recall a particular moment of your interaction and with the help of the interviewer, explore this experience in successively finer detail. The interview would conclude with you reflecting on the sound installation and interview technique. The interview stages of the study would also be filmed, and audio recorded.

The study will take place at Queen Mary's Mile End campus and take 60-80 minutes to complete.

Why am I being invited?

You are being invited to participate in this research study because you are over the age of 16 and have been identified as having an active interest in the arts and/ or music.

and

You should not take part in this study if you are under the age of 16, are unable to listen to stereo sound using headphones or would not choose to visit an art exhibition where you might encounter sound art or interactive art.

Do I have to take part?

This participant information sheet has been written to help you decide if you would like to take part. It is up to you whether you wish to take part. If you do decide to take part you will be free to withdraw at any time without needing to provide a reason, and with no penalties or detrimental effects.

What are the possible benefits of taking part?

By taking part in this study you will be supporting PhD research that investigates the experience of listening to spatial sound-based artworks. Your participation will further the development of a new artwork and allow you to experience the sound installation prior to public exhibition.

What are the possible disadvantages and risks of taking part?

This study will involve listening to a sound installation, the volume of which will not be harmful and headphone volume may be adjusted by the participant to the desired level.

Since this study is planned to take place in 2021 on campus at Queen Mary, there is some risk to Covid infection by agreeing to take part since you will need to travel to the campus. Please be assured that this study complies with health and safety regulations put in place to by the university to ensure the safety of visitors, staff and students onsite. The spaces to be used for this study are on the ground floor and quickly accessed from the main road. Rooms are cleaned and sanitised on a regular basis throughout the day.

You will be asked to wear a face covering at all times while on campus. During the study, social distancing will be maintained at all times, disposable headphone covers will be used and any surfaces that come into contact with participants will be cleaned between study iterations.

Please note, if you or a family member has develop symptoms of coronavirus in the 14 days prior to your scheduled participation in the study, to not attend, but get in contact and arrange another time to meet.

Expenses and payments

You will be paid £20 to cover your time and expenses

What information about me will you be collecting?

The information that will be collected during the study consists of audio and video capture of both your interaction with the artwork and subsequent interview. Your age, gender, musical

V2.0 28 May 2021

Queen Mary University of London

Consent Form

Title of Research Study:
Exploring the experience of listening to a spatial sound art installation

Principal Investigator:
Nicole Robson, supervised by Andrew McPherson and Nick Bryan-Kinns

Queen Mary Ethics of Research Committee Ref: QMERC20.016

Thank you for your interest in this research.

Should you wish to participate in the study, please consider the following statements. Before signing the consent form, you should initial all or any of the statements that you agree with. Your signature confirms that you are willing to participate in this research, however you are reminded that you are free to withdraw your participation at any time.

Statement	**Please initial box**
1. I confirm that I have read the Participant Information Sheet dated 28.05.2021 version 2.0 for the above study; or it has been read to me. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2. I understand that my participation is voluntary and that I am free to stop taking part in the study at any time without giving any reason and without my rights being affected.	
3. I understand that my data will be accessed by the investigator	
4. I understand that my data will be securely stored in the UK and in accordance with the data protection guidelines of Queen Mary University of London 5 years in pseudonymised form.	
5. I understand that I can access the information I have provided and request destruction of that information at any time prior to 1 month following the study date. I understand that after that date I will not be able to request withdrawal of the information I have provided.	

6. I agree to the study being audio and video recorded.	
8. I agree to screenshots of my video material to be published as part of this research in anonymized (face blurred) / identifiable form (please delete as appropriate)	
7. I understand that the researcher will not identify me in any publications and other study outputs using any other personal information obtained from this study.	
8. I understand that the information collected about me will be used to support other research in the future, and it may be shared in anonymised form with other researchers.	
9. I agree to be contacted about other research studies in the future.	
10. I agree to take part in the above study.	

Participants should read Queen Mary's privacy notice for research participants which contains important information about your personal data and your rights in this respect. If you have any questions relating to data protection, please contact Data Protection Officer, Queens' Building, Mile End Road, London, E1 4NS or data-protection@qmul.ac.uk or 020 7882 7596.

