Listening to Yourself Listening

The Metaperceptual Approach to Sound Art

BY

BLAKE REYBURN JOHNSTON

A THESIS SUBMITTED TO THE VICTORIA UNIVERSITY OF WELLINGTON IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

VICTORIA UNIVERSITY OF WELLINGTON

2019

SUPERVISORY COMMITTEE

DR JIM MURPHY

MICHAEL NORRIS

DR AJAY KAPUR

'The physics of relativity confirms that absolute and final objectivity is a mere dream by showing how each particular observation is strictly linked to the location of the observer and cannot be abstracted from this particular situation; but also rejects the notion of an absolute observer. We can no longer flatter ourselves with the idea that, in science, the exercise of a pure and unsituated intellect can allow us to gain access to an object free of all human traces, just as God would see it'.[1]

—Maurice Merleau-Ponty.

[1] Maurice Merleau-Ponty, *The World of Perception*, trans. by Oliver Davis (Abingdon, United Kingdom: Routledge, 2004).

Abstract

This thesis presents a framework for the creation and analysis of metaperceptual sound artworks. Metaperceptual is a term coined herein to describe a range of works that use the perception of the audience as their artistic materials. They provoke their audiences to direct their attention back upon themselves, inviting audiences to observe the nature of their perception and the subjectivity of their experience.

A core focus of many contemporary works is the experience of the audience. These works act as 'experience shapers', guiding the audience through their materials and creating environments in which the audience can explore on their own terms. Metaperceptual works share this focus by drawing the audience's attention back upon themselves, provoking them to attend to the subjectivity of their own experience. These works reveal facets of our perception that constantly mediate our experience, yet often go overlooked and unexplored.

The framework presents a systematic ordering of different approaches to creating metaperceptual works. Three main categories of works are identified: Deprivation, Perceptual Translation, and Perceptual Hacking.

Deprivation works involve the removal, reduction, or denial of the audience's perceptual field. They intervene in the audience's everyday modes of interaction by silencing the din of the world, revealing the facets of experience that often go unnoticed or are masked from our awareness.

Perceptual Translation works directly interface with the audience's perceptual apparatus by shifting, extending, and rearranging its orientation and organisation. These works offer the allure of experiencing what it is like to be someone or something else. By allowing us to experience the world through an altered lens, these works give us a new perspective on ourselves and the ways in which our perceptual apparatus mediates our experience.

Lastly, Perceptual Hacking works involves a rich variety of perceptual oddities and artefacts. These works creatively misuse facets of the audience's perceptual apparatus and perceptual processes, and, in doing so, reveal that our perception is not a neutral objective lens through which to perceive the world.

Metaperceptual works employ a diversity of materials and techniques, and traverse a variety of media and styles. While these themes have most extensively been explored in the visual arts, their potential for sonic exploration is a key concern subject of this research. The framework maps the artistic terrain of metaperceptual approaches, and speculates on the potential for new metaperceptual works. To this end, a portfolio of new metaperceptual sound artworks is presented. These works test the metaperceptual framework, enacting the artistic avenues identified during its development. The works span a range of the approaches identified in the metaperceptual framework, and are manifestations of the framework as a creative tool.

Acknowledgements

There are a great number of people that I would like to thank for their contributions and support to both this research and my development as an artist. I believe that all research is a collaboration, and while my name is at the beginning of this document, the ideas and influence of many others are imprinted on these pages. As there are far too many people that I would like to acknowledge, I will only name a few.

To Dr Jim Murphy, my primary supervisor and a man to whom I owe a great debt. I can't express how deeply grateful I am for your tireless effort, support, and guidance. Your endless curiosity and creativity has often helped to refine my scattered thoughts into a much stronger whole. I am very fortunate to have you as a supervisor, and furthermore, a friend.

To Michael Norris, my secondary supervisor. To this day, your knowledge on a such a range of artistic subjects astounds me. I'm especially grateful for your contributions in evolving and maturing this research, as you helped a great deal in provoking and strengthening these metaperceptual themes. Even after a decade, I still have so much to learn from you.

And to Dr Ajay Kapur, my third supervisor, and mentor. You often have believed that I could achieve things before I could, and for this, I am deeply grateful. Your guidance and support has always pushed me to strive for excellence, and I hope that this work reflects that.

I would also like to thank my other teachers who have been positive influences in my education. In particular: Dr Dugal McKinnon, Dr Ted Apel, and my high school music teacher, Graeme Young.

To all the people who have provided technical support. In particular, thanks to Graeme Crawley from the Faculty of Architecture and Design. Your help in woodworking, fabrication, and general DIY attitude, made my artworks objects that I'm proud of. To Tim Exley, Jason Edwards, and Brandon Pothoven, for your time and patience despite my lack of engineering nous. And Roy Carr, for your help with audio technology over many years.

To my wonderful colleagues, for being inspirations, critics, and for putting up with me dropping meta at the beginning of any word to make it relevant to my thesis. In particular, to Bridget Johnson, for your long time support of me as an artist and academic, and for letting me make beats with your awesome work—you're a good mate. And to Mo H. Zareei, for your collaboration and constant support of my work. Your positivity and insights have often given me the confidence that I'm on the right track.

To my friends and flatmates who have supported and put up with me along the way. Especially Joe and Amelia, Michael and Laura, and Henry. Thanks for always being there.

To Bailey, who knows what went into this work more than anyone else. Thank you for being there in the hard times, for breaking up my run-on sentences, for modelling my weird headsets, drawing my illustrations, for telling me to "do your best", and for celebrating the good times with a cheeky bevy. I will always be thankful for you.

And lastly, to my family. I'm very privileged to have you all in my life, and know that I would be a fraction of the person I am today without you. To Lisa and Jason, for years of dinners, drinks, and support. I hope I can repay you one day in shallots. To Ryan and Liz, for always being inspirational and supportive, even if I don't always eat breakfast. And to Mum and Dad, thank you for your unconditional support in every facet of my life, I deeply appreciate you.

Table of Contents

List of Figures

Part I:

Contextualising the

Metaperceptual Approach

Chapter One

Introduction

The nascent field of sound art is burgeoning with potential for new artistic exploration. Only in the last half century has sound become an established force in the gallery setting, as it has slowly expanded from the confines of the traditional performance context. The diversification of contexts for exploring sound affords new artistic avenues, and most salient to this research, the experience of the audience has become a key artistic concern. This research is devoted to the development of the metaperceptual framework, which provides a lens through which to analyse and create new works that use the perception of the audience as their core material. In particular, this framework is intended to explore the potential for sound art to create metaperceptual experiences. As will be discussed in the following chapters, metaperceptual themes are present throughout a range of disciplines, media, and artists. By discussing the exploration of metaperceptual themes across a diverse range of media, the metaperceptual framework and its potential for provoking new works is comprehensively developed.

The term *metaperceptual* is at the core of this research. The word is developed in this document to describe a certain quality of artwork, the nature of experiencing these artworks, and to generate a framework to create new artworks. In this chapter, I give an initial definition of the term 'metaperceptual', which will be further explicated throughout the document. I also present the background to, and motivation behind, this research. The chapter concludes with an outline of the document's structure and the publications, performances, and outlets that have resulted from this undertaking.

1.1 Defining 'Metaperceptual'

What is *metaperceptual*? This question is evolved throughout this document, but I offer an initial definition here. The intent for developing the term metaperceptual is to identify a range of artworks that use the perception of the audience as their core artistic material, rather than use it as a vehicle through which to experience a narrative or artistic expression. Metaperceptual works provoke their audiences to direct their attention back on to themselves, inviting them to observe the nature of their perception and the subjectivity of their experience. The works employ a diversity of materials and techniques, and traverse a variety of media and styles. The experiential elements of the works are the key factor which characterises them as metaperceptual.

The term uses the prefix ‘meta’ to denote that these works go beyond perception. The need for this prefix is due to tautological nature of describing an artwork as perceptual. Our only access to sound is through our direct experience of it. As Jonathan Sterne states: ‘the hearing of sound is what makes it.’[2] This is not to say that the perception of a work exhausts all of its interpretations and materials. Typically perception is used as a vehicle to convey a narrative, representation, feeling, or thought. While a work may create a complex network of semantic connections, our initial access is necessarily through perception.

By prefixing perceptual with meta, the term denotes that this perception is self-referential: it is perception of perception itself. As an example, this use of the prefix is akin to its use in *metaethics.* The field of ethics has three main branches: applied, normative, and metaethics. Applied ethics involves examining specific ethical issues. Normative ethics seeks to create moral standards that regulate right and wrong conduct across many situations. Metaethics goes beyond this discussion by investigating the nature of ethics itself. Metaethics asks the question: what is ethics and what is it like? The term metaperceptual similarly explores this self-referentiality, as the works provoke their audiences to reflect upon their own perception and how it mediates their experience.

This term is applied to artworks, to experiences which draw a person’s attention back onto their perception, and to artistic approaches that seek to facilitate these metaperceptual experiences through their artworks. The full definition of the term and the framework for creating metaperceptual works is analysed and developed throughout this document. This includes cataloguing various approaches to creating metaperceptual artworks, analysing the ways in which specific artworks create metaperceptual experiences, and discussing the potential for new metaperceptual artworks.

These metaperceptual themes are identified as being implicitly explored by a range of contemporary artists, both in visual and sound fields. The metaperceptual framework makes these implicit themes explicit, connecting a range of diverse artistic approaches, and provides a structure through which a related section of the nascent sound art field can be understood and explored.

---

[2] Jonathan Sterne, *The Audible Past: Cultural Origins of Sound Reproduction* (Durham: Duke University Press Books, 2003).

1.2 Motivations

'Pay no attention to that man behind the curtain!'

—The Wizard of Oz

In 2011, I had a formative experience while attending Janet Cardiff's installation *The Forty Part Motet* (2001). The work, shown in Fig. 1, is a remediation of Thomas Tallis's *Spem in Alium* (c. 1570), a complex forty-part counterpoint for eight choirs of five voices each. The installation reimagines the work using forty loudspeakers spaced in a circle, grouped in choirs with each speaker designated to one voice. The loudspeakers are roughly head sized, sitting on stands making them look like disembodied performers, hinting at the transportation of singer through a technological mediation. In the centre of the circle, two benches are placed that suggest but do not command visitors to sit and contemplate. The work endlessly repeats its eleven-minute runtime, with three minutes of 'intermission' sounds: coughing, sniffing, and gossiping between the singers as they prepare to perform the work.

copyrighted material

Fig. 1 Janet Cardiff, The 40 Part Motet

I entered the space during this intermission stage, with only quiet, intimate sounds that seemed to be almost accidental. Their quietness drew me in, as I moved close to the speaker to investigate the delicate sounds. Their accidental quality made me feel like I was overhearing something that I should not be privy to. As I walked around the space, keeping close to the speakers, I had a sense of the different 'characters' of each speaker. A deep, bassy wheeze was coughed out of one speaker, while what sounds like two small children giggling came from across the room. The shuffling noises subsided for a brief moment of silence before the performers launched into the motet. Their voices swirled around the room, creating clouds of celestial tones that moved through space. For eleven minutes I was captivated, the beauty of the counterpoint and the immersion of the being in sound were almost transcendental. As the counterpoint shifted around the room, I felt adrift, as I did not know where to stand or look. The circular arrangement of the speakers did not indicate a focal point, leaving this up to me to decide and explore. Eventually, I moved to one of the benches in the centre of the room and surrendered to the sounds as they washed over me and induced a deeply introspective state. The work provoked a heightened experience of listening for me, as I contemplated the beauty of the piece and the feeling of being enveloped in sound. My response to the work is not unique, as art critic Jim Dwyer writes in his review that visitors to the New York exhibition of the work were left speechless, with some weeping, and others describing it as transcendent.[3]

This work was influential in the motivation for this research for a number of reasons. The strong affect of the work and the deeply contemplative state that it induced in me are elements that I seek to create in my own artworks. I believe that this is one of the powers of art, and especially sound-based art. As sound artist Dugal McKinnon writes, 'we listen to music to be moved. To be transported. Enraptured. This is the experience of transcendence. Transcending the me-ness of me, the this-ness of this, the thing-ness of being a thing, a body-mind, in an unremittingly physical world.'[4] While this transcendence can be viewed as the audience's attention being directed away from themselves, works can also produce another form of transcendence. Metaperceptual works, which are the subject of this research, transcend the ordinary art experience, elevating the audience's perceptual apparatus from a vessel for experiencing the world through to the artistic subject. In doing so, the audience does not transcend the me-ness of me, but instead experience it directly and explore its idiosyncrasies. In this way, metaperceptual works can create deeply personal experiences, in which the audience become activators and enactors of the artwork.

The Forty Part Motet was one of my first experiences of sound art in a gallery setting. The new context caused me to reflect on how different the experience of the work would have been if it was

---

[3] Jim Dwyer, 'Moved to Tears at the Cloisters by a Ghostly Tapestry of Music', *The New York Times* (New York, 19 September 2013), section N.Y. / Region.
[4] Dugal Mckinnon, 'Janet Cardiff, The Forty-Part Motet', *Dugal McKinnon — Composer, Sound Artist, Researcher*, 2011.

performed by humans in a traditional live context. The gallery space afforded the ability to get close to each 'performer', to move freely through the space without the usual strict social customs that the traditional performance dictates, and the autonomy to interact with the work on my own terms. The empowering of the audience through the affordance of physical autonomy is a radical change from the traditional listening experience, and one which can facilitate metaperceptual experiences. Usually, the audience is expected to sit quietly, passively experiencing the work as it unfolds in front of them. By being able to navigate through the physical space of *The Forty Part Motet,* the audience have a greater degree of control over their experience of the work. In many metaperceptual works, the audience enjoys a similar freedom of interaction and autonomy, with their perception being the main focus of exploration.

Cardiff's *The Forty Part Motet* is indicative of the increasing diversity in the ways in which sounds are being explored in artistic contexts. Over the last half century, sound has slowly moved outside the concert hall, occupying galleries, museums, and public spaces. This diversification has its roots in the evolution of musical boundaries, with a rich history of works transgressing and stretching the definition of 'music'. Musicologist Leigh Landy writes 'ever since Edgard Varèse daringly introduced the notion of "organized sound," the broadening of potential source material within music became an entrenched part of music.'[5]

While Varèse's characterisation was made largely in reference to the performance context, sound now forms the basis for works in a large range of contexts. This has provoked the creation of a range of terms, which Landy catalogues in his book *Understanding the Art of Sound Organisation*. Most salient to my research, sound art and sonic art are often used to describe the larger field of sound-based art than the traditional concept of music. Both terms have ambiguous definitions, as they are used by their practitioners in a range of ways. In defining sound art, Landy writes that 'this term has been used inconsistently throughout the years. Currently it is typically used to designate sound installations (associated with art galleries, museums, and public spaces), sound sculptures, public sonic artifacts, and site-specific sonic art events.'[6] In contrast, sonic art has a wider scope, as it 'generally designates the art form in which the sound is its basic unit.'[7]

The ambiguity of these terms is reflective of the diversity of the field itself, as its boundaries are in a perpetual state of flux. This may be due to the relatively nascent state of the field, as in comparison to visual art, it is only recently that sound has entered the gallery as a core artistic

[5] Dwyer.
[6] Leigh Landy, *Understanding the Art of Sound Organization* (Cambridge, Mass: The MIT Press, 2007).
[7] Landy.

medium. One of the motivations for this research is to connect the implicit themes that exist in a range of works in this nebulous field. By making these implicit themes explicit, I seek to organise a section of the field into a more coherent whole. This discussion in not intended to be exhaustive of the entire sonic art field, but to catalogue those works that create metaperceptual experiences.

Compared to its visual counterpart, the burgeoning field of sound art is in its adolescence. Accordingly, there are many more examples of visual works that explore metaperceptual themes than sound art works. This relative lack of metaperceptual sound artworks compared to their visual counterparts is another motivation for this research. The visual works play an important role, in that they allow for a general discussion of the myriad ways in which artists can create metaperceptual experiences. Furthermore, some visual examples offer a paradigm for new metaperceptual sound works through the translation of their concepts into the sonic domain.

The metaperceptual framework serves two main functions. As an analytic framework, it can be applied to a range of works, drawing out their implicit experiential themes and connecting artworks that span different media, forms, and approaches. The framework catalogues approaches to creating metaperceptual experiences, which is intended to offer artists a conceptual foundation for producing new metaperceptual artworks. In this way, the framework also functions as a creative tool, offering ideas and potential new approaches to creating sound artworks. Through the categorisation of metaperceptual approaches, and the creation of a portfolio of new metaperceptual works, this research advocates for the metaperceptual approach as a powerful tool for artistic creation and analytical insights.

1.3 Document Structure

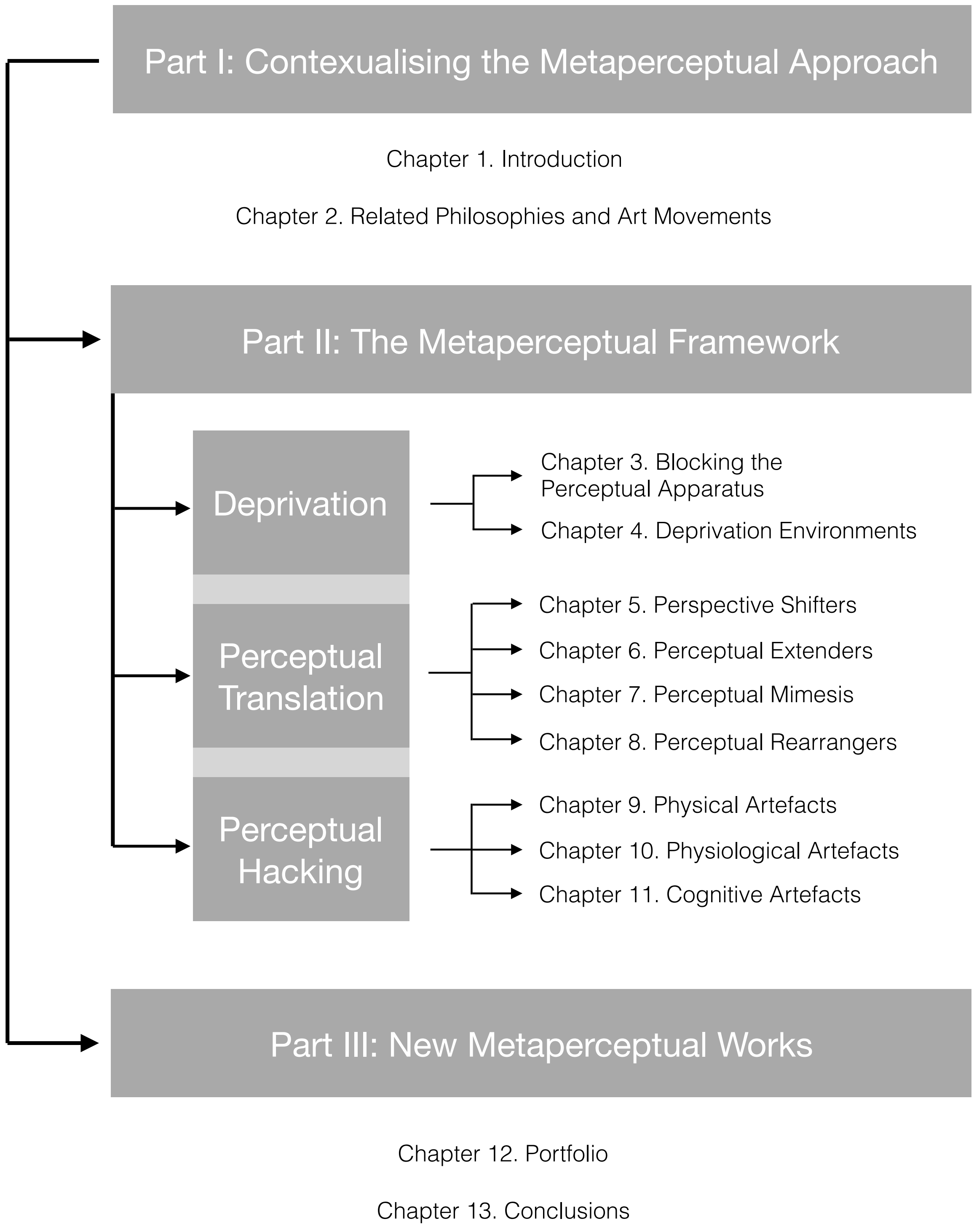


Fig. 2 Document structure overview

This thesis develops the metaperceptual framework for the analysis of existing and the creation of new works. The structure of this document is illustrated in Fig. 2, and consists of three parts: Contextualising the Metaperceptual Approach, The Metaperceptual Framework, and New Metaperceptual Works.

This chapter and Chapter Two form Part I, with Chapter Two providing an overview of philosophies and art movements related to this research. Chapter Two serves as a review of the pertinent literature concerning the development of metaperceptual framework. As this research is concerned with the experiential qualities of artworks, an overview of phenomenology offers linguistic and conceptual tools to discuss and understand the audience's experience. In particular, the notions of the fundamentally subjective nature of experience and the role of the body as an active meditator of our experience are focused upon. The history of phenomenology is heavily visual-centric, a feature that is indicative of many of the fields discussed in this research. Don Ihde's phenomenological contributions are of particular importance to this research as they offer a rare extensive discussion on the experience of sound.

While phenomenology offers linguistic and conceptual tools for describing experience, it does not seek to explain experience. For the metaperceptual framework to be useful in the creation of new artworks, an adequate understanding of the physiological and cognitive processes that play important roles in our perception of the world is instrumental. In particular, this understanding strongly informs one of the metaperceptual categories, *Perceptual Hacking*, which contains works that creatively misuse the perceptual apparatus to create extraordinary experiences. An overview of key perceptual processes and psychophysical concepts are discussed. This offers a foundation which is expanded upon when describing specific phenomena in metaperceptual artworks in later sections.

To conclude Part I, the artistic context of the metaperceptual framework is examined, as there are a number of converging factors which have led to these implicit themes being explored in a range of artworks. I identify three key movements that are precedents for the exploration of these metaperceptual themes. Section 2.3 traces the evolution of these themes throughout art history and provides a set of artistic paradigms for creating experience-based works.

Part II focuses on explicating the metaperceptual framework. I organise the framework into three main categories: *Deprivation*, *Perceptual Translation*, and *Perceptual Hacking*. For each category, I map the topography of the field through collecting and ordering different approaches to creating metaperceptual experiences. Specific artworks are then discussed in this context, with the ways in which they create metaperceptual experiences considered.

Chapters Three and Four profile metaperceptual deprivation works. The experience of these works offers a rare respite from the bombardment of stimuli that is common in our everyday experience. The works create metaperceptual experiences through the removal of an excess of stimuli, restricting the stimuli environment of the audience down to almost nothing. In many of these works, this allows for the body of the audience to be the key site of artistic exploration, revealing sounds and sights often overlooked and ignored. The category is explored in two chapters, Chapter Three: Blocking the Perceptual Apparatus, and Chapter Four: Deprivation Environments. A discussion of the potential for future metaperceptual sound artworks concludes this chapter.

Chapters Five through Eight characterise the *Perceptual Translation* category of metaperceptual artworks. This category covers a range of ways in which artworks interact directly with the perceptual apparatus of the audience through shifting, rearranging, and re-ordering their experience of the world. The term *Perceptual Translation* is interpreted in two different forms. In a geometrical sense, translation is used to describe the process of moving an object from one place to another. Many of the works in this section translate the perceptual apparatus in this geometrical sense, moving the perceptual apparatus, in part or as a whole, in physical space. The other form is more akin to translation as the process of converting words from one language to another. These works convert stimuli that is outside of the human perceivable range in order to allow a person to experience them. The category is ordered in four chapters: Chapter Five: Perspective Shifters, Chapter Six: Perceptual Extenders, Chapter Seven: Perceptual Mimesis, and Chapter Eight: Perceptual Rearrangers.

Perspective Shifters transport the audience's perspective while keeping the organisation of the perceptual apparatus in its typical form. These works can create metaperceptual experiences through giving the audience new perspectives of themselves. *Perceptual Extenders* expand and increase the perceptual abilities of their audiences in a range of ways. This chapter includes two sections, works that change the perceptual field and works that extend the perceptual range. *Perceptual Mimesis* works look to transcend the limitations of the human perceptual system by taking cues from another animals' experience. These works rearrange the perceptual apparatus of the audience to mimic the perceptual schemes of other animals. The final sub-category *Perceptual Rearrangers,* takes this alteration of the perceptual apparatus further, often creating perceptual schemes that force the audience to renegotiate their own perception. A discussion of the potential for future perceptual translating artworks concludes this chapter.

The last category, *Perceptual Hacking*, is discussed in Chapters Nine through Eleven. This category of works describes a metaperceptual approach of creatively misusing facets of the perceptual apparatus and perceptual processes. These works create metaperceptual experiences through drawing the audience's attention to their normal modes of perception by creating extraordinary experiences. The category is ordered into three chapters based on the classification system devised by psychologist Richard Gregory, Chapter Nine: Physical Artefacts, Chapter Ten: Physiological Artefacts, and Chapter Eleven: Cognitive Artefacts. *Physical* artefacts are created when the physical properties of an environment cause stimuli to behave in extraordinary ways. *Physiological* artefacts occur in the perceptual apparatus itself, when the sense organs create by-products from processing stimuli, or when they do not function normally. The *Cognitive* artefact section concludes this approach. In comparison to physical and physiological artefacts, cognitive artefacts occur higher up the perceptual processing chain in the brain. They are often caused by the misapplication of perceptual rules, which usually help us process perceptual information. The inclusion of a wide range of artefacts allows for a rigorous discussion of different interactions between audience and artwork, and different ways in which metaperceptual experiences can be created through exploring perceptual artefacts. This chapter, and Part II, concludes with a discussion of potential avenues for creating new metaperceptual works.

Part III, *New Metaperceptual Works*, uses the metaperceptual framework established in Part II as a creative tool. Chapter Twelve details a portfolio of new works created by myself. These works are informed by the metaperceptual framework, and cover a range of the categories that have been identified during this research. A key aim of the framework is to serve as a creative catalyst, and these works test the application of the metaperceptual approach. Through the development of these works, artistic considerations for creating metaperceptual works are examined. The portfolio includes three works which explore the 'Perceptual Translation' category: *Your Hearing Them, "This is the sound of my voice",* and *Your Localisation Exposed.* Deprivation is explored *∞/ø,* and *Destructive Passages One & Two,* and *rise.risset* explore the Perceptual Hacking approach.

1.4 Contributions

The key contributions that are made in this thesis are:

- The development of the metaperceptual framework for the analysis of existing works and the creation of new works.
- The identification of implicit metaperceptual themes in a range of existing artworks
- The identification of potential avenues for creating new metaperceptual sound artworks.
- The contextualisation of the metaperceptual framework in contemporary art and philosophical fields.
- A portfolio of new metaperceptual sound artworks

Chapter Two

Related Philosophies and Art Movements

In this chapter, I discuss the philosophies and artistic movements that underpin the metaperceptual framework. As the metaperceptual framework is concerned primarily with the experiential qualities of artworks, I first provide an overview of phenomenology, which offers linguistic and conceptual tools to discuss and understand the audience's experience. While the history of phenomenology is heavily visual-centric, recent philosophers have made strong contributions to understanding our aural experience. In particular, Don Ihde's phenomenological writings on aural experience are crucial, and I discuss his philosophies to conclude the phenomenology section.

While phenomenology can offer linguistic and conceptual tools for describing experience, it does not seek to explain experience. For the metaperceptual framework to be useful for artists in the creation of new artworks, an adequate understanding of the core physiological and cognitive perceptual processes is instrumental. An overview of key perceptual processes and psychophysical concepts are therefore discussed. This offers a foundation which is expanded upon in later sections when describing specific phenomena in metaperceptual artworks.

To conclude Part I and Chapter Two, the artistic context of the metaperceptual framework is outlined by discussing a number of converging movements that facilitated the exploration of metaperceptual themes. These include trompe-l'œil, through which I discuss the understanding and manipulation of the audience's perceptual processes, as well as, its aural counterpart, trompe-l'oreille, which offers a paradigm of translating visual ideas and artistic approaches in the aural realm. In addition, the Op Art movement's exploration of perceptual by-products and artefacts as core artistic materials has implications for metaperceptual works. And lastly, I discuss Installation art's focus on the shaping of the audience's experience and its elevation of the audience from receivers to activators of the work. Collectively, these philosophies and movements contextualise the study of metaperceptual artworks in subsequent chapters.

2.1 Phenomenology

'Every sensory interaction relates back to us not the object/phenomenon perceived, but that object/phenomenon filtered shaped and produced by the sense employed in its perception. At the same time this sense outlines and fills the perceiving body, which in its perception shapes and produces his sensory self. Whereby the senses employed are already ideologically and aesthetically determined, bringing their own influence to perception, the perceptual object and the perceptual subject.'[8]

—Salomé Voegelin

The genesis of phenomenology as a philosophical field lies in Edmund Husserl's two volume work *Logical Investigations*,[9] written at the turn of the twentieth century. While a detailed account of Husserl's concept of pure phenomenology is beyond the scope of this document, an outline of its key ideas provides an understanding of some elements in the metaperceptual framework. In particular, Husserl's concept of *intentionality,* his distinction between *noema* and *noesis*, and the practice of *epoché* or phenomenological reduction*,* allow for qualities of the audience's experience of metaperceptual works to be analysed and explicated.

2.1.1 Husserlian Phenomenology

In *Logical Investigations* and the following *Ideas I*,[10] Husserl outlines a complex system of philosophy, inspired by the descriptive psychological theories of Franz Brentano and William James, and the ideals of logic set forth in the writing of Bernard Bolzano and Gottlob Ferge.[11] Through the development of a descriptive and analytical framework for subjective mental activity or experience, Husserl sought to establish phenomenology as the 'science of the essence of consciousness.'[12] The philosophy is centred on the defining trait of *intentionality*, which can be defined as 'the power of minds to be about, to represent or to stand for, things, properties or states of affairs.'[13] Husserl states that intentionality is 'the fundamental property of consciousness.'[14] His

---

[8] Salomé Voegelin, *Listening to Noise and Silence: Towards a Philosophy of Sound Art*, 1 edition (New York: Bloomsbury Academic, 2010).
[9] Edmund Husserl, *Logical Investigations. Translated by JN Findlay* (Humanities Press, 1970).
[10] Edmund Husserl, 'Ideas, Trans. WR Boyce Gibson', *London: George Allen & Unwin LTD*, 19 (1931), 69.
[11] David Woodruff Smith, 'Phenomenology', in *The Stanford Encyclopedia of Philosophy*, ed. by Edward N. Zalta, Summer 2018 (Metaphysics Research Lab, Stanford University, 2018).
[12] Husserl, 'Ideas, Trans. WR Boyce Gibson'.
[13] Pierre Jacob, 'Intentionality', in *The Stanford Encyclopedia of Philosophy*, ed. by Edward N. Zalta, Winter 2014 (Metaphysics Research Lab, Stanford University, 2014).
[14] Husserl, 'Ideas, Trans. WR Boyce Gibson'.

model for intentionality can offer us insights into the analysis of the analysing the art object and the experience of the audience.

Husserl's concept of intentionality consists of three parts, the *hyletic data*, *noesis*, and *noema. Hyletic data* is the sensory information received by an observer. This can be objectively described by referring to the characteristics of stimuli to which a person is exposed. *Noesis* denotes the intentional process of consciousness, namely our ability to attend to different parts of our experience and direct our perception. *Noema* is the object or content of thought, judgement, or perception. Additionally, Husserl uses the term *adumbration* to refer to the limited hyletic data that we receive from any one perspective. Sound artist and academic Thomas Voyce offers an auditory example of how an individual may perceive in these terms. He writes 'A lone tui (a native New Zealand bird) sings in a tree, out of sight. The (aural) hyletic data imparts a sense of the tui: we experience an *adumbration* of it through the limited data we receive. Having encountered an adumbration of the tui, we intentionally perceive the tui – it is constituted in the act of noesis – and the tui is thus objectified and endowed with our intentional perspective; it is now a *noema* (intentional object).'[15]

Husserl's terms of intentionality are crucial to the discussion of metaperceptual artworks because all three components should be considered. Hyletic data pertains to the stimulus environment that the artwork creates. For metaperceptual sound artworks, we can discuss the hyletic data by describing the sonic characteristics of the work, as well as how these sounds interact in their spatial environment. The *noema* of metaperceptual artworks reveals an important defining characteristic however, for while one element of the audience's *noema* will be the artwork itself as an object of experience, as with all artworks, what differentiates metaperceptual works from other artworks is their ability to provoke the audience's own body and perception to become part of its *noema*. In other words, the work redirects the phenomenological attention of the audience back on to themselves. Accordingly, the *noesis* is the experience of the audience, and the subjective way in which they perceive the work. Metaperceptual works provoke the audience's *noesis* to be directed back on to themselves, with their body and perception acting as the *noema*. Husserl's three terms for the concept of intentionality offers a way to tease apart the multi-faceted nature of experiencing metaperceptual artworks.

The purity of Husserl's phenomenology is due to his proposed method of analysing intentionality. In *Ideas I,* Husserl presents the method of *epoché*, or phenomenological reduction, which is

[15] Thomas Voyce, 'Do I Get a Say in This? Environmental Sound Composition, the Phonograph and Intentionality', 2016.

designed to promote a phenomenological understanding of perception. By *bracketing* the question of the existence of the natural world around us, we are able to turn our attention to the structure of our own conscious experience. This isolates our experience from questions of reality, causality and sematic contexts, allowing for the description of experience to be the method of inquiry. Ronald McIntyre & David Woodruff Smith argue that the purpose of the *epoché* 'is to force us to explain the phenomenological features of acts, including their intentional character, by appealing only to what is intrinsic to the acts themselves: to the internal structures of acts that make them the mental states or experiences that they are.'[16]

While the *epoché* promotes a phenomenological understanding of perception, this bracketing of world became the subject of contention for successive philosophers. In particular, both Martin Heidegger and Maurice Merleau-Ponty expanded upon Husserl's pure phenomenology to consider the context of experience and the role of the body, respectively.

2.1.2 Post-Husserlian Phenomenology

Heidegger's conception of phenomenology, defined in his 1927 text *Being and Time*, emphasised our activities as always 'being-in-the-world.'[17] He argued that the 'bracketing out' of the world was misguided, as we interpret our activities and the meaning things have for us by looking to our contextual relations to things in the world.[18] Heidegger's argument has important implications for understanding the variability of experience between audience members of metaperceptual artworks. It is unlikely that each audience member will engage with the method of phenomenological reduction while experiencing the work. Accordingly, Heidegger's philosophies elucidate the diversity of audience's experience, as each audience member has a different personal history and contextual relationship to things in the world. If we apply this contextualisation of experience to Voyce's example of hearing the call of a lone tūī out of sight, the noesis of different people may vary drastically. As many New Zealanders can identify the tūī by its distinctive calls, upon hearing it, their noetic analysis may be one of attributing the sound to a dark black and blue bird in the trees. For them, the noema may be a clear and developed concept of the tūī, including its physical characteristics and the hyletic data that it creates. In comparison, a person new to New Zealand, who may never have encountered the tūī before, would have a completely different noetic analysis. This variability between audience members means that in discussing the experience of

---

[16] Ronald McIntyre and David Woodruff Smith, 'Theory of Intentionality', in *Husserl's Phenomenology: A Textbook*, ed. by William R. McKenna and J. N. Mohanty (University Press of America, 1989).
[17] Martin Heidegger, *Being and Time*, Reprint edition (New York: Harper Perennial Modern Classics, 2008).
[18] Smith.

metaperceptual artworks, there is no one objective interpretation that can be referred to. While metaperceptual works share a common framing of the audience's noesis back on to themselves, as the audience have autonomy over their noesis, no work can guarantee this metaperceptual experience. Accordingly, in discussing metaperceptual works in Part II of this document, I use the accounts of people who have experienced the work directly. While these accounts cannot provide a singular objective interpretation of the work, they do offer insights to the possible metaperceptual elements of the work.

Furthermore, the variability of experience is not only applicable to differences between audience members, but also between repeat experiences of the same artwork by one person. Voyce gives an example of how a person's contextual relations to things in the world can change over time. He writes 'a person may have once found the sound of church bells (the intentional object) to evoke feelings of community and reverence, may now, having lost religious conviction, find the same bells to evoke entirely different feelings. An individual's perception may change radically, though the intentional object may stay the same.'[19] The application of Heidegger's philosophies reveals how our experiences are informed by previous experiences, and our subjective contextual relations to things in the world.

While Heidegger expanded Husserl's phenomenology by contextualising our being as being-in-the-world, the experience of one's own body, or one's lived or living body, was an important motif for many French philosophers including Marcel Proust, Jean-Paul Sartre, and Maurice Merleau-Ponty.[20] In particular, Merleau-Ponty's development of phenomenology was strongly influential to the field, and offers important conceptual tools for the metaperceptual framework. His conception of phenomenology integrated experimental psychology, analysing the reported experience of amputees who felt sensations in a phantom limb.[21] This research informed his argument that consciousness is necessarily embodied, and equally, the body is infused with consciousness.[22] Merleau-Ponty's concept of the 'body image' focused on our experience of our own body and its significance in our activities. This concept is evidently metaperceptual, and can be identified as an important conceptual precursor to the metaperceptual framework. In his 1945 text, *Phenomenology of Perception,* Merleau-Ponty succinctly captures his embodied form of phenomenology, writing 'in so far as, when I reflect on the essence of subjectivity, I find it bound up with that of the body and that of the world,

[19] Voyce.
[20] Smith.
[21] Smith.
[22] Smith.

this is because my existence as subjectivity is merely one with my existence as a body and with the existence of the world, and because the subject that I am, when taken concretely, is inseparable from this body and this world.'[23]

Both Heidegger and Merleau-Ponty's forms of phenomenology react against the purity of Husserl's original conception, offering a more nuanced framework through which to understand perception. Heidegger's philosophies show how the audience's previous experience influences their contextual relations to things in the world, which in turn informs their experience. Merleau-Ponty's embodied phenomenology dispels the idea of the body and the perceptual apparatus as a neutral objective medium through which to experience the world through, revealing its role as active mediator of experience. His concept of the 'body image' is an important conceptual precursor to the metaperceptual framework as it considers our experience of our own body and its significance in our activities.

2.1.3 Phenomenology of Sound

While the phenomenological concepts of Husserl, Heidegger, and Merleau-Ponty offer a range of conceptual and linguistic tools for analysing and describing experience, the application of these concepts primarily concerned in the visual domain. Don Ihde, in *Listening and Voice*, argues that 'there is a latent, presupposed, and dominant visualism to our understanding of experience.'[24] Ihde's work addresses this visualism by providing a rare extended inquiry into our aural experience. He states that his intent is a 'deliberate decentering of visualism in order to point up the overlooked and the unheard.'[25] Furthermore, he connects this visualism to the reductionist tendencies of previous philosophers, including Husserl. He argues that their philosophies 'which in seeking to purify experiences belies its richness at the source. A turn to the auditory dimension is thus potentially more than a simple changing of variables. It begins as a deliberate decentring of a dominant tradition in order to discover what may be missing as a result of the traditional double reduction of vision as the main variable and metaphor.'[26] There are strong parallels between Ihde's intent and my own motivations for this research. As many of the existing metaperceptual explorations are visually centric, by focusing on sonic applications this research seeks to reveal what may be missing and overlooked.

[23] Maurice Merleau-Ponty, *Phenomenology of Perception* (Psychology Press, 2002).
[24] Don Ihde, *Listening and Voice: Phenomenologies of Sound*, 2 edition (Albany: State University of New York Press, 2007).
[25] Ihde.
[26] Ihde.

Ihde's work does not redefine the phenomenological methods of his predecessors but rather offers detailed, low-level descriptions of the uniqueness of our auditory experience, and compares it with the visual domain. Of most relevance to this research, he introduces linguistic tools to describe the spatial *field* of our experience, and the structures within this field to help explicate the relationship between different noetic objects.

Ihde describes the nature of our perceptual *field*, as the 'specific form of "opening" one has to the World, and as an "opening" it is the particular perspective one has on the World.'[27] The field is always a limited and bound context, in which our experience is situated. The visual field is always limited to forward focusing, bound by our direct and peripheral vision. In contrast, our auditory field is an omnidirectional sphere. We hear sounds from all directions, and the size of the auditory field can be much larger than our visual field. These differences, albeit simplistic, are quite profound: we do not always hear what we see, or see what we hear.

One of the consequences of the anisomorphic visual and aural fields is a difference in the invasiveness of each sense modality. The limited forward-focussing visual field is able to be controlled: if we do not want to look at some object, we can just turn away. The omnidirectional field of our aural sense, however, does not afford such control. We are not able to simply turn away from a sound; sound is therefore the more invasive sense. This is heightened by our physiological mechanisms to block the sense organ. While in the visual domain we are easily able to block the visual sense by closing our eyelids, as Kim Seth-Cohen puts it, 'the ear is oblivious to the notion of the blink. There is no such thing as an earlid. The ear is always open, always supplementing its primary materiality, always multiplying the singularity of perception into the plurality of experience.'[28] The difference between the fields of the visual and aural sense are the focus of some metaperceptual artworks, which renegotiate the size and shape of the audience's perceptual fields. This difference is also informed by the behaviour of light and sound, which I further discuss in Section 2.2.

Ihde structures the contents of our perceptual field into three parts: *focus*, *fringe*, and *horizon*. Entities positioned at the focus are experienced with greater intensity and clarify. In Husserlian terms, this would be the object towards which noesis is pointed. Perceptual objects at the fringe are grasped with lesser intensity but are present in experience, and the horizon represents the edge of immediate experience. This structure is fluid and dynamic, and one can control some elements

[27] Ihde.
[28] Seth Kim-Cohen, *In the Blink of an Ear: Toward a Non-Cochlear Sonic Art*, 1 edition (New York: Bloomsbury Academic, 2009).

of the relationship between these structures. Objects in the fringe for instance can be brought into the focus through attention or through manipulation of the perceptual field. As Ihde notes however, the horizon can never be brought into focus. It is the limit of the perceptual field, and therefore only indirectly experienced. Ihde summarises these structures, writing ‘Thus if focal attention is central and field attention is ordinarily a fringe awareness, then horizonal awareness is yet more removed from the center. Moreover, one cannot move the horizon into the center, and, if noted at all, the horizon is noted “from the edges” almost indirectly.’[29]

Ihde notes that inside the dynamic structure of our perceptual fields, the ratio between focus and fringe is at least partially volitional, with it constantly shifting with different interests and on different occasions.[30] This shift occurs not only between sensory modes, as we are able to more our attention between senses, but also within each sense. For example, if we are overcome by the stunning appearance of a beautiful environment, we may attempt to widen our focus so that we can take in as much of the sight and sound as possible. In comparison, in a bored state, our focus may shrink to a singular point, with all fringe thoughts and precepts becoming a dull blur. These structures of experience can be instrumental when discussing metaperceptual artworks, as it allows for the shifts of the audience’s attention to be unpacked and described. In some works, the relationship between these structures is a key element in the audience’s experience. This discussion can also help account for other fringe and sometimes even unintentional factors that affect the experience of the audience. This is evidenced in Harris Berger’s phenomenological account of walking through a museum, as he writes ‘I foreground a particular painting and background the sounds in the room, the pressure of my clothes against my skin, and so on. Like the silhouettes and the vase in the famous Rubin’s Goblet drawing, the various phenomena in the gestalt of experience define and inform one another. A bad headache, a scratchy piece of clothing, or an anxious thought may lurk on the fringe of the overall experience, only dimly apprehended but nevertheless colouring those phenomena in the focus with a negative hue.’[31]

While phenomenology offers a range of linguistic and conceptual tools to discuss and understand the nature of our experience, it does not seek to explain it. In fact, the intent to explain experience is what Husserl sought to bracket out through his method of the epoché, allowing for only the qualities of experience to be the subject of inquiry. For the metaperceptual framework to be informative as a creative tool, an understanding of core perceptual processes can help artists consider the perceptual apparatus and perceptual processes as sites for artistic explorations. In the

[29] Ihde.
[30] Ihde.
[31] Harris M. Berger and Giovanna P. Del Negro, *Identity and Everyday Life: Essays in the Study of Folklore, Music and Popular Culture* (Wesleyan University Press, 2004).

following section, I present the key perceptual processes which govern our experience of the world. Following this, I explain the differences between the aural and visual sense that Ihde observes through appealing to their physiological and physical differences.

2.2 Perceptual Science

The structures of experience that phenomenology seeks to describe are informed by the nature of our perceptual apparatus and perceptual system. Merleau-Ponty's philosophies emphasised the embodied character of our experience, arguing that our consciousness is inseparable from our body, and that the perceptual system is not a neutral medium of experience. Rather, its idiosyncrasies and characteristics colour our experience of the world, and in turn our understanding of the world. For the metaperceptual framework to be a useful tool for the creation of new art, an understanding of these idiosyncrasies and processes can help to inform the artist of possible artistic avenues. Furthermore, some of the phenomenological differences between our aural and visual experience (discussed in the previous section) are due to our perceptual physiology. In order to discuss these artistic avenues and physiological differences, I offer a brief overview of the aural and visual perceptual systems in this section. While a complete overview of psychophysics and the physiology of perception is beyond the scope of this research,[32] a discussion of the basic physiology of the eye and ear, and core perceptual processes that are most relevant to this research, provides a foundation of knowledge sufficient for examining the metaperceptual framework. I conclude this section by discussing the phenomenological differences between the visual and aural sense by contextualising them in the physiology of the perceptual system and the nature of the stimuli it perceives. This aims to connect the philosophical with the scientific in a manner that allows for the establishment of the metaperceptual framework. I expand upon this foundation in Part II when examining perceptual phenomena that are explored in specific metaperceptual artworks.

2.2.1 The Eye

As the majority of artworks focus on interacting with the audience's visual and aural senses, a discussion of the key perceptual processes that govern these senses is crucial for the analysis of metaperceptual works. The visual system is a complex network of photoreceptors, lenses, and nerve fibres. It comprises of three major components: the retina, the visual pathway, and the visual cortex. The human eye, (Fig. 3), is a roughly spherical light-tight chamber, which can be ordered

---

[32] For a comprehensive guide, see George Mather, *Foundations of Sensation and Perception: Second Edition*, 2 edition (Hove, East Sussex England ; New York: Psychology Press, 2009).

into three layers. The outer region contains the cornea, which refracts and transmits light to the lens and the retina, while also protecting the eye against infection and structural damage to the deeper parts. The middle layer of the eye contains the iris and the ciliary body. The iris controls the size of the pupil, and thus the amount of light reaching the retina, while the ciliary body controls the power and shape of the lens and is the site of aqueous production.[33] The inner layer of the eye is the retina, a complex, layered structure of neurons that capture and process light. The retina is of particular importance to this research, as it contains all of the neural circuitry connecting photoreceptors to the optic nerve. The photoreceptors are responsible for converting light energy into neural activity. Many of the visual works I discuss in Part II interact with this layer of the visual system to create extraordinary metaperceptual experiences.

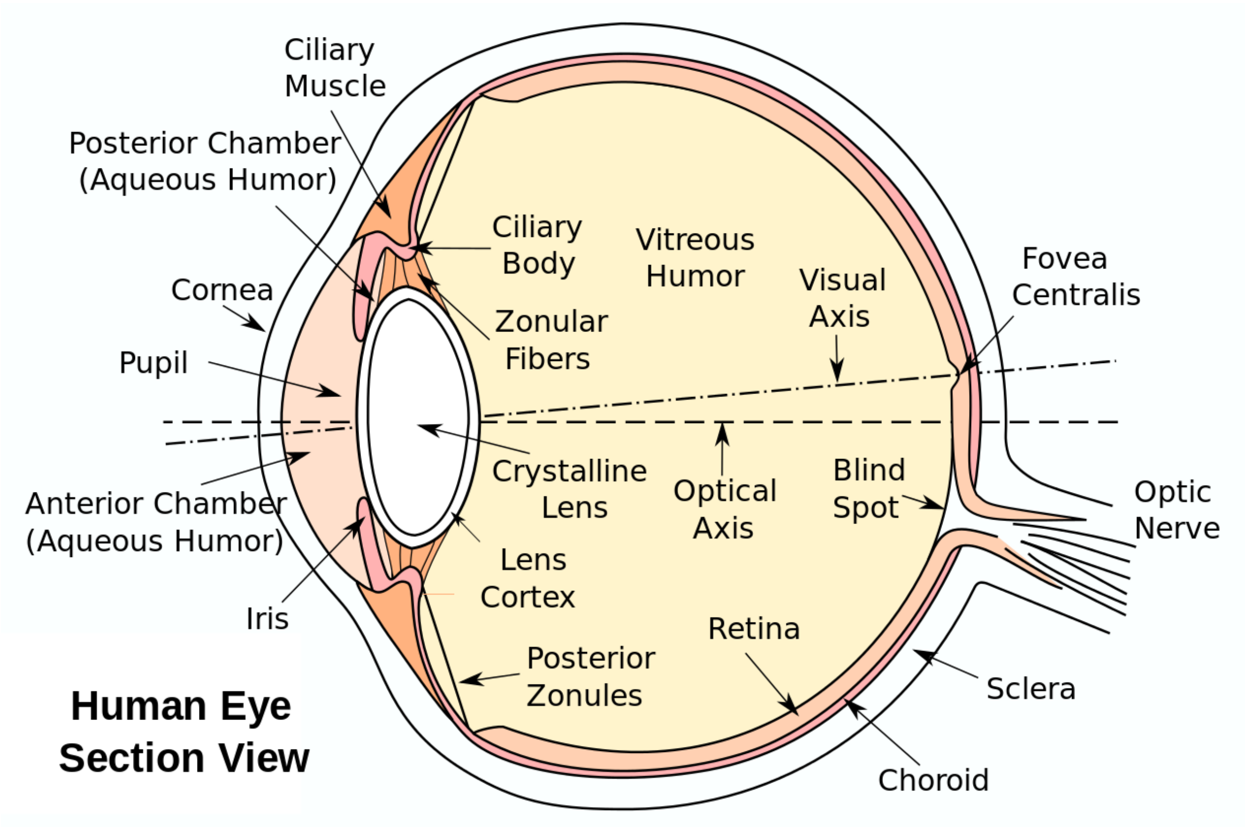


Fig. 3 Physiology of the human eye.

2.2.2 The Ear

Similar to the visual system, the ear is usually ordered into three parts. The outer ear contains the pinna, concha, and meatus. The pinna are flexible flaps of cartilage that are attached to the skull by ligaments and muscles. The funnel-shaped inner part is the concha, which funnels sounds into

[33] Willoughby Colin E and others, 'Anatomy and Physiology of the Human Eye: Effects of Mucopolysaccharidoses Disease on Structure and Function – a Review', *Clinical & Experimental Ophthalmology*, 38.s1 (2010), 2–11.

the meatus or ear canal. The shape and size of the pinna, concha, and meatus have two consequences for hearing. First, they act as an amplifier, boosting sound pressure overall, and especially reinforcing frequencies between 1.5 and 7 kHz.[34] Second, the complex folds of the pinna act as an acoustic filter that attenuates high-frequency components in sounds that arrive from above the head. This provides cues for the auditory system to locate the elevation of the sound source. These cues form an important part of our ability to localise sounds which is further discussed in Section 2.2.

Sound travels down the meatus on to the tympanic membrane, which sits at the barrier between outer and middle ear. The tympanic membrane, or ear drum, transmits sound into the three bones of the middle ear: the malleus, incus, and stapes. These bones mechanically connect the tympanic membrane to the oval window, which sits at the border between the middle and inner ear. The bones of the middle ear act to maximise the transmission of sound from the outer ear to the inner ear through two means. The diameter of the tympanic membrane is much larger than the area of the stapes' contact with the oval window, which makes the transmission of sound through the bones to be strongly focused into the inner ear.[35] Secondly, the arrangement of the bones means that they act as levers, increasing the force of the tympanic membrane by a factor of 1.3. William Yost calculates these two factors increase pressure by a factor of 44.[36]

The oval window sits at the boundary between middle and inner ear. The inner ear hosts the semi-circular canals and otolith organs which form the vestibular system, responsible for sensing our body position and movement. The inner ear contains the cochlea, which is akin to the retina in its importance to the perceptual system. It is the sense organ for hearing, converting sound energy into neural impulses. As A.J. Hudspeth states, the inner ear 'is an evolutionary triumph of miniaturization, a three-dimensional inertial-guidance system and an acoustical amplifier and frequency analyser compacted into the volume of a child's marble.'[37] Many critical features of hearing can be related directly to the mechanical properties of the cochlea. A discussion of the key perceptual processes of pitch and localisation are essential for understanding our auditory experience, and our perception of many metaperceptual works.

---

[34] William Yost, *Fundamentals of Hearing: An Introduction: Fifth Edition*, 5 edition (Lieden ; Boston: Brill, 2013).Gerald Fleischer, *Evolutionary Principles of the Mammalian Middle Ear* (Springer Science & Business Media, 2013).
[35] Yost.
[36] Yost.
[37] A. J. Hudspeth, 'How the Ear's Works Work', *Nature*, 341.6241 (1989), 397–404.

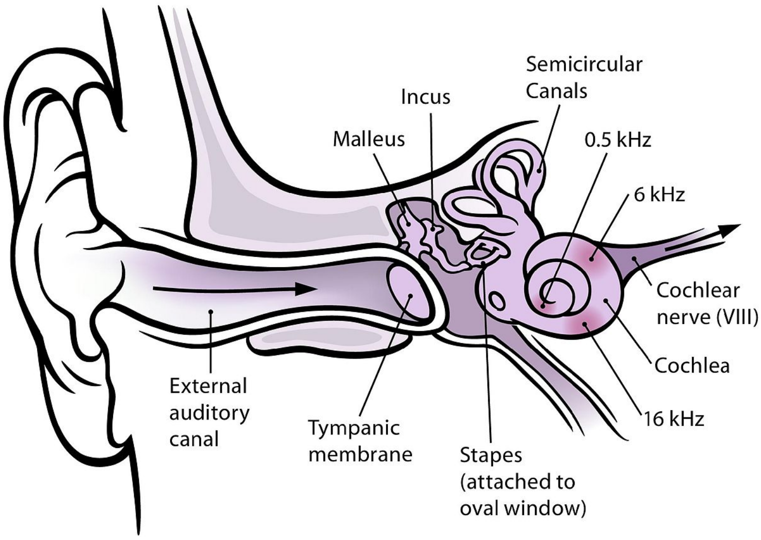


Fig. 4 Physiology of the human ear. Reproduced from Chittka and Brockmann.[38] Licenced under CC BY 2.5.

2.2.3 Pitch Perception

The two core aural perceptual processes of pitch and localisation are the site of exploration for many metaperceptual sound works. These processes can be deceived, producing artefacts that draw the audience's attention back onto themselves, creating metaperceptual experiences.

The mechanical and neural properties of the cochlea provide it with two methods of encoding the frequency of sound wave stimuli: place coding and frequency coding. At the heart of these two methods is the basilar membrane, a flexible structure that is deformed by sound waves entering the inner ear. The mechanical properties of the basilar membrane vary considerably from base to apex, so that the point of maximum displacement of the membrane varies depending on the frequency of the stimulus. Georg von Bekesy first discovered this property, finding that the point of maximum displacement occurs near the apex for low frequencies, and near the base for higher frequencies.[39] This characteristic allows for the basilar membrane to achieve a *frequency-to-place* conversion. The membrane is lined with inner hair cells, which contain nerve fibres that fire when depolarised. As the basilar membrane is deformed, it depolarises particular inner hair cells along the length of the membrane. Our auditory system interprets the place of these inner hair cells as frequency information.

When the basilar membrane vibrates in synchrony with an input sound wave, auditory nerve fibres fire during each positive phase of the wave. This behaviour is known as *phase locking*, which

---

[38] Lars Chittka and Axel Brockmann, 'Perception Space—The Final Frontier', *PLOS Biology*, 3.4 (2005), e137.
[39] Georg Von Békésy and Ernest Glen Wever, *Experiments in Hearing* (McGraw-Hill New York, 1960), VIII.

offers another cue for pitch perception. As the fibre's fire are phase locked, the response rate of a particular fibre should reflect the frequency of the stimuli. This method is described as the *timing theory*, as the timing of the neural impulses carries information about sound frequency. As neurons cannot produce action potentials at rates greater than 1000 spikes per second, this means that for input frequencies above 1 kHz, they are not able to fire every cycle of the wave. However, it is not necessary for an individual fibre to fire at every single cycle of the wave, only that when it does fire, the impulse is locked to a particular part of a cycle. An ensemble of neurons can combine to reconstruct the frequency of the stimulating waveform, which Ernest Glen Wever described as the 'volley principle'.[40]

It is thought that both timing and place information is used in our perception of pitch. Low-frequency stimuli are conveyed by a temporal code from phase locking neurons, while high-frequency information is conveyed by the place of maximum displacement on the basilar membrane. The place code information also provides important cues for the localisation of sounds, which are discussed in the following section.

By understanding these two methods of pitch perception, we can discuss various phenomena that are explored in a range of metaperceptual works. The basilar membrane can be stimulated in such a way that it causes distortion products which are perceived as new tones. A range of works that explore this phenomena are discussed in the 'Physiological Artefacts' section in Chapter Ten. The timing theory of pitch perception also plays a role in the perceptual oddity of binaural beats, which I explore in my own work *Destructive Passages One & Two.* Other phenomena related to pitch perception mechanisms are discussed further in Chapter Ten.

2.2.4 Auditory Localisation

Another core perceptual process explored by some metaperceptual works is localisation, as in my own work *Your Localisation Exposed* presented in Chapter Twelve. Auditory localisation refers to the listener's ability to judge the direction and distance of a sound source.[41] Our ability to locate sounds has an important evolutionary function, as it allows us to orient ourselves to the potential danger of unseen sound sources such as predators.[42] This information also helps to segment complex sound stimuli into components. The direction of a sound source can be specified relative to two principal planes: the horizontal plane (left-right), specified by the *azimuth* angle relative to straight ahead, and the vertical (up-down) plane, specified by the angle of *elevation* relative to

[40] Ernest Glen Wever, 'Theory of Hearing.', 1949.
[41] Mather.
[42] Mather.

horizontal. Elevation location is derived from monaural cues, whereas *azimuth* is derived from binaural cues.

The main cue for vertical localisation is thought to derive from the outer ears filtering incoming sound waves.[43] This cue is monaural, as it is not derived from differences between the two ears, but specific characteristics of sound as it interacts with the shape of the ear. The complex folds of the pinna act as an acoustic filter, selectively modifying both the amplitude and phase properties of frequency components in the incoming stimuli. The small, asymmetrical structure of the pinna has two main filtering effects on the sounds. First, the filtration only impacts frequencies above 6 kHz, as these frequencies have short enough wavelengths to be affected by the pinna. Second, the filtration effects are dependent on the direction of the sound. The pinnae introduce peaks and valleys in the high frequency region of a sound's spectrum, with the exact location of these filtrations determined by the elevation of the sound source.

The horizontal localisation of sound uses binaural cues, rather than the monaural cues of the vertical plane. The two ears are approximately 14 cm apart, separated by a mass of bone and tissue. This space causes two slight differences between the signals received at each ear, and these differences form the basis for locating sounds on the horizontal plane. First, the sound signal has to travel slightly further to reach the contralateral ear (opposite side) than to reach the ipsilateral ear (close side). This is described as the interaural time difference (ITD), as it causes a slight delay between the signals. Additionally, this difference also causes a small difference in the phase relationship between each signal. The time difference is often minute, with humans able to detect ITDs as small as 10 µs.[44] This cue relies on the neural activity being phase-locked to the stimulus, which as previously discussed in the pitch perception section, is only possible for lower sound frequencies below approximately 3 kHz. Second, as the signal passes around the head, it suffers a degree of attenuation, meaning that it is quieter at the contralateral ear than the ipsilateral ear. This is described as the interaural level difference (ILD), providing cues for sounds above the phase-locking threshold. The size of the head only attenuates sounds above 2 kHz, which makes the head a low-pass filter. These two cues are complementary, with ITD working best at low frequencies and ILDs working best at higher frequencies.[45]

---

[43] Mather.
[44] Andrew Brughera, Larisa Dunai, and William M. Hartmann, 'Human Interaural Time Difference Thresholds for Sine Tones: The High-Frequency Limit', *The Journal of the Acoustical Society of America*, 133.5 (2013), 2839–2855.
[45] Mather.