_____	_____	_____
Participant name	Date	Signature
_____	_____	_____
Name of person taking consent	Date	Signature

I Nicole Robson confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant and provided a copy of this form.

Principal Investigator (or Supervisor for student projects)

Andrew McPherson

a.mcpherson@qmul.ac.uk

020 7882 5774

Student Investigator (if applicable)

Nicole Robson

n.s.robson@qmul.ac.uk

E.2 PARTICIPATION SIGN-UP FORM

You are invited to participate in a research study exploring the experience of listening to a sound installation artwork. We are looking for people who take an active interest in the arts and would choose to visit an exhibition of sound art and/ or interactive artworks.

In the study, you would listen to a sound installation and then be interviewed about moments of your subjective experience in fine detail. The study takes approximately 90 minutes to complete. You would also be invited to meet the researcher for a 20-minute online meeting in advance for an introduction to the

micro-phenomenological interview technique used in the study. You would receive £20 cash as compensation for your time.

The study will take place at Queen Mary University of London in Mile End in early April 2022. If you are interested in taking part, please complete and submit the following form indicating your background, experience, and availability.

Thank you for your interest in this study and please share this call with anybody who would be interested in taking part.

Name:

Gender:

Email address (will be used to contact you about the study):

I take an active interest in the arts and am a regular visitor to art exhibitions
Strongly disagree, disagree, neutral, agree, strongly agree

I would choose to attend a sound art exhibition
Strongly disagree, disagree, neutral, agree, strongly agree

I would choose to attend an exhibition of interactive or media art
Strongly disagree, disagree, neutral, agree, strongly agree

I am a musical person
Strongly disagree, disagree, neutral, agree, strongly agree

Please explain why you gave the above response by describing, for example, any musical training, background, practice or experience.

Have you listened to a sound installation before?
Yes / No

If yes, provide details.

During the study, you will listen to a sound installation using a pair of over-ear headphones. If there are any issues relating to your hearing that would impact

your ability to listen such as hearing damage or deafness, please provide details below:

The study consists of a 90 minute session in-person session at Queen Mary University in Mile End. Please indicate your availability for this session using the options below. Please note that once your session time has been confirmed with the researcher, they will also ask to schedule a 20-minute online meeting in advance of the in-person study to introduce the study's aims and interview method that will be used.

Please indicate your availability for a 90-minute session at the Queen Mary campus in Mile End. Please select all times that you could attend.

If you wish to add any notes regarding your availability, please do so here:

E.3 CURATORIAL TEXT

Explore sound as a fluid presence that fills the space around you and discover stories of seaborne experience woven into an immersive composition that bends and shifts with your movement. To the naked ear, the installation appears silent, but a hidden world of voices, instrumental tones, and maritime sounds and is revealed through wearing special headphones.

E.4 POSSIBLE METHODS FOR ARTICULATING M-P MOMENTS

1. **Video-cued recall:** The first phase of the interview would entail a cued recall session. The participant would watch a video recording synced with the binaural audio capture of their entire interaction i.e. the audio that the headphones emitted. During playback they would be asked to describe what they were thinking at the time, the intentions or motivations that underpinned their movements and note any moments of realisation or transition, pausing the video as necessary to elaborate on moments of importance.
   Possible variations: The point of view from which the participant views their interaction in the video-cued recall can either be from a third-person position i.e. a camera in a fixed position on the edge of the installation space and the participant sees their whole body interaction, or from a first-person

perspective i.e. the camera feed is taken from a body-worn camera, ideally positioned in line with the participant's eyes to capture as close to their viewing experience as possible.
Pros: Video-cued recall grounds the interview in concrete evidence of the experience as it happened. Claire Petitmengin, the researcher responsible for developing and popularising the M-P interview technique, was recently asked whether video-cued recall could be used in conjunction with M-P. She agreed that it could, adding the caveat that a first-person camera perspective would be preferable to a third-person perspective.
Cons: Participants already need to wear the modified headphones and carry a portable audio recorder on their body. Taking a first-person approach to video-cued recall would entail wearing a camera as well. The findings of this PhD research so far have highlighted the sensitivity of experience to the material objects that are encountered. A concern is that the addition of body-worn camera and audio recorder may distract listeners in some way. Significantly, it may disrupt their embodiment relationship to the headphones, an aspect under study in the experiment. Also, the installation space is designed to be empty of visual distractions - there would be little variation in visual images from a first-person perspective. Taking a third-person approach to cued-recall would be less invasive but may interfere with the participant's own embodied memory of the experience, which it is necessary to evoke in the M-P interview.