This brief overview of the physiology of the visual and aural sense organs and the key perceptual processes that inform our auditory experience enables a discussion of the phenomenological differences that Ihde distinguished at the beginning of this chapter through a physiological and physical lens. I offer a discussion of the synthesis of these two fields as a conclusion to the scientific and philosophical background of the metaperceptual framework.

2.2.5 Physiological Basis for Phenomenological Differences

Ihde's discussion of the anisomorphic nature of our visual and aural fields is informed by a difference in the behaviour of their respective stimuli. The visual field is limited and forward-facing, spanning approximately 200°, while the aural field is an omnidirectional sphere. Both the eye and ear have relatively small apertures to the world that allow stimuli to enter. The key difference is the wavelength of the stimuli, and the effect this has on diffraction behaviour. The audible frequency spectrum for humans is approximately 20 Hz to 20 kHz,[46] which correlates to wavelengths between 17 m and 17 mm. In contrast, the wavelengths of the visible light spectrum range between 390 and 700 nm. The longer the wavelength, the greater its ability to diffract, which allows sound to bend around obstacles more easily than light waves. This means that sounds from all locations can diffract into the ear and be perceived, making the aural field an omnidirectional sphere. In contrast, only light that has a direct path to the pupil makes its way to the retina, creating the forward-facing limited visual field.

Ihde's structures within the field of focus, fringe, and horizon are influenced by our perceptual physiology. The physiology of the eye allows for a high degree of control over the focus of our visual perception. The retina contains over 100 million photoreceptor cells which convert light energy into neural activity. There are two types of photoreceptors, rods and cones, which are classified by their shape and role. Rods are highly sensitive at low light levels, whereas cones are 30-100 times less sensitive. Their sensitivity and absorption qualities make rods more effective in dark conditions and cones more effective in light conditions. Of particular importance to understanding the difference in focus between the visual and aural sense is the fovea, a small area in the retina that contains only cones. When we look directly at an object, its image falls on the fovea. This means that the visual focus-fringe ratio is directly related to the physiology of the eye, as the fovea corresponds to the focus, and the peripheral retina corresponds to the fringe. This structure means that we can direct our focus towards an object by physically shifting our eyes, causing the image of the object to fall over the fovea.

---

[46] Shintaro Takeda and others, 'Age Variation in the Upper Limit of Hearing', *European Journal of Applied Physiology and Occupational Physiology*, 65.5 (1992), 403–8.

By contrast, the aural perceptual system does not have this focus and fringe relationship embedded in its physiology. As sound waves easily diffract, all sound waves in the vicinity of the ear enter the perceptual system. While we can distinguish sounds by their loudness, frequency, and localisation, this information is derived from qualities of the sound (discussed in the previous sections), rather than as a direct representation in the perceptual system, as is the case in the visual sense. While we can move our heads to direct our aural attention towards a specific perceptual object, the sound wave's ability to easily diffract makes this less effective than the visual counterpart. While we may amplify sounds by moving our ear up close to it, we cannot effectively isolate a sound source from all background sound. Accordingly, the focus-fringe relationship in the aural sense is enacted through our intentionality, as we direct our attention towards sounds within the complex sonic environment. Albert Bregman offers a metaphor for understanding the directness of the two senses in his influential text *Auditory Scene Analysis.*[47] He likens the complexity of our cognitive synthesis to being able to tell the number, positions, and sizes of boats on a lake only from looking at the superposition of the resulting waves at a single location on the lake's shore.[48] In comparison, the eye can gaze across the lake and directly experience these relations.

2.2.6 The Role of Visual Art in the Metaperceptual Framework

The physiology of our perceptual apparatus and the idiosyncrasies of our perceptual processes are the main contributors to the analysis and creation of metaperceptual works. The foundation outlined in this section is expanded upon in Part II, where I discuss specific works and the way in which they create perceptual by-products and extraordinary metaperceptual experiences. While this research focuses on the development of the metaperceptual framework for sound artworks, it includes a large range of visual examples and comparisons. The intent for including these works is similar to Ihde's approach. By contrasting the two modalities, those details which have been overlooked and ignored can be revealed. Mirroring the visualist history of phenomenology, sound-based approaches are under-represented in fine arts contexts and many of the existing metaperceptual works are in the visual domain. By cataloguing their approaches, these visual works can offer potential avenues for creating new metaperceptual works, and in particular, many of the visual works offer the potential for aural analogues. Additionally, including these visual works contextualises and connects the sound-based works, situating the metaperceptual framework within the contemporary art sphere. The next section details previous artistic frameworks and movements that have similar thematic intents to the metaperceptual approach.

---

[47] Albert S. Bregman, *Auditory Scene Analysis: The Perceptual Organization of Sound* (MIT Press, 1994).
[48] Bregman.

This overview of art movements contextualises the metaperceptual framework in art history and details factors which have allowed metaperceptual themes to be explored.

2.3 Artistic Context

At the thematic core of metaperceptual works is a focus on the audience's perception, and especially the way in which the audience can be made aware of the act of perceiving. These artworks embrace the subjectivity of the audience, and the unique way in which their previous experiences, embodiment, and intentionality colour their perception. In this section I identify three key movements that can be seen as precedents for the exploration of these metaperceptual themes. This section traces the evolution of these themes throughout art history and provides a set of artistic paradigms to creating experience-based works. This includes *trompe-l'œil* and its recently identified sonic counterpart *trompe-l'oreille,* both of which use a rigorous understanding of perceptual processes to create illusory experiences. Op Art, the second key predecessor, expands upon this by making works explicitly focused on a perceptual oddity itself. Lastly, I discuss installation art as a medium that is strongly suited to the exploration of metaperceptual themes. Because installation art expands the art object into experiential, immersive environments, the audience becomes an active participant in the work. I discuss its immersivity, the role of the audience as activator and enactor of the artwork, and the shaping of the audience's experience as core defining characteristics of both installation art and the metaperceptual framework. This section follows the evolution of metaperceptual themes and contextualises the metaperceptual framework within the contemporary art sphere.

2.3.1 Trompe-l'œil

The term *trompe-l'œil,* French for 'deceive the eye', describes an art technique and movement that has been used since the time of the ancient Greeks.[49] The deception pursued by trompe-l'œil works is one of depth and illusory spaces. Célestine Dars, in her book *Images of Deception: The Art of Trompe-l'œil* writes that 'the trompe-l'œil artist aims to create an illusion convincing enough to deceive the eye of the beholder by making a flat surface appear three-dimensional when the painting is finished.'[50] An early anecdote of trompe-l'œil artists comes from Pliny the Elder, who, in his *Natural History*,[51] tells the story of the rivalry between two Greek painters, Zeuxis and

---

[49] S. Ebert-Schifferer and National Collection of Fine Arts (U.S.), *Deceptions and Illusions: Five Centuries of Trompe l'oeil Painting* (National Gallery of Art, 2002).
[50] Célestine Dars, *Images of Deception. The Art of Trompe-L'oeil*, 1st Ed. edition (Oxford: Phaidon Press Ltd, 1979).
[51] Harris Rackham, William Henry Samuel Jones, and D. E. Eichholz, *Pliny: Natural History* (Harvard University Press, 1947), VII.

Parrhasius. Pliny writes that Parrhasius 'entered into a competition with Zeuxis, who produced a picture of grapes so successfully represented that birds flew to the stage-buildings; whereupon Parrhasius himself produced such a realistic picture of a curtain that Zeuxis, proud of the verdict of the birds, requested that the curtain should now be drawn and the picture displayed; and when he realized his mistake, with a modesty that did him honour he yielded up the prize, saying that whereas he had deceived birds Parrhasius had deceived him, an artist.'[52]

The deceptive depth of trompe-l'œil creates illusory spaces and one context within which this deception has been extensively explored is churches, as artists have employed the illusion to create grandiose biblical representations. Andrea Pozzo's *Apotheosis of St Ignatius* (1688-94), shown in Fig. 5, is an imposing fresco in Rome's Saint Ignatius's Jesuit Church. On the flat ceiling of the church, Pozzo's painting depicts the work of Saint Ignatius and the Society of Jesus. The vast work, 17 m in length, is intended to be observed from a spot marked by a brass disc set into the floor of the nave. From this perspective, the work deceives the eye into seeing the flat ceiling as a lofty vaulted roof, with biblical figures ascending up into the heavens.

The style and methods of trompe-l'œil have been influential to more recent artists, with its illusory contents sharing themes with surrealism in particular. Both movements explored the dichotomy of reality and fantasy, with surrealism extending the play with perception into comments on the medium of painting itself. Christine Dars writes that the Surrealists 'delighted in the unusual, the bizarre, and had made the new science of psychoanalysis one of their favourite studies. With the Surrealists, trompe-l'œil came to life once more. They fully appreciated its illusionistic qualities, its wit and symbolism. They saw that perfection of rendering could make unusual subject-matter appear completely normal. Trompe-l'œil became a game to which they added an intellectual dimension.'[53]

[52] Rackham, Jones, and Eichholz, VII.
[53] Dars.

Fig. 5 Andrea Pozzo, Apotheosis of St Ignatius. Image: 'Triumph of St. Ignatius of Loyola Church Sant'Ignazio in Rome – Ceiling' by LivioAndronico is licenced under CC BY 4.0

copyrighted material

Fig. 6 René Magritte, The Human Condition I

René Magritte's *The Human Condition I* (1933), shown in Fig. 6, shows an interesting contextualisation of trompe-l'œil by embedding the technique within the painting itself. The work depicts a completed painting resting on an easel in a room. The painting is positioned so that it perfectly covers and replaces a real landscape outside a window, placing the audience in the artist's perspective, and questioning the reality of the depicted world. Magritte explains that 'for the spectator, it [the tree] was simultaneously inside the room, in the picture, and outside, in the real landscape, in thought. Which is how we see the world, namely outside of us, though having only one representation of it within us.'[54] Magritte's comments are revealing in their phenomenological understanding. Eric Wargo states that 'Rene Magritte thought of himself not so much as a painter (but) as a philosopher—one who used the medium of images instead of words in order, as he said, to 'put reality on trial' and thereby challenge common-sense modes of thinking and perceiving.'[55] Accordingly, the work can be interpreted as an exploration of the noetic relationship itself. The ambiguous nature of the tree draws attention to the process of perception and the relationship between the external object of perception and our internal representation of it.

The phenomenological focus and the creative exploration of the perceptual system situate trompe-l'œil as an early precursor to the metaperceptual approach. Both approaches explore the audience's perception, using it as a site for a creative dialogue. To practice trompe-l'œil requires an intimate understanding of perceptual processes. Dars reasons that trompe-l'oeil artists 'had to be familiar with the basic principles of perspective geometry necessary to convey a sense of depth.'[56] Through an understanding of the perceptual processes that determine depth and a mastery of controlling linear perspective, artists are able to creatively misuse these processes, deceiving the audience into believing that there is a depth to the image which is not actually present. The uncertainty that trompe-l'œil works create can be a key artistic material for metaperceptual works to manipulate. Art historian Ernst Gombrich reasons that the allure of trompe-l'oeil lies in large part in the knowledge or discovery of the illusion, in particular 'in our continued feeling of incredulity that the visual effect … has been achieved on a flat hard panel by a skilled hand using a brush dipped in paint.'[57] The same is true of many metaperceptual works that use illusions and perceptual artefacts, in that the we are curious to know whether what we are experiencing is real or not, and when executed well, the revelation of the deception can produce the same sense of incredulity. Trompe-l'œil offers a paradigm for metaperceptual explorations, as through the understanding of various perceptual processes, artists can creatively interact and misuse them. This is particularly relevant to the Perceptual Hacking category of metaperceptual works, which are discussed in Part II. These works create metaperceptual experiences through using the artefacts and oddities of the audience's perceptual system, drawing their attention to their normal modes of perception by creating extraordinary experiences.

---

[54] James Thrall Soby, *Rene Magritte* (Museum of modern Art, 1965).
[55] Eric Wargo, 'Infinite Recess: Perspective and Play in Magritte's La Condition Humaine', *Art History*, 25.1 (2002), 47–67.
[56] Dars.
[57] Ernst Hans Gombrich and others, *Art and Illusion: A Study in the Psychology of Pictorial Representation* (Phaidon London, 1977), V.

While trompe-l'œil artworks take advantage of artefacts in the observer's perception, this analysis does not exhaust the work. Many of the works direct the noesis of the audience towards the illusory object and its semantics, as in the heavens and narrative of *Apotheosis of St Ignatius,* rather than back onto the audience's body and perception. The degree to which trompe-l'œil works create metaperceptual experiences is dependent on the extraordinariness of the deception, and the ability of the audience to be able to interact with the visual illusion to investigate its veracity.

While the visual trompe-l'œil has been explored for many centuries, an aural equivalent has only recently been proposed and discussed. In order to further contextualise the sound-based focus of this research, I discuss this aural counterpart in the following section.

2.3.2 Trompe-l'oreille

The term *trompe-l'oreille* is the aural counterpart of trompe-l'œil, and has been defined by composer Katherine Norman as 'the experience of, not "hearing the real thing," but of "really hearing the thing."'[58] Her usage of the term is in the context of electroacoustic music, where the high fidelity of recording and playback technology allows artists to create imaginary aural landscapes that can deceive the ear. Norman argues that 'the notion of "real" listening in a work of "fictional" sound art is underexplored.'[59]

Peter Batchelor has expanded upon Norman's discussion of trompe-l'oreille by creating approaches to fabricating illusory aural landscapes, developing a taxonomy, and contextualising the approach within the acousmatic field.[60] Batchelor defines his usage of the term as 'the presentation of recognisable (or referential) sounds in a manner sufficiently indistinguishable in spatial and sonic behaviour from reality as to allow the listener to believe s/he is truly "hearing the thing."'[61] He identifies two types of trompe-l'oreille: *portal* and *inhabitable*. In a similar form to trompe-l'œil, portal is an extension of the existing space which 'we can't enter, but which offers a fictional "beyond" to existing space.'[62] This type shares qualities with the *Apotheosis of St Ignatius* fresco discussed previously, where the ceiling acts as a portal to another environment which, through techniques to deceive the senses, is perceived to be realistic.

---

[58] Paul Lansky, 'Stepping Outside for a Moment: Narrative Space in Two Works for Sound Alone', *Music, Electronic Media and Culture*, 2000, 217.
[59] Lansky.
[60] Peter Batchelor, 'Really Hearing the Thing: An Investigation of the Creative Possibilities of Trompe l'Oreille and the Fabrication of Aural Landscapes', in *Proceedings of the 2007 Electroacoustic Music Studies Conference*, 2007.
[61] Batchelor.
[62] Batchelor.

An exemplar of portal trompe-l'oreille is Batchelor's work *Studies on Canvas* (2004), consisting of 30 flat-panel speakers in a six-by-five grid that sit behind a blank white canvas. Batchelor writes that 'the canvas operates as a physical acousmatic curtain obscuring a series of sonic "images"'.[63] The vignettes explore referential material, recreating real-world landscapes and emulating their spatial and behavioural qualities. The sound images range from macro-scale landscapes (a rainstorm with cars passing, a countryside environment), to meso-scale details and 'still lifes' (an exploration of object behaviours in certain contexts including marbles rolling down a table-top and a pool of bubbles), and to micro-scale interiors.[64] Batchelor invites the listener to engage with the work as with a painting, standing back to see the full picture, or moving closer to appreciate the inner spatial/textural detail.

In *Studies on Canvas,* the canvas furthers the acousmatic situation to a certain degree, as the loudspeakers are hidden. This may lead the audience to query whether some sounds are acoustically being produced behind the canvas, such as bubbling water or marbles rolling around. While the cause of other materials will be less ambiguous such as large landscapes, the ability to fluidly move between these materials allows the work to create a discourse on the veracity of sound. The audience may be provoked into contemplating whether they are hearing the real thing, or, to use Norman's vernacular, really hearing the thing. This doubt is the key experiential component in portal trompe-l'oreille works that could provoke metaperceptual experiences. If the sounds are convincing enough to fool the audience, they present a contradiction of the senses. Their aural sense may be convinced that what they are hearing is real, yet their visual sense contradicts this.

In the case of *Studies on Canvas* and other portal trompe-l'oreille works, the extent of the deception is contingent on the artist's skill in creating realistic sound images. While this parallels its visual counterpart, in that the deception is created by the artist's craft of controlling perception, the method of crafting the illusion is quite different between the senses. Whereas trompe-l'œil is crafted through synthesising paints, trompe-l'oreille is dependent on phonographic practices of reproduction and collage. This dependency on phonographic techniques limits trompe-l'oreille to only abstracting the materials on a spatial level, as abstraction of the sonic materials would create a breakdown of its illusory qualities.

In contrast to portal trompe-l'oreille, inhabitable trompe-l'oreille involves the insertion of sonic objects into an existing space. By using sounds that naturally 'belong' to that space, the audience

---

[63] Batchelor.
[64] Batchelor.

is invited to explore the deception. Batchelor describes this experience as ‘a landscape that we can walk into, and become part of.’[65] Whereas portal trompe-l’oreille is contingent on the artist crafting illusory sonic landscapes, the deception in inhabitable trompe-l’oreille works is achieved more through the environmental framing of the inserted sonic element. Accordingly, the effectiveness of inhabitable trompe-l’orielle works may be lessened by the ubiquitous presence of reproduced sound in our urban soundscapes. This means that it can be difficult to distinguish between an artistic intervention in the soundscape and the soundscape in its normal or “natural” state.

Fig. 7 Max Nauhaus standing over the gratings where his work Times Square is installed

This is reflected in Max Neuhaus’s *Times Square* (1977), shown in Fig. 7, which Batchelor references as an example of an inhabitable trompe-l’oreille. The work is a subtle augmentation of the busy urban environment in Manhattan’s Times Square. Hidden beneath a grill over a subway ventilation shaft, a low, rumbling, synthesised texture emanates from below. The work is unlabelled, and is intended to be discovered by visitors who happen upon it. While the sound can be mistaken for the hum of the subway below, observant visitors will notice that the synthesised texture slightly differs in behaviour and timbre from other subway sounds. This creates a subtle ambiguity in the cause of the low hum, with some visitors having their attention drawn towards the noise.

[65] Batchelor.

A more effective example, and one which is much harder to be ignored, is Florian Hollerweger's *Interroutes* (2008), which frames the experience of the audience to a greater extent by drawing their attention to the ambiguity of the 'realness' of sounds. *Interroutes* is a series of site-specific electroacoustic compositions that can be characterised as augmented sound walks. The works use a range of pre-recorded environmental sounds which are intended to be experienced while walking through the same environment in which they were captured. The compositions include extended periods of silence, in which the listener will experience the everyday soundscape almost undisturbed. To this intent, Hollerweger instructs the audience that the 'pieces should be listened to … at a playback volume typically used for music listening. Since it is important to remain acoustically connected to the environment, standard open earphones should be used rather than closed-back headphones or earphones which are inserted into the ear canal.'[66]

The shaping of the audience's experience allows the work to explore metaperceptual themes. The blend of pre-recorded environmental with the everyday soundscape creates an ambiguity of causation for the listener. Although Hollerweger does not explicitly discuss the work in the terms of trompe-l'oreille or the metaperceptual framework, the common thematic materials are evident. He writes '*Interroutes* aims at challenging the listener's perception with regards to what is 'real' and what is part of the pieces. The sounds in the pieces are designed such that they could be interpreted as an actual part of the environment.'[67] The work achieves this ambiguity by presenting an experiential framework for the audience, controlling some facets of their experience, while leaving other elements undetermined. As the listener is free to move through the space at will, different listeners will experience different sounds. Furthermore, because the everyday soundscape is always in flux, no two listeners' experience will be the same. The combination of pre-recorded material and the everyday soundscape, with the audience's autonomy over their interaction in the work allows for metaperceptual experiences, as the listener is free to investigate the veracity of their experience.

The uncertainty that trompe-l'oreille works create in the listener can become a key artistic material to manipulate. The creation of the illusory sounds can be complemented by the breaking down of their deception, drawing attention to the falsity of their creation. Art historian Ernst Gombrich reasons that the allure of trompe-l'oeil (and, I would argue, trompe-l'oreille) predominantly lies in the knowledge or discovery of the illusion, in particular 'in our continued feeling of incredulity that the visual effect … has been achieved on a flat hard panel by a skilled hand using a brush

[66] Florian Hollerweger, 'The Revolution Is Hear! Sound Art, the Everyday and Aural Awareness'.
[67] Hollerweger.

dipped in paint.'[68] The same is true of the aural illusion, in that we are curious to know whether what we are experiencing is real or not, and, when executed well, the revelation of the deception can produce the same sense of incredulity. This curiosity facilitates metaperceptual experiences, as our attention is drawn to what we are experiencing and how our senses can be fooled.

While trompe-l'œil and trompe-l'oreille deceive the audience by misusing and exploiting perceptual cues, these works often direct the attention of the audience towards an environment, place, or object. The Op Art movement can be connected to trompe-l'œil and trompe-l'oreille through its exploration of the audience's perception. In contrast to trompe-l'œil and trompe-l'oreille, the deception of the eye in Op Art works is the key experiential force, which makes its core themes more closely aligned with the metaperceptual framework than trompe-l'œil or trompe-l'oreille.

2.3.3 Op Art

In 1965, the Museum of Modern Art in New York held the landmark exhibition *The Responsive Eye* which heralded the establishment of the Op Art movement. The exhibition featured a collection of international artists that were creating perception-bending works through the use of optical illusions. In the press release for the exhibition, the exhibition curator William Seitz proclaimed that 'The Responsive Eye exhibition will bring together paintings and constructions that initiate a new, highly perceptual phase in the grammar of art. Using only lines, bands and patterns, flat areas of color, white, gray or black, or cleanly cut wood, glass, metal and plastic, certain of these artists establish a totally new relationship between the observer and a work of art.'[69] A diverse range of works have been created by Op Art practitioners, employing various optical illusions and perceptual oddities to captivate their audiences. Many of these works implicitly explore metaperceptual themes; in Part II, I include these works as part of the typography of metaperceptual approaches. In this section, I trace the evolution of themes and intent from trompe-l'œil to Op Art, and discuss how their themes are precursors to the metaperceptual framework.

At its core, both Op Art and the metaperceptual framework reveal the fallibility of our perception, and the way in which our perceptual apparatus mediates our experience of the world. A Time magazine article from 1964, a year before the *Responsive Eye* exhibition, starts its introduction to this new art form as 'Man's eyes are not windows, although he has long regarded them as such. They can be baffled, boggled, and balked. They often see things that are not there and fail to see

[68] Gombrich and others, V.
[69] William Seitz, 'The Responsive Eye' (The Museum of Modern Art, 1965).

things that are. In the eyes resides man's first sense, and it is fallible. Preying and playing on the fallibility in vision is the new movement of "optical art" that has sprung up across the Western world. Op art is made tantalizing, eye-teasing, even eye-smarting by visual researchers using all the ingredients of an optometrist's nightmare.'[70]

While works of trompe-l'œil's use deceptive depth cues to enhance the worlds and figures they depict, in Op Art the perceptual processes of the audience is the work itself. This evolution can be likened to the wider movement from representational art to abstract art that occurred during the twentieth century. In the aforementioned *Apotheosis of St Ignatius*, the representation of Saint Ignatius is heightened through optical illusion, whereas works such as Marina Appollonio's *Spazio Ad Attivazione Cinetica 6B* (1966-2015), shown in Fig. 8, present the illusion itself. Appollonio's work offers a clear connection between the methods of trompe l'œil and Op Art, as both appear to be three-dimensional. *Spazio Ad Attivazione Cinetica 6B* is typical of the Op Art style, with simple forms and bold colours creating optical oddities and illusions. The work features a large spiral of concentric rings, which are painted on the floor of the gallery in black and white. The size and orientation of the rings are warped in a way that makes the floor below appear unstable. The two-dimensional floor appears to be transformed into a complex three-dimensional form that looks somewhat like a striped volcano.

Fig. 8 Marina Apollonio, Spazio Ad Attivazione Cinetica 6B

[70] 'Op Art: Pictures That Attack The Eye', *Time Magazine*, 23 October 1964, 78–85.

By presenting the deception of the visual system as the artwork itself, Op Art is more strongly aligned with the metaperceptual framework than trompe-l'œil. The purity of Op Art's focus on optical illusions, rather than trompe-l'œil's use of deception to enhance the work, results in the audience's intentionality being directed back onto themselves. This shifts the focus from the work as an *object* to the work as an *experience*. Exhibition curator William Seitz writes in the press release for *The Responsive Eye*: 'Unlike most previous abstract painting, these works exist less as objects to be examined than as generators of perceptual responses, of colors and relationships existing solely in vision; of forms, presences and variations often entirely different from the static stimuli by the artist. Such subjective experiences, brought about by simultaneous contrast, afterimages, illusions and other optical devices are entirely real to the eye, although each observer will respond to them somewhat differently.'[71] This change from object to experience is an important characteristic of metaperceptual works, and of Installation works which are discussed in Section 2.3.4. In my analysis of the metaperceptual works, their ability to frame and create experiences in which the audience's attention is drawn back onto themselves, and onto the nuances of their subjective perception, is the most salient aspect, and characterises the work as metaperceptual.

The shift from art object to art experience also changes the dynamic between audience and artwork. In the exhibition press release, curator William Seitz claims that 'these artists establish a totally new relationship between the observer and a work of art.'[72] The viewer of the Op Art work becomes an activator of the work, as their subjective perception is the core artistic material, and they interact with the work by exploring the ways in which their perception is being deceived. This interaction paradigm between artwork and audience is similarly a feature of many metaperceptual works, as it is in their presence that the artistic materials are manifested.

In works that are inhabitable by multiple people, such as Apollonio's, each audience member may become a performer. Art critic Sarah Rich writes, 'as visitors to Apollonio's disorienting update on the *Rotoreliefs*[73] stagger and fall, the work becomes a stage upon which the public performs, for one another, the spectacle of dislocated viewing. This performative viewing is characteristic of Op in general, and it is one of its most important features… museumgoers crane their necks, lean against walls, and otherwise legibly embody their viewing experience.'[74] Op Art's requirement of

---

[71] Seitz.
[72] Seitz.
[73] Marcel Duchamp *Rotoreliefs* are early precursors to the Op Art movement and their aesthetic influence is strongly evident in Apollonio's work. Duchamp's work is further discussed in in Chapter Five.
[74] Sarah K. Rich, 'Allegories of Op', *Artforum*, May 2007, 312–27.

the audience's exploration of the work makes it an inherently physical and embodied experience. As other audience members investigate the illusory work, shifting their perspective and testing the boundaries of the dubious figures the work produce, they frame the other observers' experiences and may encourage them to do the same.

The shift from art object to art experience discussed in this section is radically furthered in the field of Installation Art. While Marina Apollonio's work can aptly be described through the Op Art tradition, it can also be characterised as an Installation work. While many Op Art works extend the tradition of abstract painting, the size, immersivity, and inhabitable nature of Apollonio's visual illusions are defining characteristics of the Installation art genre. The following section discusses the evolution of Installation Art and its applicability to the metaperceptual framework. In particular, I focus on explicating the themes of immersivity, the role of the audience as activator and enactor of the artwork, and the shaping of the audience's experience.

2.3.4 Installation Art

While discussing the motivations for this research in Chapter One, I recounted my formative experience at Janet Cardiff's installation *The Forty Part Motet.* This was one of my first experiences of a sound-based installation work, and the contrast between the artistic affordances of presenting the work in the gallery setting and in the traditional performance context was a catalyst for this research. Installation art, as a genre and movement, is an amorphous and difficult thing to define. Timothy Whalen echoes this sentiment in the foreword for the book *Ephemeral Monuments: History and Conservation of Installation Art.* He states, 'Installation Art is an extremely difficult type of contemporary art to properly define. There is no restriction on materials used, and works are created to be anything from permanent to highly ephemeral. Features that are essential in some works—such as site-specificity, or interactivity with the viewer—are totally extraneous for others.'[75] This section discusses the key characteristics of Installation art and analyses their application to the metaperceptual framework. The themes build upon the perceptual themes of trompe-l'œil, trompe-l'oreille, and Op Art. Specifically, the themes of immersivity, the role of the audience as activator and enactor of the artwork, and the shaping of the audience's experience are core defining characteristics of both Installation art and the metaperceptual framework.

The genesis of Installation art can be traced back to the avant-garde investigations of the relationship between sculpture and the space in which it is presented, together with new forms of

---

[75] Marina Pugliese, *Ephemeral Monuments: History and Conservation of Installation Art*, ed. by Barbara Ferriani (Los Angeles, USA: Getty Publications, 2013).

exhibiting art and the influence of the exhibition environment on the work.[76] Rosalind Krauss writes in her 1979 formative text 'Sculpture in the Expanded Field' that 'Over the last ten years rather surprising things have come to be called sculpture: narrow corridors with TV monitors at the ends; large photographs documenting country hikes; mirrors placed at strange angles in ordinary rooms; temporary lines cut into the floor of the desert.'[77] As these new works problematized the categorisation of artworks in the gallery, the need for a new term became evident. Many of these new works explored the space of the gallery as a core artistic component, and the terms 'environment', 'project art', and 'temporary art' were used as descriptors.[78] Julie Reiss highlights the evolution of the common usage of installation as a term.[79] She points out that "Installation" was included in the 1978 *Art Index* only as a cross reference to the term "environment",[80] while in the 1988 *Oxford Dictionary of Art,* "installation" was defined as 'a term which came into vogue during the 1970s to refer to an assemblage or environment constructed in the gallery specifically for a particular exhibition.'[81]

Krauss's discussion of *Sculpture in the Expanded Field* evidences the elevated importance of the spatial elements of the artwork in Installation art. Marina Pugliese writes that 'with an installation, the space becomes the material, becomes its centre, the means through which physical entrance to the work is granted.'[82] According to Jennifer A. González, installations have broken 'the traditional semiotic and somatic boundaries assumed to exist among the audience, the work of art, the site of exhibition, and the world beyond.'[83] This was an important factor in my experience of *The Forty Part Motet*. The loudspeaker remediation of the choral work allows for the space of the ensemble to be an inhabitable and an interactive element. My ability to move around the space, and get close to each 'performer' transcended the norms of musical performance, and allowed me to become an active participant in the work. My position within the ensemble changed the blend of voices, which drastically influenced my perception of the work. The intimacy and immersiveness I felt were both created through this spatial exploration.