2. **Semi-structured interview:** The first phase of the interview would consist of a series of questions similar to those asked in the survey designed for study 2. Additionally, the participant would be asked to describe their interaction with the installation from start to finish, with the interviewer probing them for more detail regarding thought processes, intentions and transitions throughout.
Possible variations: The M-P technique could be used to guide the participant back to the beginning of their interaction and then invite a broad temporal description. The interviewer and participant could map out the unfolding of the interaction together on a piece of paper, noting moments of importance and the main phases or 'beats' of their interaction.
Pros: The participant is not required to wear extra audio-visual equipment on their body. The interview is likely to take less time than video-cued recall, leaving more time for the M-P part of the study.

Cons: This approach is not grounded in video evidence and may lead to less detailed descriptions of the participant's perceptual activity over time. In turn, this may make it harder for participants to articulate moments of singular experience within the experience of listening to the installation as a whole.

3. **Short, provoked experiences:** This approach might be used to supplement option 2. If the participant is unable to articulate singular moments of experience, they could be asked to return to the installation space and 'find' that sensation once more and once they have found it, dwell there for a few seconds before returning to the interviewer. The M-P interview would then be focused on the provoked experience that had just happened rather than a moment within the participant's first encounter with the installation. In this instance, questions such as 'how did you go about finding the sensation?' or 'how to you know that you feel sensation x?' could be asked.

E.5 INTERVIEW QUESTIONS

E.5.1 *Semi-Structured Interview*

1. In broad strokes, could you tell me the story of your experience, listening to the installation? If it makes sense for you to do so, then you could start at the beginning when you first entered the space, and then describe was happened over time.
2. What did you do to listen to the installation? Probe - physical actions, listening strategies, physical and perceptual behaviours that happened over time.
3. How did you feel while listening to the installation? Probe - emotions, bodily sensations, mental images.
4. Examining your own experience, are there ways in which the experience of listening is similar/ different to everyday listening situations? Or, an alternate framing of this question: How would you describe the sensation of listening to the installation to somebody unfamiliar with it?
5. Did you notice the listening technology?
6. Are there any moments in your experience that stand out as particularly salient or memorable?

E.5.2 *Micro-Phenomenological Interview*

Example interview questions for describing an auditory sensation:

- And when you hear x, what do you hear?
- Does this sound come from somewhere? From how far away? From which direction?
- How loud is it?
- What is its tone?
- How persistent is it?

Example interview questions for describing a bodily feeling:

- And when you feel this, what do you feel?
- Where is this sensation? Is it located somewhere?
- Does it have a size?
- How intense is it?
- If I had this feeling, what would I feel?

E.6 EXAMPLE M-P INTERVIEW TRANSCRIPT

Participant 8: A moment in which they are sat on the floor and listening deeply, experiencing a strong connection with sound.
Note that the diachronic description 1-22 was elicited before the listener was invited back to the moment – here, the description is in the past tense whereas once the M-P interview began, the present tense is used.

1 Okay (. . . .) I go in
2 and I have a look around familiarize myself with the place
3 and then it's a nice ambient sound
4 I sit down in the middle
5 first I stood there and then I sat down.
6 Then I sat down nice and comfortable kind of meditative pose, cross-legged (..) and close my eyes