---

[76] Pugliese.
[77] Rosalind Krauss, 'Sculpture in the Expanded Field', *October*, 8 (1979), 31–44.
[78] Julie H. Reiss, *From Margin to Center: The Spaces of Installation Art*, Reprint edition (Cambridge, Mass.: The MIT Press, 2001).
[79] Reiss.
[80] Alice Maria Dougan and Margaret Furlong, *Art Index* (H.W. Wilson., 1978).
[81] Ian Chilvers, Harold Osborne, and Dennis Farr, *The Oxford Dictionary of Art* (Oxford University Press, 1988).
[82] Pugliese.
[83] Jennifer A. González, *Subject to Display: Reframing Race in Contemporary Installation Art* (MIT Press, 2008).

The spatial immersion and interaction that I experienced in *The Forty Part Motet* allowed me to become an active participant in the work. This is a feature of many Installation works which has been linked by various theorists to the concept of the *theatrical space*.[84] By likening the gallery or art site to a stage, the ways in which the spectator becomes an active participator and enactor are explicated. These roles of audience as participator and enactor are key elements in many metaperceptual works, as they allow for the audience's attention to be drawn back onto their own subjectivity. Art curator Robert Storr's 1999 article *No Stage, No Actors, But It's Theatre (and Art)* argues that installations have become 'complete immersion environments.'[85] He asserts that 'the experience they provide is much like wandering onstage and picking up loose pages from a script, overhearing bits of recorded dialogue and trying to figure out what the setting is… and what actions might still be taken.'[86] In many cases, the spatial elements of the work allow for the audience to have a degree of autonomy over their experience, by audience creating an environment in which to navigate. Nicolas De Oliveira argues that in Installation works, the 'proscenium arch has been removed and that the division between actors and audience is no longer clear. The removal of the frame that separates stage from auditorium brings together the spheres of making and viewing. The *theatricality* of the work, once seen as a weakness because of the reliance on entertaining the audience, has become a virtue.'[87]

The focus on the audience's experience changes the dynamic between artist, artwork, and audience. The experience of the audience becomes the core focus of the artwork, and therefore, the artist becomes a crafter of experience as well as of objects and environments. Bruce Nauman's corridor works offer an example of creating environments and experiences. *Changing Light Corridor with Rooms* (1971), shown in Fig. 9, funnels the visitor down a narrow, high-sided passageway from which two rooms (one rectangular, the other triangular) can be entered halfway down. The darkness of the claustrophobic corridor is punctuated by intermittent, harsh flashing streams of light coming from each room. While the flashing in each room is regular, the rooms are out of sync, creating a contrapuntal dialogue of illumination. Art curator Agnieszka Gryczkowska writes that 'the work is a manifestation of the artist's fascination with the affects that physical environments can have on people, especially the feeling of unease that comes from being in a space that is too compressed or too large.'[88] She contextualises this with the role of the audience

---

[84] Pugliese.
[85] Robert Storr, 'No Stage, No Actors, But It's Theater (and Art)', *The New York Times* (New York, 28 November 1999), section Arts.
[86] Storr.
[87] Nicolas De Oliveira, Nicola Oxley, and Michael Petry, *Installation Art in the New Millennium: The Empire of the Senses* (Thames & Hudson, 2003).
[88] Agnieszka Gryczkowska, '"Changing Light Corridor with Rooms", Bruce Nauman, 1971', *Tate*, 2011.

in the experience: continuing ‘activated by the presence of a moving body, *Changing Light Corridor with Rooms* requires viewers to become participants in the work, obliging them to follow the rules of an experimental situation established by the physical parameters of the space.’[89]

copyrighted material

Fig. 9 Bruce Nauman, Changing Light Corridor with Rooms

Oskar Bätschman responds to the tactile and kinaesthetic elements of Bruce Nauman’s corridor works by describing them as *experience shapers*.[90] This is a notion that is particularly apt for metaperceptual works, as the artist shapes the experience of the audience in a way which invites their intentionality to be directed back onto themselves. The focus on the experience in many installation works is evidence of what Dorothea von Hantelmann describes as the *experiential turn*. She writes that ‘from the 1960s onward, the creation and shaping of experiences have increasingly become an integral part of the artwork’s conception.’[91] Metaperceptual works can be seen in von Hantelmann’s terms as occupying a space within the experiential turn. They are works focused on the experience of the audience, but more specifically, they are experience shapers which bring the audience’s attention back on the details of their own subjective experience.

Installation art’s focus on immersive experiences that allow for the audience to become active participants in the work make them well-suited to shaping metaperceptual experiences. As the history of Installation art can be traced back to avant-garde explorations of sculpture and space,

---

[89] Gryczkowska.
[90] Oskar Bätschmann, *Ausstellungskünstler: Kult Und Karriere Im Modernen Kunstsystem* (DuMont Köln, 1997).
[91] D. von Hantelmann, ‘The Experiential Turn’, *Living Collections Catalogue*, 1.1 (2014).

much of the writing and discussion of the works are visually focused. Janet Cardiff's *The Forty Part Motet* fits a growing minority of sound-based Installation works, and provides a paradigm for exploring the new experiential affordances that the Installation art form provides.

In Part II, I categorise and explicate the various approaches to creating metaperceptual works. Many of these works build upon the themes in the art movements of this section: the understanding and manipulation of the audience's perceptual processes that lies at the heart of trompe-l'œil and trompe-l'oreille, the exploration of perceptual by-products and artefacts found in Op Art, and the shaping of experience and audience's role as activators of the work that defines Installation art. By categorising and explicating the various approaches to creating metaperceptual works, this offers a new line of analysis for these works that form part of the experiential turn, and provides a framework for creating new works.

Part II:

The Metaperceptual Framework

In Part II of this document, I explicate the metaperceptual framework by mapping the terrain of metaperceptual approaches. The metaperceptual framework consists of three categories: Deprivation, Perceptual Translation, and Perceptual Hacking. Each category contains a myriad of approaches to creating metaperceptual experiences, which are taxonomized in this part. The mapping of artistic terrain reveals under-explored areas, which offer potential avenues for future exploration.

The intent of creating this framework is threefold. Firstly, by mapping the terrain of metaperceptual themes used in creative works, a new line of analytical insight can be amassed from existing works, and from the field as a whole. The metaperceptual themes are often explored implicitly and are approached through a range of different forms and disciplines. The act of cataloguing these themes will make them explicit and will reveal the intersection between a range of works from different artists and art fields. This line of analytical insight is not necessarily attributed to the intentions of the artists, but to the experience of the audience. The relevant question is: does the artwork create a metaperceptual experience for the audience? Secondly, by examining the history of the metaperceptual themes, the framework is situated within the history of art. This contextualises the artworks and traces the genealogy of these metaperceptual themes back to the philosophies discussed in Chapter Two. Lastly, through mapping this terrain, the uncharted areas form possibilities for future works to explore. This allows for the framework to inform the creation of new works, which are presented in Part III.

The act of taxonomizing is never neutral and objective. There are limitations inherent in the production of any taxonomy, and these shape its scope and purpose. The following taxonomy was created through reflecting on a large body of works that I have surveyed. The works have been categorized through analysing the experience that they create for the audience, and examining the methods that have been used to create metaperceptual experiences. The taxonomy seeks to define what makes a work metaperceptual, and to map the terrain of different metaperceptual approaches. This includes discussions on a range of different works about whether or not they are metaperceptual.

The taxonomy is non-hierarchical, as there is no one ideal approach to creating metaperceptual works. I do not claim that the taxonomy is fully exhaustive, as it is possible other methods exist that could create metaperceptual works. The taxonomy includes artworks which act as exemplars for discussion, and is not intended to collect all existing metaperceptual artworks. It starts with the broadest themes, splitting the field into three categories: Deprivation, Perceptual Translation, and Perceptual Hacking. These categories are ordered into sub-categories in a tree-like structure, with increasing specificity as it moves down the branches. The sub-categories differentiate methods of framing the experience of the audience. The branches continue to order the field, ending in specific artworks which are then used to discuss how each creates and explores metaperceptual themes. The structure is illustrated in with the full taxonomy shown in Fig. 11.

The works included come from a range of different fields, styles, and disciplines. Although this research is focused on metaperceptual sound artworks, to discuss the possible ways in which metaperceptual themes can be explored necessitates a wider scope of works. By including these works, a more holistic discussion of the experience of the audience is facilitated. This is particularly important for the metaperceptual framework, as our experience is never limited to one sense.

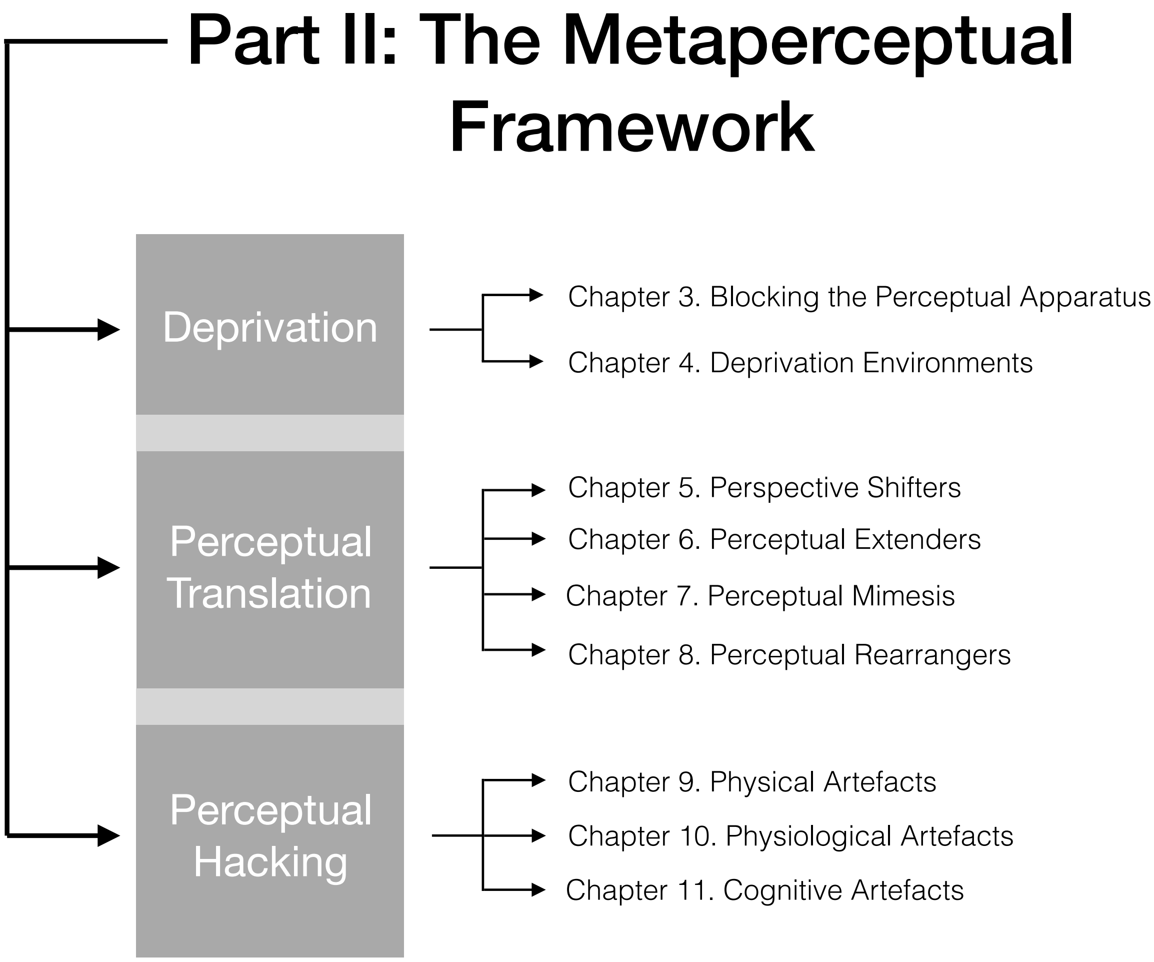


Fig. 10 Overview of the Metaperceptual Framework

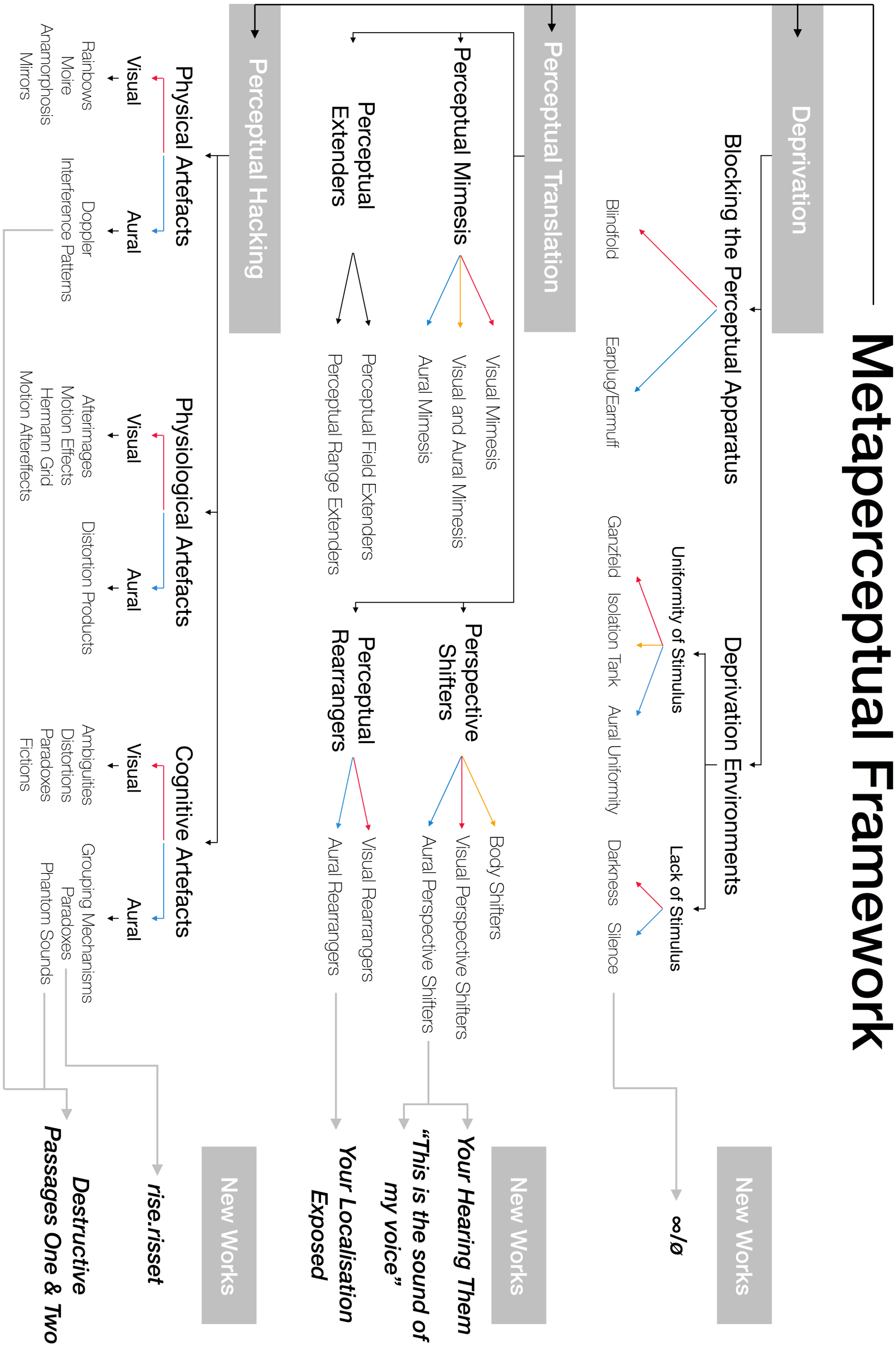


Fig. 11 Taxonomy the Metaperceptual Framework

Chapter Three

Deprivation: Blocking the Perceptual Apparatus

‘the synaesthetic system is marshalled to parry technological stimuli in order to protect both the body from the trauma of accident and the psyche from the trauma of perceptual shock. As a result, the system reverses its role. Its goal is to numb the organism, to deaden the senses, to repress memory: the cognitive system of synaesthetics has become, rather, one of anaesthetics. In this situation of "crisis in perception," it is no longer a question of educating the crude ear to hear music, but of giving it back hearing. It is no longer a question of training the eye to see beauty, but of restoring "perceptibility.’

—Susan Buck-Morris

3.1 Deprivation Preface

Our normal mode of experiencing the world involves a bombardment of stimuli. On a recent trip to Hong Kong, I was making my way to my accommodation, and upon navigating the complex train network to get to my stop, I found myself walking through one of the many night markets. Thousands of people engulfed me, flocking between vendors with ease. I was submerged in a glut of moving light and colour, a cacophony of voices and street noise, and an oppressive fog of heat and humidity of a summer Kowloon night. The amount of sensory information was almost too much for me to process, especially after a long flight, and I quickly escaped to the nearest side street.

While this may be one of the more extreme examples of our everyday interaction with the world, our environment does not have to be as busy as a Kowloon night market for there to be a wide range of different stimuli to bombard and affect us. Writing in 1903, Georg Simmel ruminated on the impact that urbanisation and the intensification of external and internal stimuli would have on our mental life.[92] As many people moved from small town and rural existences into the metropolises that developed in early 20th century, the adaptation that Simmel postulated was one of defence. The metropolitan person would deal with the fluctuations and discontinuities of their intense new environment through desensitising themselves, creating a buffer to the external world,

[92] Georg Simmel, *The Metropolis and Mental Life* (Routledge, 1997).

or a ‘protective organ’[93], to defend from the energy of a sensory overload. This is the context against which many of the deprivation pieces react. They expose elements of our experience through the removal of the chaos, inviting us to consider the rarefied materials that form the artist’s palette.

copyrighted material

Fig. 12 The dazzling lights of one of Kowloon’s many night markets

The environment in which we experience an artwork influences the way we perceive it. The experience of a musical work in the calm, white walls of the gallery will differ from the same work being heard in a dimly lit club. The framing of experience through the removal of stimuli has a rich lineage in sound art through acousmatic music. This form of music, pioneered by Pierre Schaeffer, was also the catalyst for new philosophies on sound and the listening experience. These philosophies, and the experience of listening to acousmatic music, share themes with many of the deprivation works. The established nature of this art form makes it an apt sonic entry point to the different ways that deprivation can be manifested in art works, and I will begin this chapter with a discussion of the acousmatic reduction and its associated philosophies. This contextualises the theme of deprivation in current music practice, and leads on to an extrapolation of the metaperceptual deprivation category.

---

[93] Simmel.

3.2 Acousmatic Music

The term 'acousmatic' is derived from the ancient Greek word 'akousmatikoi', the name given to Pythagoras's disciples.[94] The legend goes that Pythagoras would teach behind a curtain, hidden from view, with his students sitting in strict silence.[95] The ethos of this unusual teaching technique was that through the removal of visual stimuli, the aural communication would be the sole focus. The students would be left to consider what Pythagoras was saying without being distracted by his superfluous visual movements.

The application of this word to music is tied to Pierre Schaeffer's creation of *musique concrète*. Working with the audio technology borne out of the post-World War II technological landscape, Schaeffer started work on a new type of music that used recordings of sound as their base materials. This was radically different to traditional 'abstract' music, whose language and materials were based on notes and pitches. The new technologies allowed Schaeffer and others to work with recorded sound in a previously impossible way. Any sound could be captured and then manipulated to the composer's will: cut, spliced, reversed, or slowed down. Schaeffer defined this new music as musique concrète, stating its ethos as committed 'to compose with materials taken from "given" experimental sound in order to emphasize our dependence, no longer on preconceived sound abstractions, but on sound fragments that exist in reality, and that are considered as discrete and complete sound objects, even if and above all when they do not fit in with the elementary definitions of music theory.'[96]

Not only were the materials radically different, but also the performance ontology. The loudspeaker replaced the instrumental performer, thereby having a profound effect on the experience of these new works. The 'surrogacy'[97] of sound in a traditional performance context is always easily established, as the performers stand on stage and play their acoustic instruments. In contrast, the loudspeaker offers no visual cue to the source of the sound it is reproducing, severing the tie between visual and aural senses that were usually so closely coupled in the performance space. This is where Schaeffer saw commonalities between the 'akousmatikoi', and this experience of music. As he writes, 'In ancient times, the apparatus was a curtain; today, it is the radio and the methods of reproduction, with the whole set of electro-acoustic transformations, that place us,

---

[94] Brian Kane, *Sound Unseen: Acousmatic Sound in Theory and Practice* (Oxford University Press, USA, 2014).
[95] Pierre Schaeffer, 'Acousmatics', *Audio Culture: Readings in Modern Music*, 2004, 76–81.
[96] Pierre Schaeffer, *In Search of a Concrete Music* (Univ of California Press, 2012), XV.
[97] Denis Smalley, 'Spectromorphology: Explaining Sound-Shapes', *Organised Sound*, 2.02 (1997), 107–126.

modern listeners to an invisible voice, under similar circumstances.'[98] Thus, Schaeffer followed from the definition given by Larousse for acousmatic as an adjective, 'referring to a sound that one hears without seeing the causes behind it.'[99]

As with Pythagoras, Schaeffer believed that the invisibility of the source of sound would have a profound effect on the listener. In the case of acousmatic music, the focus was not on reducing distractions, but revealing essential qualities. The use of concrete recorded sounds means that the materials come with causal and semantic baggage. Often, we hear these sounds in everyday life, and we do not consider them as 'musical'. Schaeffer believed that through experiencing sound without its visual and physical causal elements, the audience would be able to attend to the pure sonic qualities of it. Through decontextualising the sounds of the everyday, Schaeffer presented them as sound objects worthy of being listened to for their sonic qualities. This acontextual presentation emphasised their sonic character over their usual roles of communicators of semantic or causal information.

Although the acousmatic situation bars direct access to the visible, tactile, and physically quantifiable information of the cause of the sound, it does not deprive the audience's senses. The redirection of the audience's attention to the qualities of sound, away from its cause, is a mental activity that is supported by the listening environment void of visual and tactile information. To engage an audience in Shaefferian listening, Brian Kane articulates that 'the ear would have to train itself to hear these new musical values unique to the sonic materials deployed.'[100]

While the works that are connected and discussed in this chapter share perceptual themes with the acousmatic situation, they take this removal of stimulus further. These works carefully curate the experience of the audience, reducing the range of perceptual stimuli to a refined palette. By removing extraneous signals in our everyday modes of experiencing the world, they remove their audiences from their normal experiential context. Some experiences of deprivation can provoke a feeling of malfunction, as it simulates the impairment of a sense. Other experiences of deprivation reveal the underlying processes and unperceived stimuli that are usually masked by the chaotic din of stimuli in our normal modes of experience.

There are many methods that artists have used to create an experience of deprivation for the audience. The following section organises the corpus by first splitting them into two large sets.

[98] Schaeffer Pierre, 'Traité Des Objets Musicaux', *Editions Du Seuil. Paris. France*, 1966.
[99] Schaeffer.
[100] Kane, *Sound Unseen*. 5.

One set contains works that physically manipulate the perceptual apparatus of the audience, by blocking or covering a sense organ to deprive it of stimulus. This reduces the perceptual field in size, isolating facets of the audience's experience from the outside world. The other set focuses on pieces that manipulate the environment or stimuli in order to create a deprivation environment for the audience. These works do not change the size of the field, but create a perceptual field that is devoid of stimulus. A diagrammatic representation of the framework is shown below in Fig. 13.

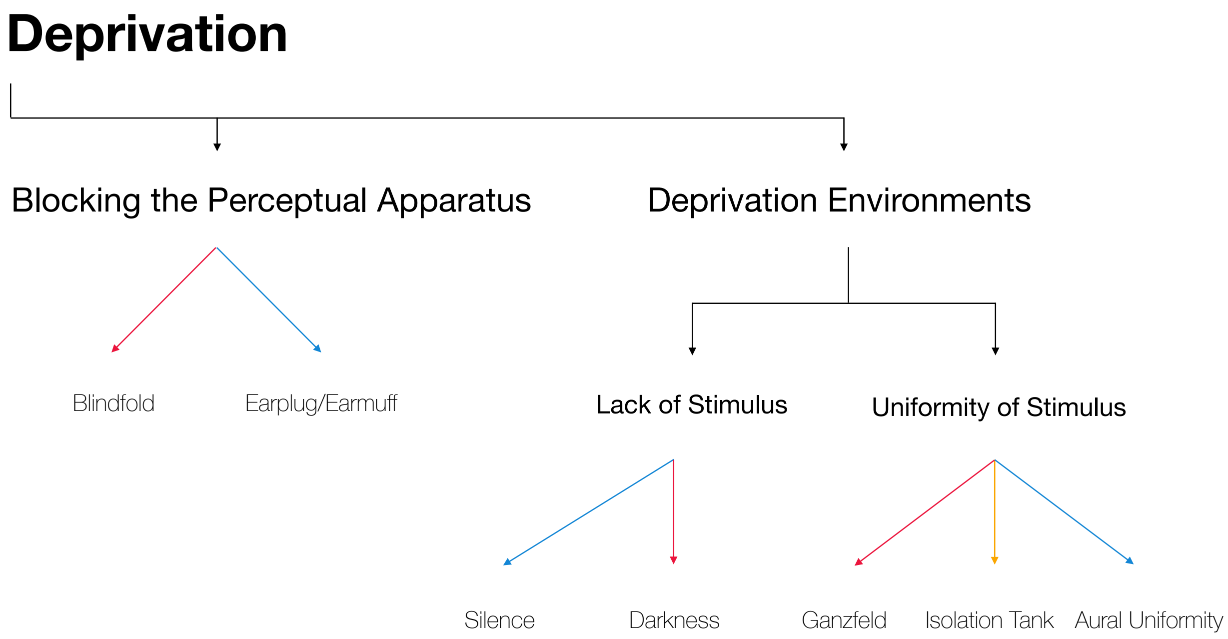


Fig. 13 The Taxonomy of Deprivation Modes

3.3 Blocking the Perceptual Apparatus

The direct manipulation of the perceptual apparatus is an approach that reoccurs within many metaperceptual sub-categories. The deprivation category usually involves a simplistic alteration by blocking and occluding one of the sense modalities. This may take the form of a blindfold in the visual domain, or earmuff/earplugs in the aural domain. By occluding one of the sense modalities, the artist creates a privileging of the other senses, guiding the attention of the audience through the removal of a normal range of sensory experience.

3.3.1 Visual Blocking

As discussed in Section 3.2, the acousmatic situation does not deprive the visual sense of stimulus, but by dislocating sound from its source, it bars direct access to the visual modes of the cause of the sound. The relative deprivation of this listening environment has been refined further by artists like Francisco Lopez through blindfolding the audience. Though he insists on performing in complete darkness, he states that 'even after having all the lights off and all the doors and windows blocked for external light, the only way to really attain this ... is by providing blindfolds for the audience.'[101]

Lopez's experiential framing of the audience is strongly tied to the elements that Schaeffer believed to be revolutionary about the acousmatic listening environment. When discussing his work *La Selva* (1998)[102], Lopez writes 'I believe in the possibility of a profound, pure, 'blind' listening of sounds, freed (as much as possible) of procedural, contextual or intentional levels of reference. What is more important, I conceive this as an ideal form of transcendental listening that doesn't denies all what is outside the sounds but explores and affirms all what is inside them.'[103]

Fig. 14 Francisco Lopez performing to a blindfolded audience. Image provided courtesy of the artist.

Lopez's extension of the acousmatic situation completely blocks the visual sense of the listener, leaving only the sonic content of his works to be experienced. This extension reveals an important element that the acousmatic situation does not remove. Without the blindfold, the audience is still left to look around the room, aware of the people next to them and of the black box of the loudspeakers that perform in front of them. Even though they cannot see the source of the sound, the visual information that tells them where the speakers are placed colours their experience of the

[101] Francisco López, Interview for DB magazine, 2004.
[102] Francisco López, *La Selva* (V2_Archief, 1998).
[103] Francisco López, 'Environmental Sound Matter', April 1998.

localisation of sounds and degree of immersion. In the typical acousmatic context, the visual sense is not deprived of stimulus; rather, it is deprived of dynamic and artistically relevant stimulus.

The acousmatic situation itself is now ubiquitous due to the advance of portable audio technology like headphones and earphones. We often experience this dislocation of sound and source, which means that this listening environment has lost some of the power it once had to provide an extraordinary experience for the audience. Lopez's actions of blindfolding the audience restores this element in two main ways. Firstly, the visual sense is fully deprived, with the visual field reduced to nothing as no light or stimulus being experienced by the audience. And secondly, the act of wearing the blindfold creates a departure from normality, taking the audience out of everyday modes of experiencing the world.

Fig. 15 The entrance to May Abdalla and May Rose's Door into The Dark. Image provided courtesy of the artists.

The visual deprivation provided by the blindfold is used for a different purpose in May Abdalla and May Rose's *Door into The Dark* (2015). The central theme of the work is loss, and the audience experience this theme in multiple ways. Participants are blindfolded before entering into a darkened space that is carefully curated. The rooms are mostly empty, except for a large rope that guides them through the space. The rope forks in multiple places, giving the participant the decision of which path to take.

With their visual sense blocked, the audience is left to focus on their senses of sound and touch. As they make their way through the space, audio is triggered. A narrator speaks to them directly throughout, asking them to explore the space through their non-visual senses and do certain tasks. They lie on a bed, and bend down to feel a patch of grass. At different points in space, three people tell their own story of experiencing loss. One describes the impact of losing his sight, and its effect on his relationship to sound and touch. Another talks about their brush with death while being alone in the mountains. Lastly, a character describes how he took to walking the streets at night to lose himself and ended up in psychiatric care.

The act of blindfolding in *Door into the Dark* creates an environment in which the audience experience the themes of loss in various ways. Entering a new space in a strange context while blindfolded creates a degree of vulnerability. It denies the audience their normal modes of traversing and exploring new spaces, and demands that they renegotiate how they use their senses. This vulnerability could be overwhelming, but is lessened by the role of the guiding rope, which acts as "safety blanket" throughout the experience. It keeps the audience oriented and guides them through the linear narrative, while also allowing them some autonomy over their choice of direction and speed.