7 so it kind of uh emptied everything else out because I was very excited coming in, to see this new thing
8 and then I sat down
23 I'm sitting cross-legged with one leg above the other
24 and my hands are next to my body (..)
25 on the floor my palms facing up,
26 and my spine is (..)
27 I'm trying to be straight I guess but my head is a bit um (..) relaxed so I'm kind of looking down.
28 My eyes are closed but is pointing down. (Long pause)
29 and I'm just breathing um (..)
30 and letting the sound sound take over
31 It's a peaceful calm (..)
32 happiness like (..) not an excitable happiness just (..) peaceful relaxed happiness (pause)
9 and I then I just uh kind of let everything else go away except the sound and just let it wash over me.
33 There's a drawn-out sound, not too deep not too high.
34 And there's (..) maybe a speech,
35 like very very hardly audible it's kind of in the background.
36 It's more like umm it's more more like sound than words. (..)
37 And maybe there's some more electronic sound but also drone-like.
38 Kind of like a buzzing, but not high-pitched.
39 I think it [the drone sound] comes from the left.
40 Maybe up from the left.
41 it's not too loud it's just the right uh (..) volume
42 It has a size like a body (..) it's quite big
43 It's bigger than medium
44 I don't know like (..) mm it's smaller than a tree if that makes some sense,
45 it's quite wide and full-bodied.
46 Length I don't know it's it's it's quite long xx xx xx.
47 But not not like infinite but just long
48 I think it enters from above from the left and then it kind of stays in the middle
49 and it covers covers the room like- um what is this called, horizontally like like a carpet or like a second floor but higher but would be about in your middle if you are standing up, like chest high when I'm sitting down.

50 Kind of like an undulating carpet (long pause)
51 It's [the sounds of speech are] (..) quite small, but dense (pause)
52 okay no heavy I think.
53 They also come from the left I think but like from behind like this (gestures)
54 a bit lower also than the other sound
55 No [the speech sounds do not cover the space like a carpet] it kind of like goes straight into the ear,
56 like it's one thing (..) it like wants something from you
57 Hmm I don't know like um (..) it's kind of like (..) bubbles and dark and like starts that wide and gets smaller so it can fit into my ear
58 (overlapping) Like I don't know bobbles (or bubbles?) maybe
59 It's getting like (..) pointing into my ear
60 (overlapping) Getting to my brain
61 I guess I start to stay pay more attention to the words.
62 I don't know if they're getting louder or I just pay more attention (..)
63 but by (..) paying attention to it it's kind of becomes smoother
64 Like less (..) threatening is not the right word.
65 Like less demanding I think
66 I guess my mind starts to make up images as an answer to the words.
67 That's when I think of um (..) this (..) quasi memory-like feel of being somewhere falling asleep but other people are still doing things, like talking,
68 maybe they have a get-together, a party and I'm falling asleep (..)
69 but falling asleep happily with this positive, physical tiredness and there's um, there's no threat from the other humans it's just it's a safe safe place.
10 And I took some deep breaths (pause) and it felt like like the space around me was also inside with the resonation,
11 resonation that's not even- with the resonance and
12 the vibration was mainly I think here in my chest bone (..)
13 maybe connected to the breathing,
14 but definitely it was very (..) peaceful and relaxing,
15 like a feeling of belonging, of being one with the environment.
16 Physically it's kind of like tiny particles moving in my lung when I breathe in.
17 I guess that's how I'd imagine like, atoms being, just vibrating there's no um borders but (..) connection into everything (..)
75 It's [this resonance in the chest bone] kind of feel like um (..) like the inside of the chest bone is vibrating (long pause)

76 like small particles or- it's hard to describe.
77 Like it doesn't vibrate as one thing, but like it's filled with a lot of tiny things and they vibrate. (Long pause)
78 but it's a good feeling (. . . .)
79 it makes me think or feel that that's how everything vibrates, like the walls and my body and everything.
80 I don't think so [this sensation doesn't have a size] it's um (pause) I think because it's part of everything else it doesn't have a separate size.
81 (overlapping) It doesn't have borders
82 (pause) It's not intense it's (. . . .)
83 it's like within everything else in my body so it doesn't feel like (..) it doesn't feel like it's peeking out or (..)
84 yeah I don't think it's intense.
85 If that's the way you're asking.
86 [If you were feeling this sensation you would feel] (pause) a bit cold here in the chest bone.
87 A bit strange (. . . .)
88 but if you just let it be it's (..) it becomes this feeling of peaceful (..) moment of I don't know letting go or (..) just being with that (..)
89 being uh I don't know like a separate entity (long pause)
90 it's really peaceful in a way of like um (. . . .) letting go everything and you don't have to (..) do things or fulfill any rules or (..)
91 all those things just go away (..) and you're just one with this um (..) vibrating
92 Like the sound (..) I think the sound is the one that caused the sensation, or allowed me to have this sensation (pause)
93 so it's like um being thankful to the sound for it I guess (..) for giving me this feeling (pause)
94 it's like a hug
95 Yeah the sound caused it
18 and then I think (..) after a while my mind came in and like started to um, bring in thoughts.
19 I don't know exactly what I don't remember but that's when I kind of thought that I should explore-
70 (long pause) I guess then I start to understand some words
71 I don't remember them but it's about something about burning in the throat, these physical sensations