The blindfold deprives the audience of their orientation and their sense of spatial scale. This ambiguity of space is articulated by the narrator, as she welcomes the audience into the space by saying "This is a labyrinth. For now, all you need to do is follow the rope."[104] As the participants follow the rope, the twists and turns disorient them, making it impossible to track how far they have traversed, or where they started. The sense of being lost is fully immersive, and can be oppressive, with salvation lying in the trust of the rope leading one through the labyrinth.

The blindfold also allows for a deeper immersion in the narrative. As the visual sense is blocked, the audience's range of stimulus is drastically reduced. Over the time of their experience in the space, their aural and touch senses become heightened as they become the focus of their attention. As Paula Bernstein, in an article for Indiewire, writes: 'experiencing a bit of what it must feel like to be blind, your senses are awakened, and you are left feeling both disoriented and hyper-alert. Though I never left the room, I climbed a mountain, explored a jungle and relaxed into a carpeted bed. By the time I found my way back to the waiting room where it was my turn to deliver

[104] 'Anagram | Door Into The Dark'.

instructions to the next participant, I felt rejuvenated and fully alive—much the way I feel after a satisfying film.'[105]

Fig. 16 A guide lightly touches the fingertips of an audience member in Symphony of a Missing Room. Image provided courtesy of the artists.

Similar forces are at work in Christer Lundahl and Martina Seitl's *Symphony of a Missing Room* (2014). The work uses visual deprivation to intensify a carefully curated audience experience that transports the audience through a myriad of virtual imagined spaces. *Symphony of a Missing Room* pushes the boundaries of immersive storytelling by creating a theatre for the senses.

The work is site-specific, with each installation of the work being developed to engage with the history, objects, and space of the museum. The audience experience multiple stages of sensorial configurations throughout the piece. A voice guides the audience through headphones. At times, the voice asks them to perform tasks and imagine virtual spaces: 'crouch, walk through the passageway, a tunnel.'[106] A section of the work is experienced through white-out glasses, which block out the external world but still allow the audience to have a sense of light and dark. Guides shepherd the audience through the work, sometimes reconfiguring their senses, removing or

---

[105] Paula Bernstein, '"Door Into the Dark" Immerses You in Darkness and Lets You Find Your Way Out', *IndieWire*, 2015.
[106] Niklas Lundell and Louise Höjer, 'Lundahl & Seitl: Symphony of a Missing Room', *Thisistomorrow*.

applying the glasses. They also engage in the sensorial play in the work, gently touching the fingertips and taking the hand of the audience to lead them to a new space.

By blocking the visual sense, the audience can enter the new worlds that their imagination and other senses are creating. Matt Trueman, an art critic for The Daily Telegraph newspaper, describes his own experience of the work: ‘One moment you’re in a courtyard – dappled light breaking through the canopy. The next, you’re being twirled around a Viennese ballroom, filled with laughter and waltzing strings. There are lifts that rumble up into the sky and cliff tops where you feel the wind in your face and a drop at your feet. You go through tunnels, down stairs, up slopes – yet you know you’re still in the Royal Academy. Aren’t you?’[107]

The virtual worlds that each audience member enter into are dependent on the visual deprivation, and this dependence becomes part of the narrative arc. At times, the immersion and fantasy is broken through the removal of deprivation. The audience are confronted with reality by being pulled out of their personally imagined worlds. As Trueman writes, ‘I am led into a magical forest inhabited by an old man. My blindfolds are removed. The worlds converge. I am still in the National Museum, yet the old man appears at my feet dressed in an amber silk gown. The tree I was touching has become a pillar. I am moved but deeply disappointed at this reappearance of reality.’[108]

In both *Symphony of a Missing Room* and *Door into the Dark,* visual deprivation creates a metaperceptual frame in which the audience is pushed to shift their perceptual attention away from their visual sense. With this sense deprived, the perception of reality becomes less rigid, as the audience cannot confirm the nature of their surroundings through sight. This context allows for the audience’s imagination and mind to fill in the gaps, creating a deeply personal and immersive experience of the narrative. Through creating this context, the artist turns the audience into creators of the work, with each visitor creating a unique experience.

Symphony of a Missing Room and *Door into the Dark* both block the visual sense to push the audience’s attention to another of the senses. Often the aural sense is used by the artist to frame the imagination of the audience, allowing the audience to complete the narrative presented by the artist. By blocking *both* the visual and aural senses, Marina Abramović, whose work is discussed in the following subsection, does not provide a narrative and instead leaves this up to the audience.

[107] Matt Trueman, ‘Symphony of a Missing Room, Royal Academy of Arts, Review: “Ticklish Trickery”‘, 22 May 2014, section Culture.
[108] Trueman.

3.3.2 Visual and Aural Blocking

In Marina Abramović's *Generator* (2014), the audience is deprived of both sight and sound. The audience is blindfolded and given earmuffs, and are then guided into a white space which may be empty, or may have up to 67 other participants in it. They are free to explore the space, and when they want to leave, they may raise their hand to signal to an attendant to come and escort them from the space. There is no narrative to follow, nor is the space itself special in a tactile or exploratory sense. The focus is much more on personal engagement with deprivation, and the social repercussions that this deprivation triggers. Normal modes of social interaction are denied, and this forces the audience to renegotiate how to traverse and explore the space. Ken Johnson, an art critic for The New York Times, describes a short period of his experience in the work: 'Someone passes by, grazing my back. Someone else comes near and puts a hand on my arm. The hand stays there. I feel its warmth. Would it be rude to back off? The person touches my hand. I touch back and feel skin. I run my hand up to a bare shoulder. I get the feeling the person wants to interact more, but I fear creepiness, and I turn away. Should I be more open?'[109]

Fig. 17 Marina Abramović, Generator. Image provided courtesy of Sean Kelly, New York and Marina Abramović Archives

The artwork becomes the behaviour of the audience: how they react and adapt to the deprivation of their senses and the new social environment. This new context reveals some of the normal

---

[109] Ken Johnson, 'At Marina Abramovic's "Generator," Blindfolds Are Required', *The New York Times*, 6 November 2014.

modes of communication and behaviour that are informed by our visual and aural senses. The audience is not able to use vision to assist with their balance or spatial positioning, making each step and movement a moment of negotiation. They cannot see or hear where anyone else is in the room, creating a completely unmapped terrain for them to explore.

Marina Abramović's *Generator* is emblematic of many of the themes that drive the deprivation category of works. The act of blocking a sense is in itself one which takes the audience out of their normal modes of experiencing the world. While it is true that the experiences that audiences have inside gallery spaces are often not 'normal', Abramović pushes this further. Through denying the visual and aural sense, the audience's attention shifts to the vestibular, olfactory, and proprioceptive senses. For some, this environment facilitates introspection. With the lack of visual and aural stimulus, the audience is left with only the task of existing in the space, and their own thoughts. There is no narrative to follow, or acts to perform.

Another effect that the deprivation of a sense, or in this case two senses, can create is a heightening of perception in other sensory modes. Becky Chung, an art journalist for Vice magazine, describes navigating through the space: 'I pass the smell of the remnants of mint gum and wet cigarettes. I hear the ghost of a woman's laugh slip through the blocks around my ears. I sweep the floor with my shoe and feel a metal grate. I swing my arms as wide as I can, and spin around, charting the emptiness around me. When my hands graze what I imagine is the shoulder or the hand or the shoe of another person, I feel electricity again and again.'[110] To Chung, the space seemingly devoid of interest becomes a microcosm of stimuli.

It may be instructive to compare the experience of this work with the normal experience of works in this gallery space. If this room was filled with paintings, with people milling around the space, these smells, textures, and social situations could still be present. The power of the artwork is the ability to facilitate and provoke the audience into becoming aware of these details through selective perceptual deprivation. It presents the benign as something more profound: a new state of existing.

3.3.3 Blocking as an Artistic Act

Altering the perceptual apparatus to block one, or more, of the senses can be a powerful framer of the audience's experience. Depending on the context, the audience may have a heightened perceptual experience of their non-blocked sensory modes, revealing often overlooked details of

[110] Becky Chung, 'I Looked Into The Void And Saw Marina Abramovic', *Creators*, 2014.

their perception. The alteration can also create an immersive experience, allowing their imagination to run wild and offering a deep escapism.

The blocking of the visual sense through blindfolds has been much more prevalent than its aural equivalent. There may be multiple reasons for this. Blocking the visual sense has a more dramatic effect on the audience. It can create an uncertainty of balance, as the vestibular system integrates the visual sense. It also impedes spatial awareness, making the audience unsure about their spatial position, as well as the size and nature of the space they are in. As we tend to rely more on our visual sense in everyday modes of experience, the deprivation of this sense creates a bigger departure from normality than the aural sense. As with many metaperceptual works, the richer history of visual works in the installation art field means that more artists have explored these themes in the visual domain, leading to a deeper investigation of the possibilities afforded by depriving the visual sense.

There are no major works that I have uncovered through conducting this survey of research which are centred upon only depriving the aural sense through blocking the ears. This makes exploring the repercussions and artistic affordances of aural deprivation salient. The possibilities for new works in this underexplored field are varied and numerous, and this is a main driving factor in the new metaperceptual works that I have created, presented in Chapter Twelve.

While the deprivation of the visual sense creates a large departure from normal modes of perception, deprivation of the aural sense also creates a large departure but in a different form. One of the differences between the way we see and the way we hear is our ability to block out the sense ourselves. To some degree, we 'are condemned to listen'[111] and we lack the aural equivalent of eyelid.[112] This is not to say that the ear is purely passive, however we do have less control over physiologically shutting out stimulus. This means that the deprivation of our aural sense is a rarity. Blindfolding is roughly equivalent to shutting the eyes, which we do very regularly. Wearing earmuffs is more equivalent to putting our fingers in our ears, an uncommon action that is usually done only for defence against extremely loud sounds. This difference means that the effect of blocking our aural sense could have a profound change in the audience's experience of an environment.

---

[111] R. Schafer, *Murray: The Soundscape. Our Sonic Environment and the Tuning of the World* (Destiny Books, Rochester, Vermont, USA, 1994).
[112] Schafer.

The blocking of a sense modality through physically altering the perceptual apparatus is only one half of the deprivation topography. Another form of deprivation is created through carefully controlling an environment to deny the audience of sensory information. These works are the subject of the following chapter.

Chapter Four

Deprivation: Deprivation Environments

The experience of deprivation can be engendered through carefully controlling the perceptual environment of the artwork. The 'Deprivation Environments' branch can be divided into two main groups: those works that deprive through lack of the stimulus, and those that deprive through uniformity of stimulus. These groups and their subcategories are shown below in Fig. 18.

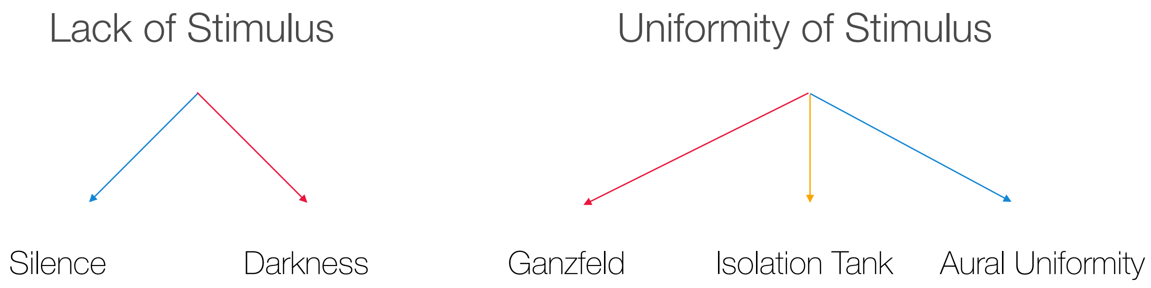


Fig. 18 Deprivation Environments subcategories

4.1 Lack of Stimulus

'It was after I got to Boston that I went into the anechoic chamber at Harvard University. Anybody who knows me knows this story. I am constantly telling it. Anyway, in that silent room, I heard two sounds, one high and one low. Afterward I asked the engineer in charge why, if the room was so silent, I had heard two sounds. He said "Describe them." I did. He said, "The high one was your nervous system in operation. The low one was your blood in circulation."'[113]

—John Cage

This branch of works create deprivation through environments and situations that lack aural/visual stimuli. This is the realm of silence and darkness. Somewhat ironically, silence in sound art has been a major creative and philosophical provocation. John Cage's influential collection of essays, *Silence*[114], detailed his conception of the musicalisation of sound. Cage's philosophies often ruminated on the concept of silence, and what could be deemed as musical materials. These philosophies about silence forms the essence of his work, *4'33"* (1952).

4.1.1 Cagean Silence

Famously, John Cage's notorious 'silent' work *4'33"* rejected the aesthetic values of the Western art music world. First performed in 1952, pianist David Tudor took to the small wooden stage at the aptly named Maverick Concert Hall in Woodstock, New York, sat down at the piano, closed the lid over the keys, and looked at a stopwatch. 'Twice in the next four minutes he raised the lid up and lowered it again, careful to make no audible sound, although at the same time he was turning pages of the music, which were devoid of notes. After four minutes and thirty-three seconds had passed, Tudor rose to receive applause'[115]—there was none.

Cage abandoned the established formal system of music by expanding the palette of 'musical' sounds.[116] This was not the first questioning and expansion of the concept of 'musical' materials. Luigi Russolo's 1913 Futurist manifesto, *L'arte dei Rumori,* urged composers to 'enlarge and enrich the field of sound.'[117] Russolo created a family of mechanical noise-intoners, *intonamori,* that created a range of rich, noisy timbres. Russolo's manifesto was an embracement and promotion of noise and extra-musical sound as music.

---

[113] John Cage, *Silence: Lectures and Writings* (Wesleyan University Press, 2011).
[114] Cage.
[115] Kyle Gann, *No Such Thing as Silence: John Cage's 4'33"* (Yale University Press, 2010).
[116] Brian Kane, 'Musicophobia, or Sound Art and the Demands of Art Theory', *EDITORIAL BOARD*, 2013, 76.
[117] Luigi Russolo, *The Art of Noises*, 6 (Pendragon Press, 1986).

Cage took Russolo's avant-garde approach to its logical conclusion. As Douglas Kahn writes, 'Cage exhausted this strategy by extending the process of incorporation to a point to every audible, potentially audible and mythically audible sounds, where consequently there existed no more sounds to incorporate music.'[118] Through the silencing of the performer, *4′33″* disrupts the ontology of the musical performance – shifting the site of musical aestheticisation from the performer creating sound to the audience listening to sound. The incidental sounds of the audience and the space become the artwork. According to Kahn, this extension of Russolo's avant-garde philosophy 'opened music up into an emancipatory endgame.'[119]

In many ways, the common description of *4′33″* as the *silent piece* is a misnomer. The piece is not silent at all, and instead embraces all sound as music. It was heavily informed by Cage's experience of an anechoic chamber; a room designed to completely absorb reflections of sound and produce a silent space. Instead of experiencing silence, Cage heard two sounds in the room, one high and one low. He asked the engineer what he was hearing and was told that the high sound was his nervous system in operation and the low sound was his blood in circulation.[120, 121.] Cage wrote after the experience, 'There is no such thing as an empty space or an empty time. There is always something to see, something to hear. In fact, try as we may to make a silence, we cannot.'[122]

This experience changed the way Cage thought about sound, and informed the creation of *4′33″*. Although the environment was devoid of sound, we are always active creators of sound, and therefore never experience absolute silence. This revelation of the impossibility of absolute silence parallels Cage's embracement of all sound as music. As Kahn reflects, 'This was a very important moment since it was here that all sound was joined to always sound.'[123]

John Cage's experience in the anechoic chamber, and his philosophies that informed the creation of *4′33″*, share themes with many of the artworks which explore deprivation through using a lack of stimulus. *4′33″* acts as perceptual framer of the audience. Through the removal of the normal modes of musical expression, the audience is invited to redirect their attention to those sounds that are often ignored. Dugal McKinnon writes, 'To experience Cagean silence … is to give attention

---

[118] Douglas Kahn, *Noise, Water, Meat: A History of Sound in the Arts*, Reprint edition (Cambridge, Mass.: The MIT Press, 2001).
[119] Kahn, *Noise, Water, Meat*.
[120] Cage.
[121] The factuality of this claim has been disputed, as several doctors have confirmed that no one can hear the operation of his or her own nervous system. Cage was possibly hearing tinnitus. He would also have heard his breathing, however, he omitted this from his story.
[122] Cage.
[123] Kahn, *Noise, Water, Meat*.

to what is already there to be heard—all sound—and which is most often ignored or, in a long obsolete sense of the word, overheard (as in over-looked), by attention to what is supposed to be heard (music and speech).'[124]

Although *4'33"* shares many themes with the metaperceptual approach, it explores them through the context of the musical performance rather than by creating a true lack of stimulus. The redirection of the audience's awareness is contingent on the etiquette of the performance context. The expectations of the audience are created by their past experiences of what a musical performance entails, and it is Cage's radical rupture of this norm that changes the audience's awareness. In some ways, *4'33"* could be described as meta-musical, rather than metaperceptual. It questions the ontology of what musical materials and performance is, and through this, opens music up to include all sounds. It does this not by creating an experience of deprivation for the audience, but by disrupting the musical discourse.

As Cage found, the experience of absolute silence is impossible. We are always active creators of sound as we breathe, our heart beats, and we create noise as we move around our environment. While this makes it impossible to create a truly silent environment, this does not exclude us from experiencing deprivation in our aural sense. A lack of stimulus can redirect our attention back onto our perception, as those sounds that are constant and often ignored become our focus.

4.1.2 Silence

The experience of visiting an anechoic chamber shares many elements that metaperceptual works explore. The anomaly of such a quiet space creates an intrusion to our normal functioning and unveils the roles that our aural sense unconsciously plays. Speaking of his first encounter of an anechoic chamber, Thomas Howell, a contributor for Vice magazine, writes 'It's an oppressive sensation; much of our spatial awareness is defined by echo-location, and even with my eyes open the disorientation is irrefutable.'[125]

Extended periods in this space can create the awareness and introversion that many of the metaperceptual works seek to evoke. Howell continues 'Things that before were merely feelings—digestion, the relaxation of muscles—become audible. I hear the snapping of sinuses and a faint scraping sound as I raise my eyebrows and scalp shifts across skull.'[126] After around 45 minutes,

---

[124] Dugal McKinnon, 'Dead Silence: Ecological Silencing and Environmentally Engaged Sound Art', *Leonardo Music Journal*, 23.1 (2013), 71–74.
[125] Thomas Howells, 'Inside a Room Built for Total Silence', *Motherboard*, 2015.
[126] Howells.

Dance continues, 'I'd start to hear the blood moving through the capillaries around my ears. Eventually, there it is—a soft whooshing sound, the blood literally pumping around my head. The experience is hypnotic, even existential—I've never felt so aware of my body as a churning, organic machine.'[127]

An anechoic chamber is a highly technical and expensive space to create. Most of the chambers that exist have been built for industrial purposes, as they provide the ability to isolate a sound creator and analyse their sonic attributes. A rare exception is Doug Wheeler *PSAD Synthetic Desert III* (1971). First conceptualised in 1971, Wheeler was inspired by the experience of flying over vast expanses of desert with no traces of life. Wheeler described his experience of this void as hearing and seeing distance itself. This created a change of perspective, causing him to remark that 'you become conscious of yourself, it changes your perspective of how we fit into the mix of the whole universe.'[128]

PSAD Synthetic Desert III is a semi-anechoic chamber installed in The Guggenheim, transforming one of the rooms of the museum into a captivating quiet space. Audiences are let into the space for a set time, without electronic devices or distractions, and stand or sit on a platform that hovers above the floor. The room contains jutting stalagmite-like forms of acoustic foam that rise from the floor, dampening all hard surfaces and bringing the room's noise level down to 10 dB.

Fig. 19 Doug Wheeler, PSAD Synthetic Desert III

[127] Howells.
[128] 'Doug Wheeler: PSAD Synthetic Desert III', *Guggenheim*, 2016.

Wheeler is often associated with the Light and Space art movement which also included artists James Turrell, Robert Irwin and Mary Corse. Wheeler's works are predominantly visually based, and in *PSAD Synthetic Desert III*, the reduction of stimuli is also reflected in the visual elements of the room. All surfaces are a common blue-white, with no border visible between the wall and ceiling. This creates an illusion of a large environment with no horizon or distance reference point.

PSAD Synthetic Desert III presents the experience of the anechoic chamber to a wider audience, through its installation in the gallery. The audience's experience in the room is often similar to Thomas Howell's description of being in an anechoic chamber described above. Over time, their intentionality is drawn back upon themselves, becoming aware of their own body and the sounds that they cannot escape. Daniel McDermon writes 'Deprived of stimuli, my ears got hungry fast, and quickly recalibrated themselves… I tried to quiet my breaths, and got to the point where I wasn't sure if I heard them or felt them, or if there were any difference. The nerve signals of an ache in my foot seemed like actual noise, which gradually amplified into an inaudible scream and made me change positions. The sound of my legs shifting came from a distance.'[129]

copyrighted material

Fig. 20 Jaqueline Kiyomi Gordon, I Want You To Want Me To Want You To Want Me

Anechoic chambers and Wheeler's *PSAD Synthetic Desert III* create an immersive environment of deprivation, but this is not the only way to create an experience of aural deprivation. Another

[129] Daniel McDermon, 'How Much Silence Is Too Much? I Found Out', *The New York Times*, 7 April 2017, section Art & Design.

method is to create an isolated, focused area of deprivation, which can be found in Jacqueline Kiyomi Gordon's work. *I Want You To Want Me To Want You To Want Me* (2011) is a sculpture made from large wedges of melamine foam protruding from the wall that creates an isolated space of silencing. The foam is the same material used in anechoic chambers, and acts as an acoustic dampener. The audience is expected to get close to the wall, which effectively creates a constrained sonic void.

The presentation of aural deprivation in isolation creates a strong juxtaposition. The difference between *I Want You To Want Me To Want You To Want Me* and an anechoic chamber is that Gordon's work simultaneously presents both ends of the aural continuum. One can experience the busy milieu of sonic stimuli that exists in the gallery space while also experiencing the silencing of that stimuli. Through the contrast of these two elements, the act of silencing becomes the key perceptual material for the audience to explore, directing their aural awareness to the lack of stimuli. Gordon describes the experience of silence in her work as 'not mere subtraction, but an active absence.'[130] This active absence is the audience being aware of the subtraction, and is predicated by the audience being exposed to the noise present in the gallery space.

While the creation of a truly silent space has been proven to be problematic, the experience of deprivation can nevertheless be achieved by dramatically reducing the amount of stimulus. The perceptual result of this rupture of normality is that the audience's intentionality is lead to search through their perceptual field, straining to expand their perceptual horizon perceive any stimuli in their environment. Any sound in the environment sits on a horizon of their perception, its scarcity engendering it with a sense of liminality.

Deprivation is easier to create through directly blocking the ears, as sound is difficult to contain. This difficulty makes the experience of a silent space becomes more striking due to its rarity. While Gordon's work contrasts the noise of the gallery with its negation, my work, '∞/ø', discussed in Part III, extends these themes by contrasting white noise with its negation.

The visual analogue of silence is darkness; however, the closeness of this isomorphism is open for questioning. By examining works that create deprivation through the visual sense, the differences between the senses can be teased out. This comparison has the potential to uncover new avenues for metaperceptual sound artworks by showing unexplored aural analogues, and possible combinations of both visual and aural deprivation. The ways in which works have explored deprivation through darkness are discussed in the following section.

---

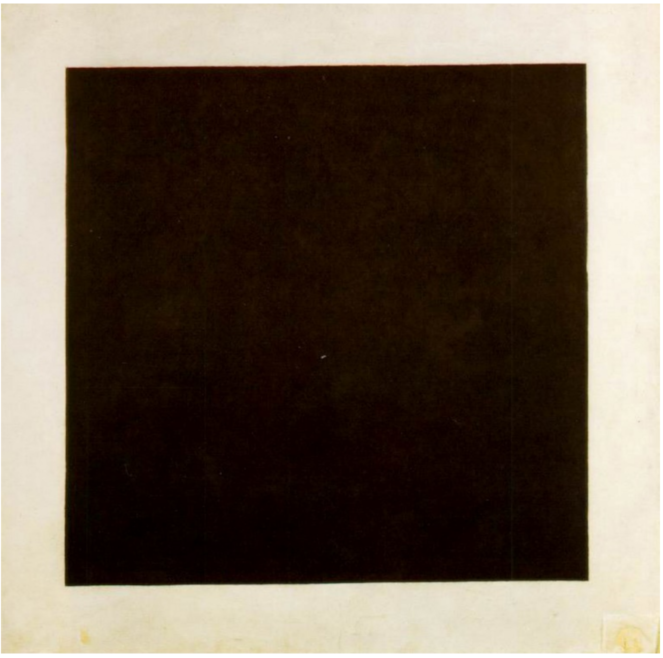
[130] Jacqueline Kiyomi Gordon, Artist Profile: Jacqueline Kiyomi Gordon, 2012.

4.1.3 Darkness

'Blind Sight refers to a condition, brought on by trauma or dysfunction, which inhibits people with sight from actually seeing. I am interested in the seeing that occurs within. In the lucid dream there is a greater sense of color and lucidity than with the eyes open. I am interested in a place where the imaginative seeing and the seeing of the external world meet, where it is difficult to distinguish the seeing from within from the seeing from without. The image is of no interest other than it triggers the seeing from within. This seeing occurs near the edge of the cone area of the retina and it moves towards the rod area, which generates seeing over which you have complete control.' [131]

—James Turrell

Just like silence in sound art, darkness in visual art has been subversive material. In 1915, Kazimir Malevich produced *Black Square* (1915), a roughly shaped rectangular canvas painted purely black. The work marked an important moment in the history of the visual arts. This was debatably the first time that an artist had created a painting that was not depicting something, although many would attribute this feat to Wassily Kandinsky.[132] The work dramatically announced 'suprematism', Malevich's term for a new form of abstract art that rejected the representational art of the time. Suprematism also rejected the multiplicity of the creative conventions of Cubism for a delimited palette of basic planar geometrical figures in simple block colours. This signalled an important shift away from representing reality through art to abstraction.



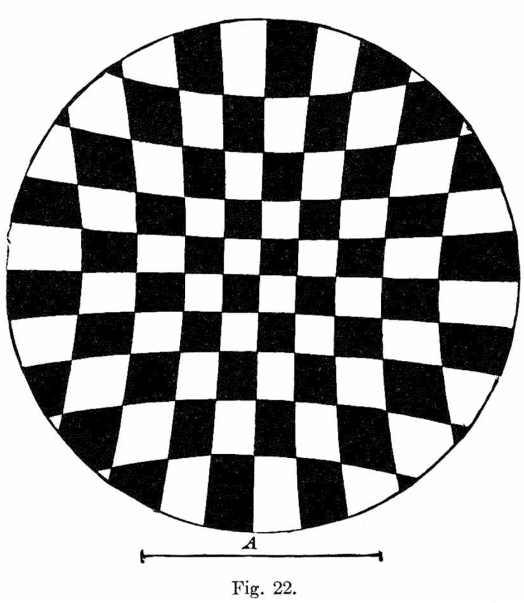


Fig. 21 Left: Kazimir Malevich, Black Square; Right Helmholtz's pincushion chessboard

---

[131] Michael Govan and others, *James Turrell: A Retrospective*, 1st edition (Los Angeles : Munich ; New York: Prestel USA, 2013).
[132] Susan Holtham and Fiontan Moran, 'Five Ways to Look at Malevich's Black Square', 2014.