72 and I think by understanding that I kind of come out of this, um so it's not a trance, but it's like a full conscious listening moment
73 and I start to think about the situation
74 and then I decide to stand up and look around the room (..) to see if there's anything uh (..) anything that I need to explore, that is part of the work like the lights, the different parts of the room.
20 I should explore the room more to see if there's any changes, anything changes when I walk around.
21 To see the lights and the setup a bit more.
22 That's that's how I came out of it I think.

F

APPENDICES FOR CHAPTER 8

F.1 RESEARCH ETHICS DOCUMENTS

Queen Mary
University of London

Participant Information Sheet

Study title
Examining the Curation of a Sound Installation and Methodology for Eliciting Listening Experiences

Version number and date
Version 2.0: 29.12.2023

Researcher's name
Nicole Robson, supervised by Prof Andrew McPherson and Prof Nick Bryan-Kinns

Queen Mary Ethics of Research Committee reference number:
QME23.0190

You are being invited to participate in a research study. Before you decide whether or not you wish to participate in this study, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us questions if there is anything that is not clear or if you would like more information.

What is the purpose of the study and what would taking part involve?

A key objective of this study is to examine the process of designing and curating a sound installation artwork; interrogating how the various media interact to create embodied experience and meaning.

The sound installation, *Being Honeyed* (working title), is being exhibited at no format gallery in January 2024. The installation consists of eight speakers positioned around the installation space that emit a spatial sonic composition. To the naked ear, the installation is silent and only by wearing a set of modified headphones are listeners able to hear it.

Taking part in this part of the study will involve meeting with the lead researcher on several occasions in the lead up to the public exhibition, to discuss and experiment with aspects of the installation's design. Each of these meetings will be audio recorded. The total time commitment is 10-15 hours.

Why am I being invited?

You are being invited to participate in this research study because you have relevant expertise to the study's aims – as, for example, a dramaturg, a curator or lighting designer.

and

You should not take part in this study if you do not have this expertise.

Do I have to take part?

This participant information sheet has been written to help you decide if you would like to take part. It is up to you whether you wish to take part. If you do decide to take part you will be free to withdraw at any time without needing to provide a reason, and with no penalties or detrimental effects.

What are the possible benefits of taking part?

By taking part in this study you will be supporting PhD research that investigates the experience of listening to spatial sound-based artworks. Your participation will further the development of a new artwork.

What are the possible disadvantages and risks of taking part?

This study will involve listening to a sound installation, the volume of which will not be harmful and headphone volume may be adjusted by the participant to the desired level.

Expenses and payments

You will be paid £20/ hour to cover your time and expenses.

What information about me will you be collecting?

The information that will be collected during the study consists of audio and video capture of both your interaction with the artwork and subsequent interview. Your age, gender, musical experience, attitudes to interactive art and sound art, and relevant information regarding hearing ability will also be collected via a pre-study survey.

How will my data be stored and who will have access to it?

Your data will be stored in an identifiable format, meaning that your name and other identifiers will be present in the data. This is because we wish to your expertise and contribution to the study in any future written outputs such as conference/ journal papers. If you do not wish to be identified in publishable outputs, please indicate this on the consent form.

Your data will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 2018 and comply with data processing and storage policies of Queen Mary University of London:

- Data Protection Policy
- Information/Data Governance Policy – DG14 – Storage of information

When and how will my data be destroyed?
In accordance with university policies, your data will destroyed 5 years after the end of the study and erased through hard drive formatting.

How will my data be used and shared?

The data collected during this study will be analysed and findings will be reported in a PhD thesis and may be published in a conference paper or journal article in the future. Verbal descriptions collected during the study may be directly quoted in these publications. Should

Version 2.0: 29/12/2023

Queen Mary University of London

Consent Form

Title of Research Study:
Examining the Curation of a Sound Installation and Methodology for Eliciting Listening Experiences

Principal Investigator:
Nicole Robson, supervised by Andrew McPherson and Nick Bryan-Kinns

Queen Mary Ethics of Research Committee Ref: QME23.0190

Thank you for your interest in this research.