The origin and inspiration for Malevich’s negation of Cubism and representational art has themes in common with the metaperceptual approach. In her book on the creative processes in Malevich works, Patricia Railing argues that Malevich’s Suprematism was heavily influenced by Hermann von Helmholtz’s descriptions of experiments with optical phenomena.[133] Helmholtz created a pincushion chessboard, shown in Fig. 21, to show the distortion of the human visual field. To see the figure in the way Helmholtz intended, the figure should be enlarged. At a normal viewing distance, the chessboard appears as it is, with distortions increasing as it moves away from the centre. However, when viewed closely at a critical distance, denoted by the line below the chessboard, the chessboard appears undistorted and composed of roughly equal-sized black and white squares separated by roughly parallel lines.[134]

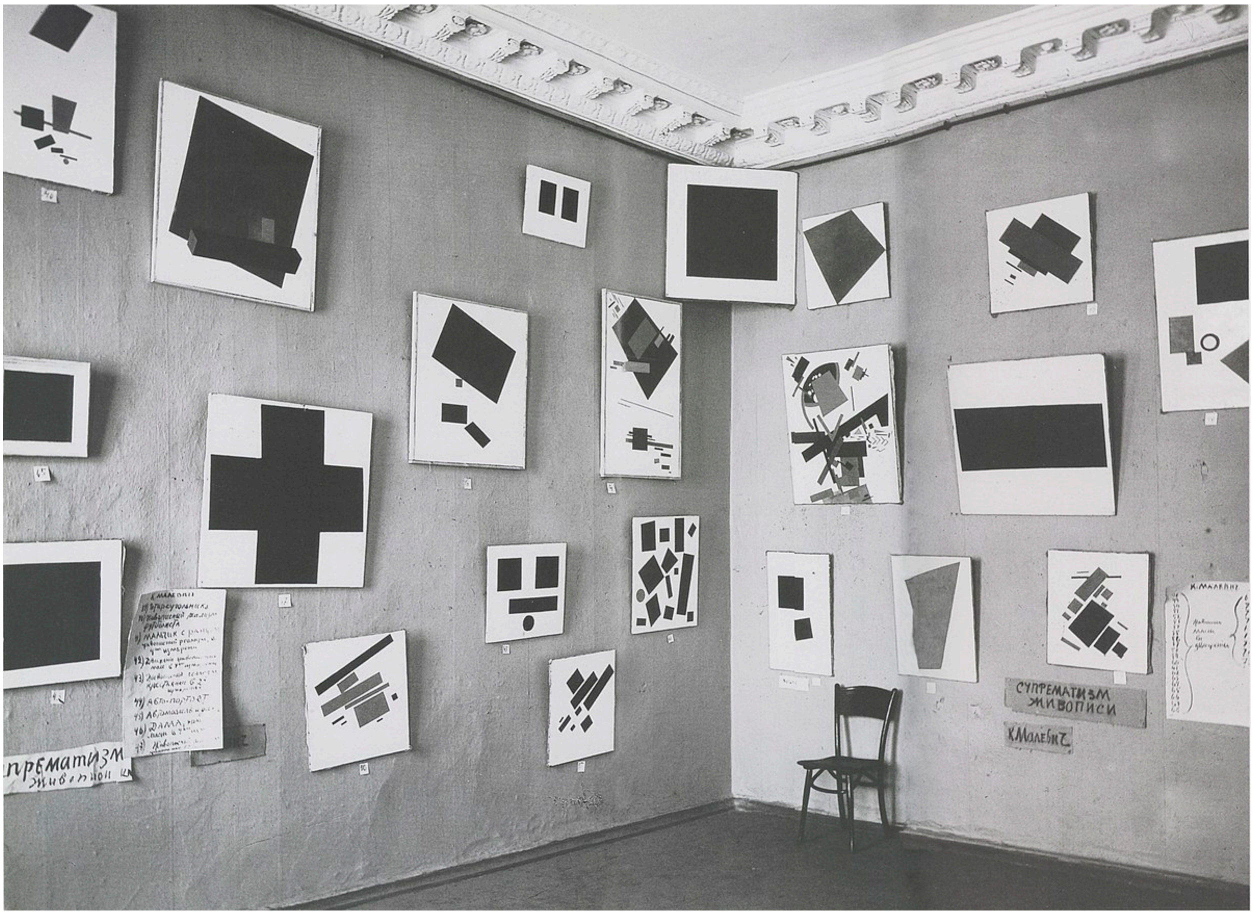


Fig. 22 The Last Futurist Exhibition 0.10 in Petrograd, 1915. Kazimir Malevich’s Black Square is shown at the top and centre of the room

The influence of Helmholtz’s writing and figures about optical phenomena can be seen in multiple elements of Malevich’s works. Helmholtz’s revelation of a fracture between the objective world and our perception is emblematic of Malevich’s adoption of abstraction. His move away from representing reality to using basic geometrical forms in limited colours marks a shift towards

---

[133] Patricia Railing, *Malevich Paints: The Seeing Eye* (London: Artists Bookworks, 2018).
[134] Brian Rogers and Kenneth Brecher, ‘Straight Lines,“Uncurved Lines”, and Helmholtz’s “Great Circles on the Celestial Sphere”‘, *Perception*, 36.9 (2007), 1275–1289.

perception, and the way that we see, as artistic materials. As Railing writes on the creation of Suprematism, 'In an iconoclastic gesture, Malevich wiped his canvas clean and began to explore the phenomena of colour and light as pure optical sensations.'[135]

Furthermore, the iconography of Helmholtz's work can be seen throughout many of Malevich early works. Railing tracks the visual lineage of *Black Square* back to the centre of Helmholtz's pincushion chessboard. Malevich transformed planar geometric figures from Helmholtz's diagram into the primary paintings of Suprematism which included *Black Square*, *Black Rectangle*, *Black Cruciform*, and *Suprematist*. These seminal works were first shown at 'The Last Futurist Exhibition 0.10' in Petrograd, 1915, alongside a range of other works by fellow artists who had adopted a similar visual vernacular. *Black Square* forms the philosophical crux of Malevich's new artform, which is reflected both in its purity and position in the exhibition. The work was raised above all the other works, positioned in the top corner of the room and taking the place traditionally reserved for Russian religious icons. The other works which are derived from different positions on Helmholtz retinal map were placed around the room. For instance, *Black Rectangle* is positioned on the right in Fig. 21, and shows the shape of seeing at the periphery of the field of vision in indirect vision, elongating the pure square form.

Malevich's suprematist artworks are informed by the nature of perception and seek to create a form based on pure sensation; a theme they share with many of the metaperceptual works. Like John Cage's *4'33"*, *Black Square* is an iconoclastic artwork that, through an act of reduction, challenges the audience to renegotiate their notion of the artwork. While the reduction in Black Square brings attention to the norms of its medium, it does not deprive the audience perceptually. The audience still experience the work in the context of a dimly-lit room, surrounded by other visual works in a similar vernacular. For the blackness of the artwork to create a sense of visual deprivation and become the perceptual material, either the blackness needs to be more immersive, or more focused.

The 'black' paint that covers the canvas of *Black Square* does not completely absorb all light, and therefore is not truly black. A true black paint would completely absorb all light, creating a perceptual void and a lack of stimulus. The search for the ultimate black has been shared by many artists, and a range of different materials have been employed to create closer approximations of true black. Anish Kapoor has used pure pigment in a range of 'void' works, which create an isolated negation of space. In *L'origine du monde* (2004), shown in

[135] Railing.

Fig. 23, the audience sees a large black oval centred in the middle of a slanted concrete slab angling against one wall of the gallery. While the oval appears to be flat, closer inspection reveals that it is a large recess, with its walls coated in dark blue pigment. The purity of the pigment absorbs most of the light, making for a perceptual confusion of space.

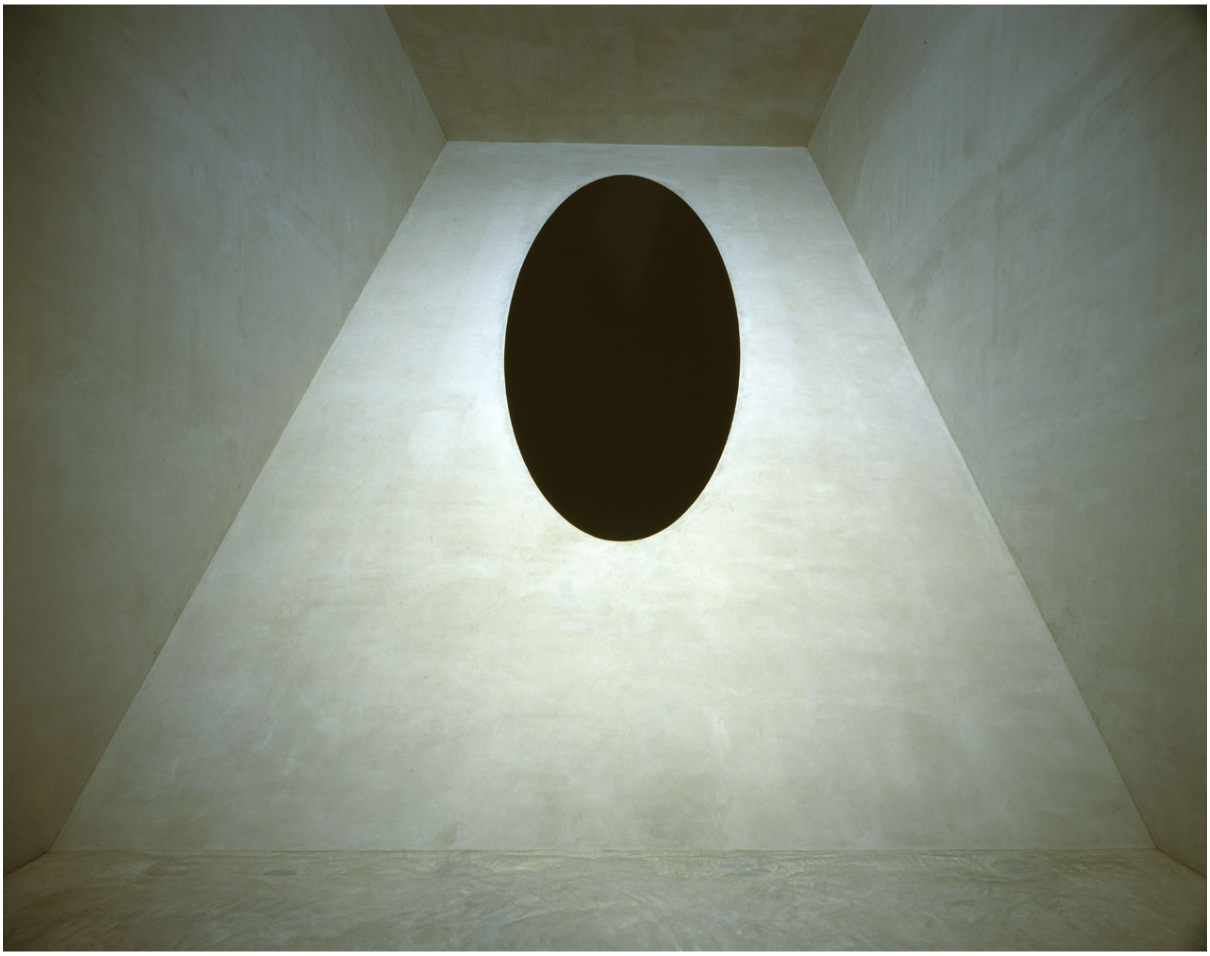


Fig. 23 Anish Kapoor, L'origine du monde. Image provided courtesy of the artist.

In a similar mode, *Descent into Limbo* (1992) creates a perceptual void on the floor of a cubed building. The work also uses pure dark pigment, lining the walls of a cavity created in the floor, absorbing almost all light. Kapoor writes in the works notes that 'This is a space full of darkness, not a hole in the ground.'[136] Perceptually, the void creates a confusion of depth, making it difficult for the audience to determine if it is a hole or flat. This caused an audience member to furiously react after waiting in line for around 45 minutes. He exclaimed that 'I have never stood in line for all that time to look at a piece of carpet.'[137] He then took his glasses off and threw them on to the carpet, and of course, they disappeared into the hole. Kapoor describes this shift in perspective as

[136] Anish Kapoor, *Descent into Limbo*, 1992.
[137] Charlotte Higgins, 'A Life in Art: Anish Kapoor', *The Guardian*, 8 November 2008, section Art and design.

a ‘sublime moment’[138], where a thing becomes not a thing. This is a moment where our perception fails us and makes us question the difference between the qualities of the material world and how we perceive it.

Fig. 24 Anish Kapoor, Descent into Limbo. Image provided courtesy of the artist.

---

[138] Anish Kapoor and Andrew Marr, Anish Kapoor on Light and Dark, Start the Week - BBC Radio 4, 2016.

In his search for creating these void works, in 2016, Anish Kapoor gained exclusive rights to use 'Vantablack', a new material which is now the darkest material ever made. Vantablack is not a pigment, but a material consisting of billions of carbon nanotubes clustered together that absorbs up to '99.965% of the visible light spectrum.'[139] The pigment was being developed for scientific and military purposes, with potential uses ranging from hiding stealth aircrafts, to blocking out light entering powerful telescopes, enabling them to see the faintest stars.[140] As yet, Kapoor has not produced a work with this new material, as it is currently too difficult to make sufficient quantities to apply to artworks. However, this may be more perceptually powerful method of creating his void pieces in the future, as the materials approaches pure blackness.

Kapoor's void works involve an isolated area of space that absorbs light, in a similar method to Jaqueline Kiyomi Gordon's silencing of sound in *I Want You To Want Me To Want You To Want Me*. Both works absorb stimuli, leaving behind a perceptual void. In parallel to the silencing of sound, another approach is to create immersive environments of deprivation.

James Turrell's artworks are often immersive environments that have a transformative effect on the audience. Given this, many of his works fit into the metaperceptual framework. Along with Robert Irwin, Mary Corse, and Doug Wheeler, Turrell spearheaded a new minimalist movement on the American West Coast in the 1960s called 'Light and Space'. These artists focused on using perceptual phenomena as materials, creating installations that brought attention to the qualities of light itself. Turrell especially has dedicated his career to exploring the 'thing-ness' of light. Michael Govan writes that 'By devising means to hold light as an isolated and almost-tactile substance, Turrell has created opportunities for us to experience it as a primary physical presence rather than as a tool through which to see or render other phenomena.'[141]

Turrell's ability to control and present light itself is often channelled towards creating experiences of appreciation for the act of seeing. However, as phenomenologist Gernot Böhme notes, 'Light is not the only precondition of visibility. Darkness is another.'[142] In his Dark Spaces series, Turrell explores this other precondition through visual deprivation. The series of works, including *Selene*

---

[139] S. P. Theocharous, E. Theocharous, and J. H. Lehman, 'The Evaluation of the Performance of Two Pyroelectric Detectors with Vertically Aligned Multi-Walled Carbon Nanotube Coatings', *Infrared Physics & Technology*, 55.4 (2012), 299–305.
[140] Brigid Delaney, '"You Could Disappear into It": Anish Kapoor on His Exclusive Rights to the "Blackest Black"; Architect and Artist Defends Controversial Deal with Developers of Vantablack, the Blackest Material "after a Black Hole"', *The Guardian (London, England)*, 2016.
[141] Govan and others.
[142] Gernot Bohme and others, *James Turrell: Geometry of Light*, ed. by Ursula Sinnreich, 1 edition (Ostfildern: Hatje Cantz, 2009).

(1984) shown in Fig. 25, typically consist of an unlit corridor leading to a completely sealed and darkened room. The size and shape of the room are indeterminable for the audience. The viewer sits in complete blackness for an extended period, at least ten minutes. Over this time, the audience's perception goes through the process of adaption, the eyes slowly adjusting, and a faint glow starts to appear. The light is so faint that the room is never revealed; instead, the light itself seems to be a discrete object. Its presence is often hard to place, provoking questions of whether it is an illusion or not. As critic Kenneth Baker describes it as 'too dim to "place" spatially, and since you can get no sense of the shape of the space around you, the nimbus of light begins to play strangely upon your optical nerves. It starts to pulse, to move towards you and lose its definition as something distinct from the activity of your own sensory apparatus. Gradually, aided by the total silence of the soundproof space, it dissolves your normal sense of your body as a boundary dividing what you see from what enables you to see it.'[143]

Fig. 25 James Turrell, Selene

The darkness allows for a redirection of the audience back on to themselves, questioning whether what they see is real, or their perception straining to see something in the dark. As Turrell's writes,

[143] Kenneth Baker, 'Meg Webster and James Turrell at the Mattress Factory', *Art in America*, May 1985, p. 19.

'It becomes difficult to differentiate between seeing from the inside and seeing from the outside.'[144] The darkness condenses the audience's perceptual field, blurring the boundaries between outside and in, and between body and space.

Lack of stimulus works use silence and darkness as their core perceptual materials. The lack of stimulus in these environments creates an experience of deprivation, in which the audience is left with only vestiges of light and sound. This deprivation often reveals that which is overheard and overlooked, inviting the audience to take their time and attend to their environment, and to their own perceptual faculties. When this deprivation is captured and contained to an isolated area of space, the contrast between chaos and nothingness becomes magnified. And in cases like Anish Kapoor's void works, the audience questions if what they are experiencing is real or a hallucination.

When we think of deprivation, usually we think of darkness and silence. However, we can be presented with an abundant amount of stimulus and still experience deprivation, such as when the perceptual field is devoid of difference. The following section surveys works that explore deprivation through creating environments and experiences in which the audience is unable to perceive any differentiation throughout their perceptual field.

4.2 Uniformity of Stimulus

Another form of deprivation is experienced when we are immersed in a homogenous perceptual field. Over time, the perceptual apparatus can start to shut down when there is a lack of differentiation in the perceptual field. This section looks at works that employ uniform fields of stimuli to create a sense of deprivation for the audience.

4.2.1 Ganzfeld Effect

In the visual sense, Ganzfeld is a German term meaning 'complete field' used to describe an undifferentiated region of stimuli. The effect of a Ganzfeld can be compared to the natural visual phenomenon of a whiteout that occurs during a blizzard. The visual sense is bathed in a pure field of light, which denies the viewer any cues of differentiation. Over time, this leads to the sense of deprivation as the visual sense shuts down. In some cases, it leads to visual hallucination, making it difficult for a person to tell if what they are seeing is real or imagined.[145]

[144] Govan and others.
[145] Govan and others.

Lack of stimulus and a Ganzfeld operate on different neurophysiological principles. In darkness and silence, the body's receptors (the rods and cones of the retina and the hair cells of the inner ear) are in a dormant state and do not send any information up the neural pathways to the higher centres of the brain. There is no perceptual event, other than the awareness of nothingness. Contrastingly, in the experience of a Ganzfeld, the cones are strongly stimulated, and as the stimulus remains constant, the cones maintain a fixed charge. These receptors excite parts of the neural pathway in the higher centres of vision. Since external visual input is minimal, the only significant perception is of the perceptual process itself.[146]

The deprivation of the Ganzfeld effect is unlike the experience of a lack of stimulus, as it debilitates the visual orientation of the viewer, and alters their perception of colour. The homogeneity of the perceptual field often causes the viewer to continuously scan the environment with jerky eye movements, shifting their intentionality in search of cues to establish visual orientation. The viewer eventually loses awareness of the direction of their gaze and eye movements become slow.[147] The viewer's sense of colour becomes affected, dramatically changing over time. The perceived colour 'bleaches'[148] over several minutes and, if viewing is prolonged, may reach a neutral shade of grey.[149] Eventually, total visual cessation or 'blank-out' may occur.[150] The viewer experiences not merely the presence of a dark empty field, but a complete disappearance of the sense of vision. Without any new information, the visual sense is kept in an equilibrium that causes the brain to stop processing the stimuli. This deprivation can be to the extent that the viewer can be doubtful of whether their eyes are open or closed. Subjects of a psychophysiological trial on the Ganzfeld effect reported that 'they were uncertain whether their eyes were open or closed, or even unable to control their eye movements. In the 'luminous fog' of the Ganzfeld the subjects do not see anything; in the 'blank-out' periods, they may experience presence of 'nothingness.'[151]

---

[146] Scott Daly, 'The Ganzfeld as a Canvas for Neurophysiologically Based Artworks', *Leonardo*, 17.3 (1984), 172–175.
[147] James W. Miller and Robert J. Hall, 'The Problem of Motion Perception and Orientation in the Ganzfeld', *Visual Problems of the Armed Forces. Washington: National Academy of Science-National Research Council*, 1962, 14–20.
[148] Jiří Wackermann, Peter Pütz, and Carsten Allefeld, 'Ganzfeld-Induced Hallucinatory Experience, Its Phenomenology and Cerebral Electrophysiology', *Cortex*, Special Issue on 'Neuropsychology of Paranormal Experiences and Beliefs', 44.10 (2008), 1364–78.
[149] Julian E. Hochberg, William Triebel, and Gideon Seaman, 'Color Adaptation under Conditions of Homogeneous Visual Stimulation (Ganzfeld).', *Journal of Experimental Psychology*, 41.2 (1951), 153.
[150] Walter Cohen, 'Form Recognition, Spatial Orientation, Perception of Movement in the Uniform Visual Field', *Visual Search Techniques*, 1960, 119–123.
[151] James J. Gibson, *The Ecological Approach to Visual Perception: Classic Edition* (Psychology Press, 2014).

The uniformity of stimulus can also provoke hallucinations, ranging from murky lights to vivid scenes comparable to dreams. One subject described their first experience as such: ‘For quite a long time, there was nothing except a greengreyish fog. It was really boring, I thought, “ah, what a nonsense experiment!” Then, for an indefinite period of time, I was “off”, like completely absent-minded. Then, all of sudden, I saw a hand holding a piece of chalk and writing on a black-board something like a mathematical formula. The vision was very clear, but it stayed only for few seconds and disappeared again. The image did not fill up the entire visual field, it was just like a “window” into that foggy stuff.’[152]

This hallucinatory effect is not restricted to a tightly controlled Ganzfeld environment. Ganzfeld-like conditions may be found in exceptional natural environments. Long-haul truck drivers have reported seeing lights during extended periods of driving through the white-out conditions in snowstorms. The same phenomenon has been reported by prisoners confined to dark cells and kept in darkness. Airplane pilots often experience these conditions when they are flying alone at high altitudes, where the sky is cloudless and empty of the usual depth cues.[153]

Fig. 26 James Turrell, Breathing Light

This illusory experience while flying is one of the forces that inspired a series Ganzfeld works by James Turrell. His exploration of deprivation through darkness has been discussed previously in

[152] Wackermann, Pütz, and Allefeld.
[153] Gerald Oster, ‘Phosphenes’, *Scientific American*, 222.2 (1970), 82–87.

4.1.3, and his Ganzfeld series continues his creation of immersive deprivation environments. He writes 'I am interested in this new landscape without horizon. If you go into the Ganzfeld pieces it is a little bit like the landscape that you can find when flying around through cloud or fog…We are moving into the territory of horizonless space that you can also experience in outer space without gravity.'[154]

In a series of works, including *Breathing Light* (2013) shown in Fig. 26, Turrell creates rooms which bathe the audience in coloured light. All surfaces are smoothed; walls, floor and ceiling, softly running into each other creating an imperceptible barrier of space. All surfaces are finished with reflective white paint, adding to the effect of the negation of physical space. Instead, light itself seems to become structural, holding the audience up and enveloping them. Over time, the light changes slowly in colour, Esther Kirschner writes of her experience: 'If you plunge into the dimensionless world where all architectural features—light, color, and space—blend into one, the eye is lost in the diffuse mist of light, which is evenly lit by the reflected light of the white walls… an undifferentiated void that could be anything.'[155]

Turrell's Ganzfeld spaces are dynamic, with their colour changing slowly over time. This allows for a phasing in and out of the Ganzfeld effect. As can be seen in Fig. 26, often there is a main geometrical figure, that at times offers a point of differentiation. The contours and borders offer visual information that orients the viewer. Over time, the colour between the main figure and the room unify, creating a pure sensory field. At this point, Vice magazine contributor Chris Hampton, writes of his experience: 'The walls sublimate. The field ahead appears like a mist. I can feel the ground underfoot. But to my eyes, I'm walking in the void. It's as intense as any psychedelic experience I've had.'[156]

As with many of the deprivation works, not everyone enjoys the Turrell experience. There is a degree to which the audience must surrender themselves to the work. The comfort of knowing what is real and what is not starts to be decayed, which can be exhilarating or distressing. The disorientation can be so powerful that it can be dangerous for a small number of viewers. During one of Turrell's exhibition at the Whitney Museum of American Art in 1980, a few visitors to a piece called *City of Arhirit* (1976), shown in

[154] Govan and others.
[155] James Turrell, Richard Andrews, and Peter Weber, *James Turrell: The Wolfsburg Project* (Hatje Cantz, 2009).
[156] Chris Hampton, 'I Stared Into the Void at a Secret Light Show in Las Vegas', *Motherboard*, 2015.

Fig. 27, became unsteady in the bright blue haze and tried to brace themselves against a wall made of light. Some of them fell and a few were hurt. One woman, who broke her arm, sued the Whitney and Turrell for more than $10,000, claiming that the show made her so "disoriented and confused" that she "violently precipitated to the floor."[157]

copyrighted material

Fig. 27 James Turrell, City of Arhirit

[157] Wil S. Hylton, 'How James Turrell Knocked the Art World Off Its Feet', *The New York Times*, 13 June 2013, section Magazine.

The ‘infinite fog’[158] that viewers often experience in the Ganzfeld works of James Turrell can be experienced in a more direct and literal way in Antony Gormley’s *Blind Light* (2007). The work is a large glass room constructed within the gallery, filled with a dense white mist and lit up with brilliant diffused light. Participants walk into the room, inhabited with up to 25 other visitors, to be engulfed in the light fog. It consumes the audience’s vision, reducing their perceptual field to only a few centimetres in front of them. The embodied element of the work pushes past the visual sense, with the fog penetrating the audience, filling their lungs and noses, flooding their visual and olfactory senses. The experience deprives the audience of their depth perception, creating an ethereal space. Deborah Wilk, reviewer for ‘Time Out New York’, writes that ‘Entering the mist is a little like walking on the moon: You lose all sense of direction.’[159]

copyrighted material

Fig. 28 Antony Gormley, Blind Light

The environment may not be quite as dislocating and hallucination-inducing as James Turrell’s Ganzfeld spaces, as the fog environment does not completely produce the Ganzfeld effect. There will always be some amount of differentiation throughout the audience’s visual field. The fog itself has inconsistencies in its density, and because the environment is dynamic with people moving through it, the gaseous clouds will have a degree of movement to them. *Blind Light* sits somewhere

[158] Hampton.
[159] Deborah Wilk, ‘Antony Gormley, “Blind Light”‘, *Time Out New York*, 2007.

between the Ganzfeld effect and the occluding of the senses, as the density of the fog consumes the visitor's perception.

Blind Light also shares thematic elements of social interaction that are explored in Marina Abramovich's *Generator*. The fog-filled room is occupied by up to 25 visitors, and the pervasion of the visual sense of the audience creates spatial deprivation. In both *Generator* and *Blind Light*, the audience must renegotiate the physical and social environment of the gallery space. One perceptual difference between the works is that *Blind Light* does not deprive the aural sense of the audience. This creates an interesting change of dynamic between the senses, as the visitors can be aware of other people in the space, but only through the aural sense. In this way, the visual deprivation forces a reordering of the privilege between the senses, provoking a renegotiation of the ways in which they traverse their physical and social environment. This renegotiation provokes a metaperceptual experience for the audience.

The reaction to being enveloped within the illuminated fog of *Blind Light* varies between each visitor. As with many of the other deprivation works, the initial response may be of anxiety, as the normal modes of experiencing are removed. One reviewer's sensational warning was: 'Those who enter the *Blind Light* room, above, take their lives in their hands… No one with asthma or a heart disease of any kind should enter it; my immediate response was difficulty in drawing breath, followed by violent sneezing, then equally violent coughing and a crazily erratic heartbeat.'[160] However, as the audience adapts to the space, many find the experience a transcendental one. As reviewer Deborah Wilk writes, 'The visceral intensity of *Blind Light* treads far beyond gimmicks of shock or beauty. Its effect of displacement imparts an odd sort of euphoria, a feeling of transcendence like the one described by crash survivors. But Gormley's chamber is far more serene than near death, suggesting the key to such rapture is a relaxed, albeit rigorous pursuit.'[161]

4.2.2 Isolation Tank

Deprivation through the uniformity of the perceptual field is not limited to the visual sense. Through research into sensory deprivation, techniques were developed to keep the body's sense of touch and balance in equilibrium. In the 1950s, John C. Lilly created the first isolation tank: a dark, soundproof tank of warm salt water in which a person could float for long periods in sensory isolation.[162] Lilly sought to investigate the effects of isolating the brain from external stimulation,

---

[160] Evening Standard, 'Lost in the Fog', *Evening Standard*, 2007.
[161] Wilk.
[162] John C. Lilly, 'Mental Effects of Reduction of Ordinary Levels of Physical Stimuli on Intact, Healthy Persons.', *Psychiatric Research Reports*, 1956.

and in his book *The Deep Self*, he shows readers how to unfold and experience new degrees of self-awareness and personal harmony.'[163]

Inside the tank, a participant floats in salt water that is kept at skin temperature, in complete darkness and silence. The density of solution allows the body to float supine and have the whole body at or near the surface of the liquid. Through the suspension of the body, and with the skin kept at an even body temperature, the somatosensory and vestibular systems are kept in a constant equilibrium. As Lilly explains, 'The tank eliminates the presence of these shifting physical input patterns and their changes and reduces the intensity of stimulation down to the most minimum level possible.'[164]

The equilibrium of the touch and balance senses of the participant is coupled with darkness and silence, creating a fully immersive environment of deprivation. The tank was one of the methods that allowed for experiments into the effects of sensory deprivation on the body and mind. In the 1950s, sensory deprivation research became a growing academic field, with its effects invoked to explain a wide range of phenomena from religious revelations to the very structure of psychoanalysis.[165]

There are a wide range of effects that sensory deprivation has been reported to cause in various psychological trials. These effects are dependent on the length of deprivation, and the perceptual conditions that the subjects endure. *Panic, fear,* and *anxiety* were found in many studies, with anxiety or panic given as the reason for leaving isolation given by 16 of the 19 subjects in one study.[166] The *affective level* of the subjects were reported to change, varying from depressive episodes,[167] large mood-swings,[168] and one subject developing a childish sense of humour, irritability, and annoyance.[169] *Perceptual qualities* experienced by the subject were reported to be effected, including the size and shape of the room appearing to alter over time, colours becoming brighter and highly saturated or luminescent,[170] and straight lines appearing to move, change shape

---

[163] John Cunningham Lilly, *The Deep Self: Profound Relaxation and the Tank Isolation Technique* (Simon & Schuster, 1977).
[164] John Cunningham Lilly.
[165] Mical Raz, 'Alone Again: John Zubek and the Troubled History of Sensory Deprivation Research', *Journal of the History of the Behavioral Sciences*, 49.4 (2013), 379–95.
[166] S. Smith and W. Lewty, 'Perceptual Isolation Using a Silent Room', *Lancet (London, England)*, 2.7098 (1959), 342–45.
[167] Smith and Lewty.
[168] Jay T. Shurley, 'Profound Experimental Sensory Isolation', *American Journal of Psychiatry*, 117.6 (1960), 539–545.
[169] B. K. Doane and others, 'Changes in Perceptual Function after Isolation.', *Canadian Journal of Psychology/Revue Canadienne de Psychologie*, 13.3 (1959), 210.
[170] Doane and others.

and size, and haloes to develop.[171] The perception of *time* was often effected, with both overestimation[172] and underestimation[173] of time passed observed in different trials. Some studies found *body image disturbances,* with subjects developing a feeling of strangeness towards their own body, including one subject reporting 'my arm is like a ton wright and feels fatter than my body.'[174] Lastly, some studies found that sensory deprivation caused hallucinations, both in the visual and auditory domains. Visual hallucinations included shapes and colours, with one subject reporting to see 'an inverted V in brilliant blue and white flame moving through dark space.'[175] Auditory hallucinations were less frequently reported, with some subjects describing hearing voices, and banging sounds, and one participant hearing 'the gliding sound of his own large joints.'[176]

These profound perceptual, psychological, and physical effects, were also used for nefarious purposes. Researchers turned their attention to examine how psychological methods could be used to modify and control human behaviour. These experiments provided part of the scientific basis for the CIA's now notorious research program on behaviour modification: MKUltra. From the early 1950s and until 1963, MKUltra supervised 149 projects focused explicitly on behaviour modification and the control of human consciousness. Sensory deprivation was one of the fields in which MKUltra was deeply invested. In the early 1950s, the CIA began funding sensory deprivation experiments within the United States.[177] Within the context of the Cold War, speculation around this field of research quickly established 'mind control' as a topic of public fascination and academic research.[178] The result of this was that the newly coined term 'brainwashing' emerged as a significant concern for military officials and the lay public, as newspapers, books, and movies depicted the psychological dangers.[179]

The experience of sensory deprivation has been shown to have the potential to cause dramatic effects in range of experiential areas, especially over extended periods of times. The deprivation

---

[171] Henry U. Grunebaum, Sandford J. Freeman, and Milton Greenblatt, 'Sensory Deprivation and Personality', *American Journal of Psychiatry*, 116.10 (1960), 878–882.
[172] Smith and Lewty.
[173] Robin Banks and Daniel Cappon, 'Effect of Reduced Sensory Input on Time Perception.', *Perceptual and Motor Skills*, 1962.
[174] Smith and Lewty.
[175] Shurley.
[176] Leo Goldberger and Robert R. Holt, 'Experimental Interference with Reality Contact (Perceptual Isolation): Method and Group Results.', *Journal of Nervous and Mental Disease*, 1958.
[177] Alfred McCoy, *A Question of Torture: CIA Interrogation, from the Cold War to the War on Terror*, Reprint edition (New York: Holt Paperbacks, 2006).
[178] Raz.
[179] Raz.

effects of the isolation tank can be used as a perceptual framer in artworks like *Iso-phone* (2003), shown in Fig. 29, by Jimmy Loizeau and James Auger. *Iso-phone* uses sensory deprivation to force the audience to renegotiate their normal behaviour during a phone call. Before the advent of mobile phone technology, the act of having a phone call was often restricted to the telephone box. This created a designated space in which the caller ceased to continue other activities, and forced the individual to concentrate solely on the conversation. Mobile phone technology allows for the caller to communicate in an expedient, rather than attentive manner. It is now common for the caller to be preoccupied with other activities, and only pay part of their attention to the conversation. In this way, the mobility of the technology delocalises and can distract from communication.

Fig. 29 Jimmy Loizeau and James Auger, Iso-phone. Image provided courtesy of the artists.

Iso-phone creates an environment which attempts to redress the decay of purity in telephone communication. The participant enters into a large body of water that is heated to body temperature. They wear a helmet apparatus that blocks their visual and aural sense, reducing their perspectival field to a small area around their head. Floating in the warm water, they are enveloped up to their neck. Over time, the uniformity of the stimulus that the water produces a feeling of disembodiment, which they claim frees up 90 percent of their brain's workload. In this environment, they are then free to make a phone call, and communicate with someone else, who, in some versions of the work, are in a reciprocal tank in the same deprivation conditions.

Loizeau and Auger effectively detach the participant's body from their external world of stimuli world by reducing their visual and aural sense, and keeping their touch and balance sense in a constant equilibrium. The deprivation in *Iso-presence* disrupts the normal modes of behaviour involved with making a phone call. This disruption asks the participant to renegotiate their normal modes of behaviour, and partake in a focused experience of communication. The distractions of the everyday are removed, leaving only the sound and content of their conversation with another person.

The renegotiation in *Iso-phone* detaches the audience from their bodily senses, and redirects their attention to the conversation space of their phone call. Although this work shares many themes with other metaperceptual works, the redirection away from the audience's perception makes this work not metaperceptual. This work highlights that the deprivation of the audience in itself, is not sufficient for creating metaperceptual works. The content of the work and the intent of the redirection need to be centred around creating a metaperceptual experience for the audience.

There is great potential for works that use the isolation tank as a powerful deprivation environment. It is well-suited to exploring the metaperceptual theme of redirecting the audience's awareness back onto themselves, allowing for facets of their perceptual apparatus to be revealed. This could be achieved by carefully curating the audience's stimuli, as the environment allows for the negation of multiple senses. Alternatively, the environment could also be used to further some of the deprivation themes that are present in current art practices. Many acousmatic works seek to create coherent and realistic soundscapes in which we are immersed. Francisco Lopez's advancement of the acousmatic situation by blindfolding his audience, as discussed in Section 3.3.1, could be furthered through this multi-modal deprivation environment. This may allow for a deeper immersion in the soundscapes that Lopez creates, in a similar vein to the way that Loizeau and Auger are able to create a focused experience of a telephone call.

4.2.3 Aural Uniformity

As the core focus of this framework is to contextualise and support the realisation of aural works, a discussion of the possibility of a uniform aural stimulus field creating similar metaperceptual experiences is needed. The closest aural analogue of the Ganzfeld effect, or the uniformity of stimulus present in the isolation tank, is noise. In scientific trials to study the effect of the Ganzfeld, a wide range of acoustic stimuli have been used to create a homogenous sensory input for the aural sense. In the pioneering experiments on the Ganzfeld effect, the participant would wear a set of headphones through which white or pink noise would be played.[180] The noise complimented the visual uniformity, created through the participant wearing halved ping-pong balls over their eyes and having a red light shone on them. The ping-pong balls acted as diffusers of light, creating a uniform light field. Following these initial experiments, other forms of aural stimuli have been used as well. Wackermann et al. argue that 'equivalent results may be obtained using monotonous natural noises or sounds',[181] including the sounds of waterfalls.

These complex, noisy soundscapes are constantly irregular, which oxymoronically, turns the chaos into uniformity. However, the perceptual effect is not the same as with its visual equivalent. The exposure to a uniform field of white noise does not create the vibrant experiential effect as one of James Turrell's Ganzfeld works, where the uniformity creates a sense of deprivation through the sense being kept in an equilibrium.

This may be due to a difference in adaptation between the senses. Most of the bodily senses become subjectively weaker under prolonged stimulation. A common experience is of olfactory fatigue, where the sense of smell is quickly blunted. While the initial scent of an odour can be powerful, this rapidly diminishes, to the point where it becomes impossible to detect a smell clearly, or even to smell it at all for a time. [182] On the other hand, our perception of loudness does not usually diminish over time due to prolonged exposure. There are only a few exceptions to this: for pure tones within approximately 30 dB of the perceptual threshold; for sounds heard in the presence of other intermittent sounds; and lastly, for some people who are suffering from retrocochlear lesions.[183]

The process of adaptation in the Ganzfeld or isolation tank environment makes the audience aware of the deprivation. They move from an initial stage of immersion in a sea of stimuli, to experiencing a lack of differentiation. In some cases, this leads to the experience of not sensing at all. It is the process of removal which makes the deprivation become a key experiential element for the audience. Due to the aural sense not adapting over time, except in special conditions, the same experience of deprivation through uniformity of stimulus does not seem to be possible. Based upon the survey of sound-based works, as far as I am aware there have not been any artworks which have used a uniform sound field to explore the theme of deprivation.

---

[180] Philip John Tyson, Dai Jones, and Jonathan Elcock, *Psychology in Social Context: Issues and Debates* (John Wiley & Sons, 2011).
[181] Wackermann, Pütz, and Allefeld.
[182] R. W. Moncrieff, 'Olfactory Adaptation and Odour Likeness', *The Journal of Physiology*, 133.2 (1956), 301–16.
[183] Georges Canévet, Bertram Scharf, and Marie-Claire Botte, 'Simple and Induced Loudness Adaptation', *Audiology*, 24.6 (1985), 430–36.

The exposure to a uniform aural stimulus can create some interesting perceptual artefacts. These include hallucinatory effects such as audio pareidolia: the psychological phenomenon of the mind perceiving a familiar pattern where none exists, and the Zwicker tone effect: a short-term auditory illusion, resembling the experience of tinnitus. These will be discussed further in Chapter Ten.

4.3 Deprivation as an Artistic Material

Deprivation involves the removal, reduction, or denial of the audience's perceptual field. These works often involve an intervention in the everyday mode of interaction, silencing the din of the world around us. This, in itself, can be a powerful experience, offering a brief moment of respite, and provoking awareness of the unconscious patterns of everyday behaviour. As can be seen in the wide range of works discussed, the use of deprivation can be used to frame the audience's awareness in many different ways.

By altering the perceptual apparatus, a sense modality can be blocked. This is easy to achieve and can create a pure form of deprivation, where no stimulus is perceived by the audience. Most existing works that have employed this form of deprivation have blocked the visual sense. This creates the largest intervention of everyday modes of behaviour, and forces the audience to renegotiate their senses, using the other modes to navigate the work. This form of deprivation can also create a deeper form of immersion, as the audience becomes unable to use their visual sense to verify the reality of the world around them. When this visual blocking is coupled with aural deprivation, the audience are further pushed to renegotiate the modes in which they use their senses to navigate the work. As in *Generator*, by Marina Abramović, the audience is forced to confront deprivation, and their reaction becomes the artwork.

The creation of deprivation environments can be more complex, as it involves the careful control of an environment. This may be easier in the case of the visual sense, as darkness is easier to create than silence. This asymmetry means that the experience of silence is less common, and therefore more striking, as it contrasts everyday modes of experience more than darkness. It is also possible to create isolated spaces of deprivation, as in the void works of Anish Kapoor and the silencing wall of Jacqueline Kiyomi Gordon. These works allow for the juxtaposition of deprivation and provision in one space, accentuating the contrast of the two.

The special case of creating deprivation through uniform fields of stimulus has similarities to the Perceptual Hacking category, which is discussed in Part II. These environments reveal a facet of the way in which our perceptual apparatus processes uniform stimuli, resulting in the experience of deprivation. These environments have been explored in visual artworks, notably by James Turrell, but are underexplored in other domains. The use of these environments in future metaperceptual sound works could be a fruitful field of artistic investigation, especially for sound-based artists.

The theme of deprivation for future sound art works is a nascent field. The framing of the audience's perceptual apparatus can focus their attention towards the refined materials of the artwork, creating an intervention of everyday modes of experiencing. The range of artworks discussed shows that many works have explored visual deprivation, with far fewer sound art counterparts. My own contribution to the field of deprivation works, which is informed by the survey conducted and framework presented in this chapter, will be discussed in Chapter Twelve, where I will present my collaborative work with Mo H. Zareei entitled '*∞/ø'*.

Chapter Five

Perceptual Translation: Perspective Shifters

'What is it like to be a bat?'

—Thomas Nagel

5.1 Perceptual Translation Preface

In Chapter Three and Four, artworks that removed, reduced, or deprived the audience of their normal perceptual fields were discussed. Deprivation works create metaperceptual experiences by disrupting the everyday modes of interaction, silencing the milieu of stimuli that bombards us. This reduction of stimuli can offer a powerful respite, allowing the audience's attention to be drawn onto themselves and their perception.

Chapter Five, Six, Seven, and Eight catalogue Perceptual Translation artworks, that interact directly with the perceptual apparatus of the audience by shifting, rearranging, and re-ordering their experience of the world. At the thematic crux of this category is an understanding and acknowledgement of the limitations and subjectivity of our experience. The nature of our senses and our previous experiences colour the way we perceive and interpret the world. Many of the metaperceptual works in this chapter explore the allure of experiencing what it is like to be someone or something else. This may be achieved by replicating the perceptual apparatus of other animals, or by shifting the perspective of the audience. The question of what it is like to be another animal or person is not only an abundant provocation for artistic exploration, but also has important philosophical implications for the nature of our experience. This is still an active philosophical field in metaphysics, and I discuss Thomas Nagel's foundational article 'What it is like to be a bat?' in the following section.

The question of what it is like to be someone or something else is often contemplated when discussing the mind-body problem.[184] This problem explores the nature of the relationship between mind and body, and at the core of which is the difference between the mental and the physical

[184] Richard Warner, *The Mind-Body Problem: A Guide to the Current Debate* (Wiley, 1994).

realm. Humans have both mental and physical properties: they have beliefs, emotions, and intentions, as well as, weight, size, and colour. The mind-body problem is centred on how these two realms interact and intersect.

Metaphysical philosopher Thomas Nagel argues that one of the most difficult questions related to the mind-body problem is what is consciousness, and how is it manifested by the mind and body?[185] He starts his highly influential article 'What is it like to be a bat?' by asserting 'Consciousness is what makes the mind-body problem really intractable.'[186] Nagel is responding to popular rival theories that promote reductionism and physicalism: the schools of thought that argue that the mind-body problem can be solved by reducing the mental realm to physical interactions. Nagel's arguments are centred on the subjective character of experience. He argues that physicalists and reductionists' arguments fail as they cannot explain the existence and qualities of consciousness, nor the subjective character of experience.

To tease out the insufficiencies of his contemporaries' arguments, Nagel poses the question 'what is it like to be a bat?' There is an important distinction to be made between what it would be like for a human to be like a bat, and what it is for a bat to be a bat. He writes 'It will not help to try to imagine that one has webbing on one's arms, which enables one to fly around at dusk and dawn catching insects in one's mouth; that one has very poor vision, and perceives the surrounding world by a system of reflected high-frequency sound signals; and that one spends the day hanging upside down by one's feet in an attic.'[187] To imagine these things is a means of trying to understand what it would be like for us to be bats. But Nagel is asking what it is like for a bat to be a bat. This distinction shows the limitations in trying to fully comprehend what it is to be someone, or something, else. The comparison between humans and bats is chosen by Nagel because of the difference in the fundamental structure of the perceptual systems. A bat's sense of distance, size, shape, motion, and texture of things through sonar can be likened to our visual sense, but cannot be considered equivalent. We cannot imagine what it would be like for us to perceive through echolocation without directly experiencing it ourselves. As Nagel argues, as long as there is a difference between the 'fundamental structures'[188], our experiences will never be like those of a bat.

[185] Thomas Nagel, 'What Is It Like to Be a Bat?', *The Philosophical Review*, 83.4 (1974), 435–50.
[186] Nagel.
[187] Nagel.
[188] Nagel.

While Nagel's bat comparison offers a clear difference in the perceptual modes of experience, the problem is not limited to other creatures. Nagel extends this line of thought to differences between people. He writes 'The subjective character of the experience of a person deaf and blind from birth is not accessible to me, for example, nor presumably is mine to him. This does not prevent us each from believing that the other's experience has such a subjective character.'[189]

Nagel's argument reveals that our perceptual apparatus frames our subjective experience of the world, and it is problematic to translate and reduce this subjectivity to language or other sense modalities. This makes exploring different forms for the perceptual apparatus more salient. The framing of our subjectivity is usually unconscious and unexamined. The works in this metaperceptual category make the audience aware of the way our perceptual apparatus frames the way we perceive the world. In doing so, these works challenge how our view of the world differs from others, and the implications that the limitations of our perceptual system have on us.

The Perceptual Translation category explores the experiential repercussions of the alteration and extension of our perceptual apparatus. By changing the fundamental structure, or perceptual apparatus, of the audience, these works provoke new modes of experience, offering perceptual structures based on other people's and another creatures' experience. The category contains two different interpretations of the term 'translation'. In a geometrical sense, 'translation' describes the process of moving something from one place to another. Many of the works in this section move the perceptual apparatus, in part or as a whole. This form of perceptual translation pertains to the physical manipulation of the audience's perceptual apparatus. The other form is more akin to 'translation' as the process of converting words from one language to another. Some 'Perceptual Translation' works convert perceptual stimuli from outside the human-perceivable range, to within it, in order to allow a person to experience them. This can involve a change in the modality of the stimuli, similar to a change in the language. In this case, stimuli can be perceived, but not in their original form. This may mean that some particularities are altered by this translation, as the artefacts of translation imprint new qualities on the stimuli. Both forms of translation share the potential for creating metaperceptual experiences by treating the perceptual apparatus as the core artistic material to be manipulated and ordered.

In this chapter, I contextualise the ways in which the perceptual apparatus can be altered, extended and rearranged to create metaperceptual experiences. The 'Perspective Shifters' keep the perceptual apparatus intact, but shift its point of perspective. 'Perceptual Extenders' look at our limited perceptual fields, and offer the audience ways of experiencing the stimuli that we cannot

[189] Nagel.

perceive with our normal sensory faculties. These works often intersect with those of the next category, 'Perceptual Mimesis', which translate the audience's perceptual apparatus to closely represent the perceptual scheme of another animal. Finally, 'Perceptual Rearrangers' push this translation into unnatural schemes by creating new forms of order for the audience's perceptual apparatus. The outline is illustrated in Fig. 30 This category of works offer a diverse range of manifestations that create metaperceptual experiences for their audience. In this chapter, I connect the implicit themes in a range of visual and sound artworks that directly interface with the perceptual apparatus, and make their metaperceptual applications explicit. This leads to a discussion of potential approaches for new metaperceptual works.

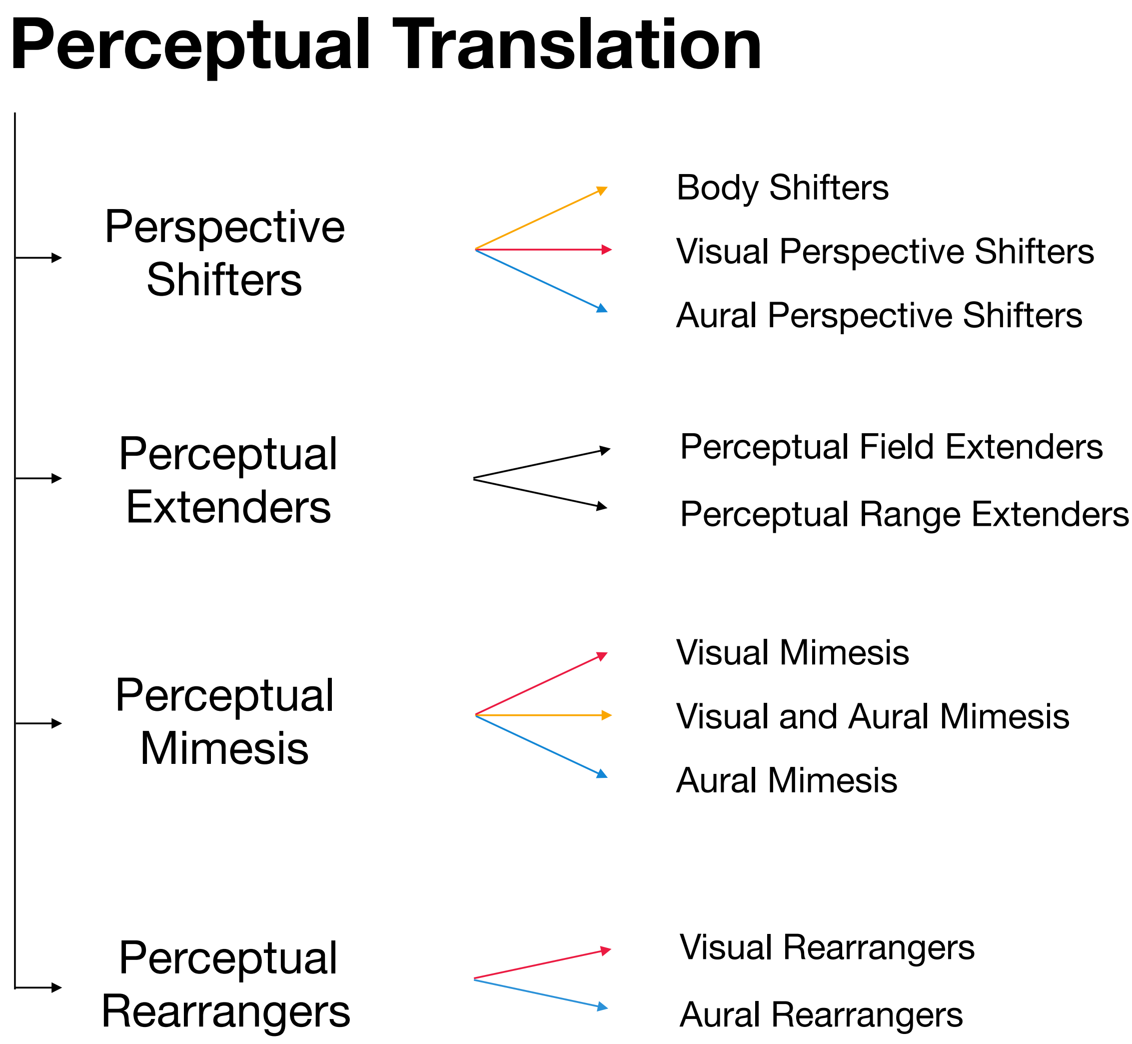


Fig. 30 Outline of Perceptual Translation Approach

5.2 Perceptual Shifters

'You never really understand a person until you consider things from his point of view … until you climb into his skin and walk around in it.'

—Harper Lee

'Perspective Shifters' is a category of metaperceptual artworks that translate the audience's perspective while keeping the organisation of the perceptual apparatus in its typical form. Many of the metaperceptual themes are centred on awareness of the body, and the subjectivity of the audience's experience. The works in the 'Perspective Shifters' category explore this metaperceptual theme by offering the audience new perspectives on their own subjectivity. This can provoke the audience to renegotiate their own positionality and their relationship to the world.

The artwork's ability to create a redirection of attention for the audience back onto themselves is predicated by the realism of the experience that they create. The audience needs to feel like they are truly present and are experiencing the world from a new position in space. There are multiple facets to the realism of an experience. The degree of experiential fidelity is important in creating, or translating, realistic sensory environments. If the experience is mediated by technology, then the quality of the stimulus needs to be of a sufficiently high standard in order for it to be convincing in its 'realness'.

The intent of creating realistic environments has been facilitated by technology since at least the birth of cinema. While films rarely create metaperceptual experiences, for reasons I discuss below, they offer an important technological foundation and precedent for creating experiences that are convincing their 'realness'. In 1877, an article in Scientific American states 'It is already possible by ingenious optical contrivances to throw stereoscopic photographs of people on screens in full view of an audience. Add the talking phonograph to counterfeit their voices and it would be difficult to carry the illusion of real presence much further.'[190]

Even though the quality of the image and sound of these early films pale in comparison to our present-day technology, the effect on the audience was still one of powerful immersion. Jan Holmberg, a cinema history academic, shares a tale of the experience of an early film-goer: 'An elderly lady one evening went to the town's cinema theatre. It was her first time in such a place,

[190] 'The Talking Phonograph', *Scientific American*, 37.25 (1877), 384–85.

and everything seemed to her very strange and real. As the lady in question was gifted with unusually good sight, she could hardly imagine that her observations were erroneous. Then, all of a sudden, a large automobile approached. Far distant at first, it seemed to move with incredible speed, right toward the spot where the old lady was seated. Just as the disaster seemed to her unavoidable, it took a turn and disappeared. The old lady could not take it anymore. Taking her niece by the hand, she walked hastily toward the exit, saying: "Come on dear, this is not a safe place to stay anymore. That thing just passed me by two feet!" '[191]

The current state of technology in films has greatly surpassed the fidelity of these early examples even though the search for greater immersion and realism continues. Attempts have been made to transform the flatness of the two-dimensional theatre screen into a three-dimensional display, with '3D' movies having popular periods since their 'golden era' in the 1950s.[192] Experiential innovations do not stop at just three dimensions, with some films being marketed as 4D, 5D, and even up to 9D. These films include physical effects including: rain, wind, fog, smoke, odours, vibrations, and leg and back ticklers.[193] This shift to including more sensorial elements share themes with the metaperceptual approach, as the sensorium of the audience is considered rather than just a limited facet.

These film innovations seek to create immersive and captivating experiences that draw the audience into the reality that the movie creates. This transportation means that it is rare that the experience of a film is metaperceptual however, as the audience is often taken away from their own positionality, and are absorbed in the film's constructed world. For a film to be metaperceptual, the content of the film would have to pertain to the perception of the audience in a way that makes them self-reflexive. One reason that this is rarely the case is that the audience members lack autonomy over what they experience. The film format is not inherently interactive, which means that the audience is at the will of the predetermined film.

A recent development in technology that allows for the transportation of the senses while also giving the audience a degree of autonomy over what they are experiencing is the spate of advances in Virtual Reality (VR). The term was originally used to describe the illusory nature of the theatre, the same feature which caused the elderly movie-goer to run out of the theatre to escape the

---

[191] Jan Holmberg, 'Ideals of Immersion in Early Cinema', *Cinémas : Revue d'études Cinématographiques / Cinémas : Journal of Film Studies*, 14.1 (2003), 129–47.
[192] Giovanna Fossati, *From Grain to Pixel: The Archival Life of Film in Transition* (Amsterdam University Press, 2009).
[193] Murray Leeder, 'Collective Screams: William Castle and the Gimmick Film', *The Journal of Popular Culture*, 44.4 (2011), 773–95.

oncoming trains in the aforementioned account. Currently, VR is still in its infancy with VR peripherals only becoming widespread commercial products in the last few years, but it does have the potential to become a powerful, immersive experience platform for artists and creators.

While VR presents a powerful platform for artistic expression, most of the current focus is more aligned with the intent of immersion in films and extending the interaction dynamics in games. A recent TechRadar.com article detailed some of the newest VR experiences which they argued demonstrated that ‘2017 is the year VR went from gimmick to game-changer’[194]. They included *Lone Echo*[195], where the player experiences being an AI called Jack, housed in a robot body on a spaceship floating through space. Also cited was *Marvel Powers United VR,*[196] which lets the player become a Marvel superhero, and lastly, *Secrets of the Empire*, a game from the Star Wars franchise where the player is a Stormtrooper.

These VR experiences create immersive, interactive environments which, in a similar vein to most films, seek to make the audience fully absorbed in the virtual worlds of the works. The addition of interactivity, and allowing the audience to have autonomy over their interaction is not sufficient to create a metaperceptual experience. The content of the VR interaction needs to work with the immersion and interactivity of the experience to offer new perspectives of the self for the user. While the technology exists for effective use of VR in a metaperceptual context, most existing VR applications instead focus on immersion, interactivity, and most of all, escapism.

The following section surveys a range of artworks which shift the perspective of their audience’s through translating their visual, aural, and sometimes tactile senses. These works are then contrasted with other perspective shifters that only translate one of the senses.

5.3 Body Shifters

The work of BeAnotherLab is a rare example of a metaperceptual VR experience. The interdisciplinary collective has created a range of VR experiences under their *The Machine to be Another* (2014) project that explore the questions of: ‘If I were you, would I better understand myself? What would the world be like if one could see through the eyes of another? Would it help us to understand each other? Would it help us to understand ourselves?’’[197] Their works seek to

---

[194] Andrew London, ‘2017 Is the Year VR Went from Gimmick to Game-Changer’, *TechRadar*, 2017.
[195] Ready at Dawn, *Lone Echo*, 2017.
[196] Sanzaru and Oculus Studios, *Marvel Powers United VR*, 2018.
[197] ‘Research Concept’, *The Machine to Be Another*.

promote empathy and understanding of the experience of others through shifting the perspective of the user, allowing them to experience the world through the subjectivity of someone else.

Fig. 31 A performance of The Machine to be Another involving a Gender Swap. Image provided courtesy of the artists.

The Machine to be Another is a platform for creating an embodied VR experience that allows for a user to experience the world from the perspective of another. The experience involves a user and a performer (or multiple performers). Through immersive goggles, the user sees through the eyes of the performer, who follows the user's movements. This creates a mirroring of behaviour, giving the user a sense of autonomy and immersion in the experience of being the other. Furthermore, the experience is not only visual, but tactile and aural, as the user can move and interact with objects inside a room, while listening to the performer's thoughts through a set of headphones which gives the user an insight in to the mind of the performer. The performer will often tell a short story about their existence which is connected to the objects in the room (a photo of someone, a childhood toy, a pack of cigarettes, a mirror, etc). With all of these elements working together, the total sensory illusion that they are inhabiting the performer's body is created.

Different iterations have put the user in the perspective of people from other ethnicities, genders, professions, and, in the case of the iteration *Being Youssoupha* (2013), the body of a Senegalese dancer. Their exploration of experiencing the world as another gender has been especially influential, provoking conversations around trans issues. Jessica Janiuk, contributor to Polygon Magazine, draws parallels between the dysphoria she experienced prior to her gender transition and the experience of wearing an Oculus Rift. She writes 'The game of life has given us a character gender that doesn't match us as the player.'[198] The gender swap enables the user to have a greater sense of empathy for the perspective of an another, and in some cases, can 'provide a sense of peace from the dysphoria we experience throughout our day-to-day lives.'[199]

The Machine to be Another explores the same ideas that Nagel used as arguments in his thought experiment. There is an important difference between imagining what is like to be someone else and truly experiencing what it is like to be another. Although *The Machine to be Another* does not truly swap the bodies of user and performer, it approximates the experience in a way that can create powerful self-insights and a better understanding of others. This is mirrored in the experience and feedback of users. One of the artists behind the work, Philippe Bertrand, says that 'this machine can work to promote empathy between people with bias and there are neuroscientific experiments that prove that this kind of technology can reduce this implicit bias. Just seeing yourself in a black avatar, it reduces your bias, it's really incredible, and very powerful.'[200] This reflection emphasises the strong metaperceptual themes in this work, as the experience can provoke an audience to reflect upon themselves and their own subjectivities.

Although common in VR experiences, the concept of transporting yourself virtually to somewhere your body is not, is not unique to VR. In a 1980 essay, MIT Artificial Intelligence Lab founder Marvin Minsky popularised the term of 'Telepresence'[201,202]. Minsky proposed a twenty-year plan that would develop robotics and technology to allow a person to work from a remote position, which he described as telepresence. He writes 'Your remote presence possesses the strength of a giant or the delicacy of a surgeon. Heat or pain is translated into informative but tolerable sensation. Your dangerous job becomes safe and pleasant.'[203] Almost 40 years after Minsky's proposal, the commercial applications of telepresence have become widespread, with the internet facilitating communication systems like Skype, Google Hangouts, and Facebook. These platforms have resulted in video calling becoming ubiquitous, and attempts have been made to create specialised systems that create the illusion that remote participants are in the same room, as shown

[198] Jessica Janiuk, 'Gaming Is My Safe Space: Gender Options Are Important for the Transgender Community', *Polygon*, 2014.
[199] Janiuk.
[200] Aaron Souppouris, 'Virtual Reality Made Me Believe I Was Someone Else', *The Verge*, 2014.
[201] Marvin Minsky, 'Telepresence', 1980.
[202] The term 'telepresence' itself was first coined by Futurist Patrick Gunkel
[203] Minsky.

in Fig. 32. A range of medical applications for telepresence have also become established including remote surgery and telemedicine.

Fig. 32 Teliris VirtuaLive telepresence system from 2007. Image: 'Teliris VirtuaLive Telepresence System' by Fuelrefuel is licenced under CC BY 3.0

An early example of an artistic exploration of telepresence that shares themes with *The Machine to be Another* is James Auger and Jimmy Loizeau's *Social Tele-presence*.[204] The work consists of two parts. A camera and binaural microphone are mounted on a controllable platform that can rotate through three dimensions. This is connected to a headset that has a pair of TV glasses, speakers, and a gyroscope to track the wearer's head movement. The head movements of the user are monitored and translated directly to the remote camera in real time so that they can control the directionality of their transported perceptual field, while the camera and microphone stream the audio and visual perspective from the surrogate body. The authors speculate on different uses for this technology, including a 'rent-a-body'[205] service, where the wearer could rent the physical body of another person and direct them around so they see and hear a place without having to physically be there.