Should you wish to participate in the study, please consider the following statements. Before signing the consent form, you should initial all or any of the statements that you agree with. Your signature confirms that you are willing to participate in this research, however you are reminded that you are free to withdraw your participation at any time.

Statement	**Please initial box**
1. I confirm that I have read the Participant Information Sheet dated 29th December 2023 version 2.0 for the above study; or it has been read to me. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2. I understand that my participation is voluntary and that I am free to stop taking part in the study at any time without giving any reason and without my rights being affected.	
3. I understand that my data will be accessed by the student investigator and their supervisors	
4. I understand that my data will be securely stored in the UK and in accordance with the data protection guidelines of Queen Mary University of London 5 years in pseudonymised form.	
5. I understand that I can access the information I have provided and request destruction of that information at any time prior to 1 month following the study date.	

I understand that after that date I will not be able to request withdrawal of the information I have provided.	
6. I agree to study sessions being audio and video recorded.	
8. I agree to screenshots of my video material to be published as part of this research in identifiable form	
7. I agree to the researcher identifying me by name in any publications and other study outputs as a result of this study.	
8. I understand that the information collected about me will be used to support other research in the future, and it may be shared in identifiable form with other researchers.	
10. I agree to take part in the above study.	

Participants should read Queen Mary's privacy notice for research participants which contains important information about your personal data and your rights in this respect. If you have any questions relating to data protection, please contact Data Protection Officer, Queens' Building, Mile End Road, London, E1 4NS or data-protection@qmul.ac.uk or 020 7882 7596.

_____	_____	_____
Participant name	Date	Signature

_____	_____	_____
Name of person taking consent	Date	Signature

I Nicole Robson confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the participant and provided a copy of this form.

Principal Investigator (or Supervisor for student projects)

Andrew McPherson

a.mcpherson@qmul.ac.uk

Student Investigator (if applicable)

Nicole Robson

n.s.robson@qmul.ac.uk

F.2 PHONIC.AI SURVEY TEXT

Page 1

Thank you for visiting *Sonographies* at no format Gallery. You are invited to participate in our research by completing a short online survey, which will help us to understand how people experience the artwork and inform its development.

Page 2

This research activity has been approved by Queen Mary Ethics of Research Committee (ref: QME23.0190). You should read the following information and only agree to take part if you want to, it is entirely your choice.

Sonographies is a sound installation that forms part of a PhD research project exploring the experience of listening to spatial sound art installations. This survey consists of three questions to which you will be invited to offer spoken responses by speaking into your device.

Page 3

By proceeding with this survey, you agree with the following statements:

- I have visited Sonographies at no format gallery today and I am over the age of 18.
- The research project has been explained to my satisfaction and I agree to take part in this study.
- I consent to the processing of my personal information for the purposes of this study.
- I understand that such information will be treated strictly confidentially and handled in accordance with the provisions of the Data Protection Act 2018 and comply with data processing policies of Queen Mary University of London.

Page 4
Let's begin.

Before answering these questions, we invite you to take a few moments to allow the experience of listening to Sonographies to return to you.

Please offer as much detail as you can.

Page 5
How did you feel when listening to the installation?

For example, were there particular emotions, bodily sensations or mental images that arose for you at the time?

Page 6
How would you describe the experience of listening to Sonographies to a friend?

Page 7
What does the title 'Sonographies' mean to you?

F.3 MARKETING TEXT

Concealed in near silence, the sound installation Sonographies explores hidden and intimate spaces of experience. An eight-channel composition sounds physically in the gallery space but above the range of human hearing. Unstable and sensitive to movements of the body, an alternate acoustic landscape is revealed to individual listeners wearing wireless headphones created specially for the work. Sonographies is an invitation to dwell in sound, to probe space with your listening, and to notice how your body meets with sound and space. The composition slowly unfolds as though a journey through imagined, interconnected rooms. Drawing on themes of interior and domestic space, miniature and barely audible sounds of the home expand into the gallery space as immersive, sonic landscapes comprising field recordings, instrumental tones, and synthesised layers.