[204] Jimmy Loizeau and James Auger, *Social Tele-Presence*, 2001.
[205] Loizeau and Auger.

Fig. 33 James Auger and Jimmy Loizeau, Social Tele-presence. Image provided courtesy of the artists.

As with their deprivation work *Iso-phone* (whose quasi-metaperceptual themes were previously discussed in Section 4.2.2), Auger and Loizeau explore themes that verge on being metaperceptual. *Social Tele-presence* was created in 2001, with the technology needed to create this shift in perspective only recently having been developed. The user in *Social Tele-presence* may well have had a metaperceptual experience, as this rare translation would have created a self-reflection on their own senses. Now, with the ubiquity of telepresence technology, the experience has become normalised, with many people partaking in telepresence every day. Experiencing Auger and Loizeau's work today would likely be widely different from its original reception, as the technological context will have influence on the expectation and attitude of the audience. *The Machine to be Another* takes some of the types of speculations that Auger and Loizeau were exploring in *Social Tele-presence*, and through narrative and additional sensory elements, extends them into a stronger metaperceptual experience for their audience. *The Machine to be Another* provokes the user to think about their own positionality with the world and others, through both the sensory experience of being another, as well as semantic details included in the narrative.

5.4 Visual Perspective Shifters

While both *The Machine to be Another* and *Social Tele-presence* transport the senses of the user to a different person's perspective, Takehito Etani's work *The Third Eye Project* (2002) only shifts the visual sense in order to provide a new perspective of the self. This metaperceptual work is a headset consisting of a pair of goggles that blind one eye while exposing the other to a two-inch LCD monitor. This is positioned very close to the eye, bracketing out all other visual stimulus. The screen is wired to a small black and white surveillance camera, mounted above and behind the user's shoulders on cantilevered poles. The wearable device gives the user a live feed of their world from an elevated, third-person perspective.

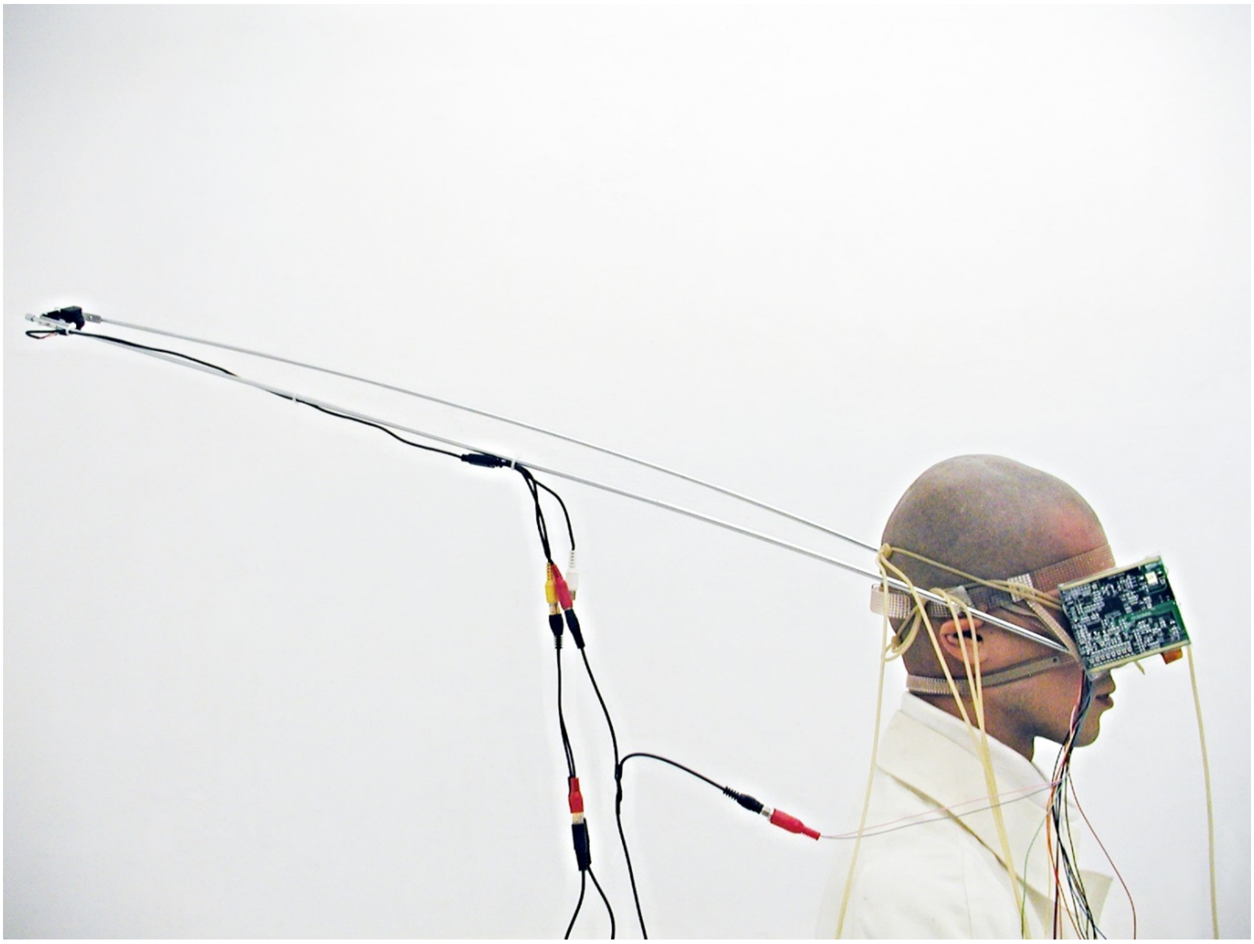


Fig. 34 Takehito Etani, The Third Eye Project. Image provided courtesy of artist.

Etani's work draws upon the interactions found in 3D video games, creating a sense of virtualised reality. As Anne Pasek writes in her article 'Seeing Yourself Strangely: Media Mirroring and The Third Eye Project', 'Part of the shock of wearing Etani's device is the degree to which one's body becomes dramatically virtualized. Rather than situating vision within the body, *The Third Eye Project* shifts this site outside of its habitual envelope to a third-person perspective, mimicking the popular camera angles of video game avatars.' [206] This contrasts the work to most virtualised experiences that transport the audience's perspective to new contexts, leaving behind their physical surroundings and their own body. *The Third Eye Project* effectively blends the wearer's body into their environment by situating it at the centre of their virtualised experience. This explores metaperceptual themes by reducing and challenging the distinction of body and the world, and

[206] Anne Pasek, 'Seeing Yourself Strangely: Media Mirroring in Takehito Etani's The Third Eye Project', *Metaverse Creativity*, 4.2 (2014), 121–38.

questioning objective and subjective concepts of the body, and of perception. Etani writes ‘by replacing the subjective view with an objective one, *The Third Eye Project* points out the relativity of one’s perspective to his/her body. It also raises the question, "what is real and what is virtual to one’s body?"‘[207]

The shift of perspective in *The Third Eye Project* gives the wearer a new and strange perspective of themselves, showing their back, and the back of their head. Although this may seem somewhat trivial, the forward-facing nature of our visual perception means that we never directly perceive this part of our body. By presenting a part of the body that is not usually viewed by oneself, the perspective shift aligns the perception of one’s body with other’s bodies. Pasek argues that ‘Etani’s device, therefore, merely virtualizes what already exists as virtual content: a part of the body that is absent from normal optical access to one’s own form granted by the forward orientation of the eyes.’[208]

The shift of the origin of the visual field causes the wearer of *The Third Eye Project* to renegotiate their movement and interaction with the environment, as now their senses are deconstructed. A documentation video shows the artist wearing the camera apparatus while completing everyday tasks, and walking through New York City. While he manages to complete these interactions, he clearly struggles as he negotiates this shift in perspective. When trying to eat, he manages to bring a spoon to his mouth, but moves cautiously, slowly putting the spoon in his mouth and dropping some of the food back onto the plate.

The experiential fidelity in *The Third Eye Project* is much lower than *The Machine to be Another* and *Social Tele-presence*. While small colour cameras and higher quality screens were available in 2002 when *The Third Eye Project* was created, Etani seems to intentionally choose technology with lower experiential fidelity. The use of a black-and-white camera and only one screen does not create an experience approaching realism. Instead, the technological mediation is presented as part of the experience, furthering the virtualisation of the body. Despite the lower experiential fidelity, the content of the experience makes the work deeply metaperceptual. The work is idiomatic to the ‘Perspective Shifters’ sub-category, as the work is focused on creating new perspectives of the body. By presenting the body as an object of their perception, it blurs the distinction between objectivity and subjectivity.

[207] Takehito Etani, ‘The Third Eye Project’, *Takehito Etani*, 2016.
[208] Pasek.

5.5 Aural Perspective Shifters

In the aural domain, immersive and convincing shifts of perspective can be created through binaural and higher-order ambisonic techniques. Wieslaw Woszczyk writes in the foreword for the book *Immersive Sound: The Art and Science of Binaural and Multi-Channel Audio*, that 'immersive sound produced over loudspeakers or headphones has the capacity to deliver a seamless illusion of alternative reality and change the way we relate to and behave in sound.'[209] This seamless illusion is akin to its visual counterparts found in cinema and advanced in VR. Recent VR applications also include binaural or ambisonics in an attempt to create immersive and realistic sonic environments. Binaural techniques in particular are focused on creating realistic aural experiences by recreating the conditions of human hearing. Binaural sound refers to the two streams of sound that enters a listener's left and right ears, and is specifically used to refer to sound which has been filtered by a combination of time, intensity, and spectral cues in a way that mimics human localization cues. This filtration may be a physical or technological process. The physical filtration of the head can be emulated by placing microphones in the ears of a person or a dummy head. Conversely, the physical filtering of the head can be emulated by digital signal processing of sounds that manipulates their temporal, intensity, and spectral qualities. In replicating the perceptual apparatus of listeners, binaural audio reproductions are able to create highly convincing shifts in perspective. Agnieszka Roginska writes that this 'results in a "you are there", first-person perspective, in contrast to the loudspeaker "they are here."'[210]

While these recording techniques offer a powerful technological platform for controlling the experience of the audience, many binaural works are not metaperceptual. Similar to the intent that many of the VR works that I have previously discussed, many binaural works offer a transportation of the senses to another place, rather than to an emulation of another person's, or animal's, perspective. This can be evidenced in Janet Cardiff's soundwalk series, which use binaural recording to vividly capture environments through which she walks. In her book *The Walk Book*[211], she writes that after first being introduced to binaural recording, she 'had found a way to be in two different places at once. I was able to simulate space and time travel in a very simple way. I really felt like it was pushing past the novelty of the experience and entering into the type of conceptual dialogue that I was interested in pursuing. I've always loved to escape, whether it was through walks, books, films or dreams, and it's only now that I realize what I've been doing this past

---

[209] Agnieszka Roginska and Paul Geluso, *Immersive Sound: The Art and Science of Binaural and Multi-Channel Audio* (Milton, United Kingdom: Taylor & Francis Group, 2017).
[210] Roginska and Geluso.
[211] Mirjam Schaub, *Janet Cardiff: The Walk Book* (Köln: Walther König, Köln, 2005).

decade. I've been creating portholes into my other worlds.'[212] This manifests her interest in creating soundwalks as portals to another place in which the audience can become immersed in.

It could be argued that listening to binaural sounds recorded by microphones placed in the ears of another person is similar to having your perspective shifted to that person. While this is true due to the nature of the recording process, for the listener to have the experience of having their perspective shifted to the recorder's, their presence must be made evident. This could include the sounds of breathing, movement, and even dialogue as the person doing the recording becomes an active sound producer in the recording, and in the work. While binaural recording techniques offer a technological basis for creating convincing shifts in perspective, they can only be metaperceptual if these shifts are combined with artistic materials that draw the attention of the listener back onto their own perception.

A work that explores shifting aural perspective both experientially, as well as conceptually, is Florian Hollerweger's *Music for Lovers* demonstrates. The work is for two people who are close, either in the emotional or spatial sense of the word (or both). This work allows for two people to swap their aural positionality. Hollerweger writes 'to love is to put oneself in somebody else's shoes. Or ears. *Music for Lovers* (2009) facilitates this process by allowing two people to exchange what they are hearing.'[213]

The work consists of two pairs of headphones which are augmented through the inclusion of binaural microphones. The audio signals are swapped through a small electronics enclosure, shaped like a heart, in keeping with the theme of the work. The work creates metaperceptual experiences for both participants, as they share a perspectival shift that can be both deeply empathetic and introspective. *Music for Lovers* shares many themes with my own work *Your Hearing Them*, which is discussed and contrasted with *Music for Lovers* in Chapter Twelve. In both works, the positionality of the two participants is swapped.

Shifting perspectives has the potential creating powerful metaperceptual experiences, as they can force the audience to become acutely aware of their own subjective perception. The scarcity of sound artworks in this domain shows that there is a vast potential for new metaperceptual sound works that explore the repercussions of shifting the aural perspective of the audience. Chapter Twelve, which includes my work *Your Hearing Them,* is informed by the identification of this potential.

---

[212] Schaub.
[213] Hollerweger.

Chapter Six

Perceptual Translation: Perceptual Extenders

In 'What is it like to be a bat?', Thomas Nagel uses the limitations of our own perceptual system to argue that we are unable to fully comprehend what it is like to be another animal or person. He writes, 'Our own experience provides the basic material for our imagination, whose range is therefore limited.'[214] The 'Perceptual Extenders' section contains works that use the limitations of our own perceptual system as their base materials. The works redefine the range and modes of stimuli that we are able to perceive. This affords new perspectives on the world, revealing ways in which our sense organs always filter and effect the way we experience the world.

The historical origins of the 'Perceptual Extenders' category lie in technological innovations for correcting perception. While these technological innovations are not intended as artworks in themselves, the intense research and development in the field of perception correctors allowed for technologically mature artworks (that utilise the correctors' technology) to be realised. These practical correctors are the first coupling between technology and the perceptual apparatus, and the first tools that are deliberately intended to alter the wearer's perception. Anthropologists George Sines and Yannis A. Sakellarakis's research indicates that the use of lenses was widespread throughout the Middle East and the Mediterranean Basin over several millennia.[215] These early lenses were used for a range of purposes, including starting fires and as magnifying glasses to authenticate seal impressions. The lens was not incorporated into a wearable design until the invention of the eyeglasses in the seventeenth century,[216] which required a semi-permanent coupling of the technology and the eye. Eyeglasses were invented as a corrective tool, allowing a malfunctioning visual sense to be repaired. As the technology for corrective lenses developed, an even closer and more embedded coupling was invented in contact lenses.

This use of technology as a corrector is not limited to our visual sense, with deafness also being aided by technology. Early hearing aids included ear trumpets, hearing fans, and conversation

[214] Nagel.
[215] George Sines and Yannis A. Sakellarakis, 'Lenses in Antiquity', *American Journal of Archaeology*, 91.2 (1987), 191–96.
[216] Edward Rosen, 'The Invention of Eyeglasses: Part II', *Journal of the History of Medicine and Allied Sciences*, 11.2 (1956), 183–218.

tubes.[217] In a similar design to the magnifying lens, ear trumpets were first used as passive amplifiers of stimuli to help people who were hard-of-hearing, by funnelling and amplifying sound waves. The end of the tube is pushed up against the ear, which allows for better transmission of sound energy to the eardrum. Similar to visual aids, as the technology developed, the coupling between perceptual apparatus and technology became more embedded. One notable difference to the largely passive field of visual correction is the adoption of digital electronics in modern hearing aids. The current technology transforms the hearing aid from a simple amplifier to a device that is capable of signal processing for speech enhancement, noise-reduction, and feedback cancellation.[218] This allows for a dynamic relationship between signal and stimulus, automatically adjusting its filtration and amplification of sound depending on the environment. These aural perceptual correctors are early technological precedents that afford the creation of metaperceptual sound artworks discussed in this section.

The technological developments that enabled perceptual correctors have also been used to amplify the perceptual range. The early uses of lenses for magnifying vision have been extended to much higher amplification levels with technology, such as in the case of microscopes that have been used since the seventeenth century.[219] They enable a radical change in our perceptual limits, powerfully increasing the angular resolution of the viewer to be able to see objects that were once so small that they were invisible. This is what historian Catherine Wilson describes as 'the extension of the empirical horizon to the *subvisibilia*'.[220] Concurrent to the invention of the microscope, the telescope gave the viewer access to the opposite end of the perceptual horizon. Telescopes transport distant objects into the perceptual realm, expanding the perceptual field into the cosmos. Both microscopes and telescopes played an important role in the scientific revolution by allowing us to observe the human body's processes on a minute level, and offering a glimpse into the vast cosmos, thus redefining our human-centric understanding of the universe.

In the sonic domain, the advent of the microphone not only afforded the capturing of sonic environments, but also the amplification of previously unheard sounds. A gruesome yet captivating example comes from Chris Watson's field recordings of animals eating. The liner notes for one work, *Cracking Viscera* (2012), read 'Vultures taste the dry, crackling viscera inside the rib cage

---

[217] M. Mills, 'Hearing Aids and the History of Electronics Miniaturization', *IEEE Annals of the History of Computing*, 33.2 (2011), 24–45.
[218] Harry Levitt, 'A Historical Perspective on Digital Hearing AIDS: How Digital Technology Has Changed Modern Hearing AIDS', *Trends in Amplification*, 11.1 (2007), 7–24.
[219] Catherine Wilson, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton University Press, 1997).
[220] Wilson.

of a zebra carcass. Nine birds feeding on a zebra carcass. Itong Plains, Kenya. Sept. 1994.'[221] Watson often employs small discrete microphones to vividly capture sounds that are either difficult to experience because they are in dangerous environments, or are too quiet to hear naturally. During the filming and recording for Richard Attenborough's *Life in the Undergrowth*,[222] Watson captured the sound of a solitary ant walking.[223]

These technological paradigms allow for the creation of metaperceptual artworks that extend the perceptual apparatus. I discuss these 'Perceptual Extenders' in two main subcategories, 'Perceptual Field Extenders' and 'Perceptual Range Extenders'. 'Perceptual Field Extenders' redefine the shape and size of the perceptual field, allowing the user to experience stimuli that would normally be outside of their perceptual horizon. These works take multiple forms, discussed in the next section. Following this, I introduce 'Perceptual Range Extenders' which redefine the range of perceivable stimuli, allowing the audience to experience strata of stimuli that are normally invisible and/or inaudible. This section involves an investigation of perceptual extension to the electromagnetic spectrum and the ultrasonic frequency range.

6.1 Perceptual Field Extenders

Rebecca Kleinberger's work *PHOX Ears* (2015) shares themes with Chris Watson's work by expanding the size of the aural field. *PHOX Ears* is a wearable technology work that consists of a pair of head-mounted, independently articulated parabolic microphones. The microphone feed is passed to two surface transducers that are placed of the cheekbones allowing the wearer to hear through bone conduction. The surface transducers act as speakers, but instead of a speaker cone creating vibrations in the air, the surface transducer vibrates a physical body. Through a controller, the parabolic dishes are able to be repositioned by the wearer, allowing the wearer to sharply direct their aural attention to faraway sound sources. The wearer is invited to go for a walk with the headset on, experiencing their sonic environment with their newly augmented perceptual field.

One of the interesting ways that *PHOX Ears* mediates the aural perception of the wearer is by making the shape of the aural field interactive and malleable. Normally, we hear sound from all directions, creating an auditory field that is shaped as an omnidirectional sphere. But *PHOX Ears* changes this rigid shape, as the parabolic dishes capture narrow beams of sound, allowing the wearer to interactively negotiate their auditory field. By making the aural field interactive and

[221] Chris Watson, *Outside The Circle Of Fire* (Touch, 2012).
[222] *Life in the Undergrowth* (BBC Home Entertainment, 2006).
[223] David Crawford, 'The Sound of One Ant Walking – inside the World of a Wildlife Audio Expert', *Radio Times*, 19 February 2013.

malleable, *PHOX Ears* creates a metaperceptual experience by affording the wearer autonomy over elements of their perceptual apparatus. The wearer is able to effectively change the organisation of their perceptual apparatus, and as the parabolic microphones are strongly directional, this alteration has a profound experiential effect.

Fig. 35 Rebecca Kleinberger, PHOX Ears. Image provided courtesy of the artist.

Additionally, the independence of the two parabolic dishes disrupts the normal modes in which we localise sounds. The interaural level difference will be obscured through the positioning of the parabolic dishes, and there is no guarantee that the dishes will be diametrically opposed. Our aural perception is usually thought of as a unified whole, with both ears working in harmony to create a full picture. But the ability of the parabolic dishes to be independently articulated means that the unity of the wearer's aural perception can be deconstructed, with each ear becoming its own distinct component of the system.

Kleinberger and her team have also developed a mobile device that pairs with the *PHOX Ears* headset to create a wearable field-recording platform.[224] This contextualises the work in the domain of field recording and soundscape composition. While this suggest that the artist's intent is not necessarily metaperceptual, the work explores the experiential implications of extending the perceptual apparatus. *PHOX Ears* allows for a heightened experience of the wearer's sonic environment, transforming the mundane sounds of the everyday into aesthetic objects and provoking contemplation of the bi-faceted nature of our aural sense.

[224] Rebecca Kleinberger and others, 'PHOX Ears: Parabolic, Head-Mounted, Orientable, EXtrasensory Listening Device'.

It is important to compare the experiential effect of bone conduction with that of headphones in this work. The skull itself acts as a complex filter, changing the timbral characteristics of the sound.[225] The experience of hearing through bone conduction is itself an unusual one. In my own experiences with bone conduction, I have noticed how the localisation and spectral filtering of the sound is radically different to normal hearing. The sound seems to emanate from within the head, and can move around the skull depending on the frequency content of the source. In general, bone transduction works best for lower frequencies, as higher frequencies are strongly attenuated.

The bone transducers used in *PHOX Ears* do not seem to serve a specialised function, and in some ways may muddle the themes of the work. The transducers sit on the cheekbone of the wearer without blocking the ears off to the world. This may allow the wearer to stay aware of the full auditory field of their environment, but the simultaneous presentation of two conflicting aural fields may prove to be confusing. The addition of another layer of aural stimuli may reinforce the points in space that the *PHOX Ears* are directed towards through amplifying them, but phase relationships between the two stimuli and the frequency shaping of the bone transduction may add unrelated additional layers to the experience that challenge its metaperceptuality.

A work that does use bone conduction for a specific experiential purpose is *Eidos* (2012). Designed by Tim Bouckley, Millie Clive-Smith, Mi Eun Kim, and Yuta Sugawara, *Eidos* is a sensory augmentation wearable technology that changes the user's aural and visual perception. *Eidos Audio* focuses on filtration of the aural field, allowing the wearer to single out and clarify a sound source in a busy environment. In the words of the designers, 'while we experience the world as many overlapping signals, we can use technology to first isolate and then amplify the one we want.'[226] The technology is housed in a mask that covers the face of the wearer. A directional microphone embedded in the device captures audio and processes it though a computer application to reduce background noise. The sound is then transmitted to the wearer through headphones in the mask, alongside a central mouthpiece containing a surface transducer. This transducer vibrates the jawbone of the wearer, creating an experience that approximates someone talking directly inside the wearer's head.

---

[225] Zhi Cai and others, 'Response of Human Skull to Bone-Conducted Sound in the Audiometric-Ultrasonic Range.', *The International Tinnitus Journal*, 8.1 (2002), 3–8.

[226] Rose Etherington, 'Eidos by Tim Bouckley, Millie Clive-Smith, Mi Eun Kim and Yuta Sugawara', *Dezeen*, 1 May 2013.

Fig. 36 Tim Bouckley et. al., Eidos Audio. Image provided courtesy of the artists.

The auditory enhancement in *Eidos Audio* is a technologically amplified version of the 'cocktail effect'.[227] This is the human brain's ability through auditory attention alone, to filter out parts of the auditory field, and focus in and make sense of one element. We are able to segregate a dense field of stimuli into streams and isolate one that is pertinent to us. This happens often in busy social settings, such as cocktail parties, to one listener to follow another's voice against background chatter. *Eidos Audio* seeks to extend this effect by using a directional microphone that allows the user to isolate a person's voice, and amplifies it through a bone transducer and headphone set. In a demonstration video, they offer some speculative applications including hearing one person speak in a busy train station, isolating different instruments while listening to a band live and as a hearing aid for people who have diminished perceptual faculties.

Eidos Vision seeks to enhance the perception of the wearer in a different domain by unveiling patterns of motion. A pair of oversized goggles host a camera that captures imagery and sends it to a computer, where it is processed by custom software to detect and overlay movement. The image is then composited to show the patterns of objects and people moving through space. The designers describe the visual result as similar to 'long-exposure photography, revealing otherwise hidden traces of movement, but it does this live.'[228] They speculate that the tracking of motion patterns could have potential applications in sports, allowing teams to visualise and improve

[227] E. Colin Cherry, 'Some Experiments on the Recognition of Speech, with One and with Two Ears', *The Journal of the Acoustical Society of America*, 25.5 (1953), 975–79.
[228] Etherington.

technique in real time, and performing arts where effects normally limited to video could be applied by individuals to live performance.

Fig. 37 Tim Bouckley et. al., Eidos Vision. Image provided courtesy of the artists.

Both *Eidos Audio* and *Eidos Vision* mediate the perception of the wearer in an attempt to enhance it. *Eidos Audio* shares perceptual themes with *PHOX Ears,* as the wearer's aural field is changed, and, in this case*,* a single narrow beam focuses the wearer's attention towards one object. The use of bone conductance creates a unique experience, with the potential for another person to seemingly be heard as speaking inside the wearer's head. These elements combine to create a focused metaperceptual experience, giving the wearer further control over their auditory field and transporting a sound source from external to internal. This work shares themes with my own work, *Your Hearing Them,* discussed in Chapter Twelve, which also uses surface transducers to create metaperceptual experiences of other people's voices.

While the visual enhancement in *Eidos Vision* may reveal hidden traces of movement, the augmentation may be more of an interesting visual effect rather than a metaperceptual experience. Long-exposure photography has the power to condense time and reveal temporal processes that are untracked by the naked eye. This temporal compression directs the attention of the audience towards processes in their environment rather than towards their own perceptual processes and limitations. Works like *Sunburned GSP 666* (2013) by Chris McCaw, shown in Fig. 38, condense a temporal period of multiple hours into a single image, showing the movement of the sun across the sky. In McCaw's practice, the temporal process allows for the sun to literally burn the negative of the film, making a poetic process of creation and destruction inside the camera itself. While this creates stunning imagery, it is unlikely to elicit metaperceptual responses, as the audience's attention is not likely to be redirected back onto their own perception.

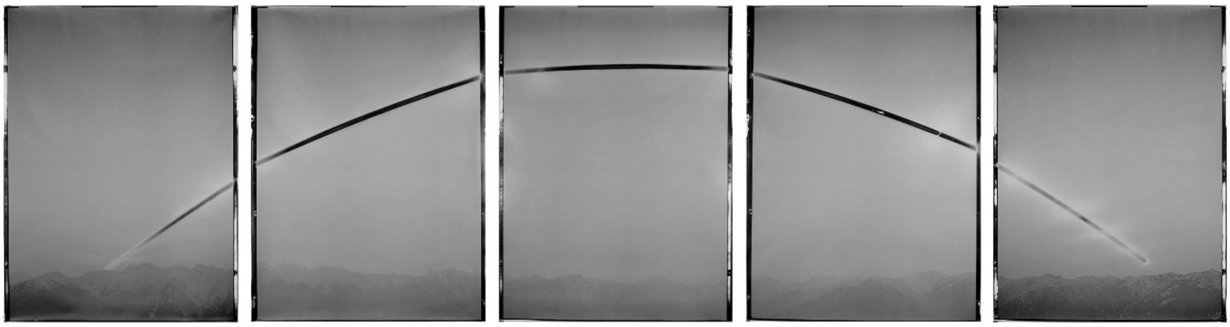


Fig. 38 Chris McCaw, Sunburned GSP 666. Image provided courtesy of the artist.

A metaperceptual approach to exploring our temporal experience can be found in Lorenz Potthast's *The Decelerator Helmet* (2012). Instead of presenting a condensation of a temporal period, *The Decelerator Helmet* allows the wearer to experience time at a different speed. The helmet fully encloses the head of the wearer, hosting a camera and microphone that sits on the outside. The signals from both inputs are processed by a small computer, slowing them down and displaying them to the wearer's eyes via a display. The visual stream is also sent to a screen on the outside of the helmet, allowing other people to see what the wearer sees. The user can control the behaviour of the temporal change through a small hand-held remote control. There are three different modes: In 'auto-mode', time is slowed down automatically and re-accelerated after a defined interval. The 'press-mode' allows the specific deceleration of time and in the 'scroll-mode' the user can completely control the speed of the elapsing of time.

The Decelerator Helmet is a rare work which looks to extend our perceptual experience in the time domain. The stream of time is often thought of as an invariant constant, if thought of at all. *The Decelerator Helmet* breaks this stream and makes it malleable, revealing its role in our experience. In the artwork's description, the artist writes 'The idea to decouple the personal perception from the natural timing enables the user to become aware of his own relationship to time. The helmet works as a reflection-bubble to think about the flow of time in general and the relation between sensory perception, environment and corporality in particular.'[229] His writing reveals that his intentions are strongly related to the metaperceptual framework.

[229] Lorenz Potthast, 'The Decelerator Helmet', 2018.

The origin of the work shares themes with the deprivation works described in the deprivation chapters. Potthast writes ‘More. Better. Faster. In an increasingly hectic, overstimulated and restless environment the calls for deceleration are omnipresent. The inconceivable amount of information and influences in our everyday lives leads in many cases to an excessive demand.’[230] Many of the deprivation works react to the same glut of stimuli through a reduction, curating the experience to form a refined palette. Potthast’s response is to give the wearer autonomy over their temporal experience, allowing the wearer to navigate the deluge of sensory information on their own terms.

Fig. 39 Lorenz Potthast, The Decelerator Helmet. Image provided courtesy of the artist.

While *The Decelerator Helmet* slows down the visual and aural sense of the wearer, it does not remove the other senses from the present. The work splits the wearer’s perceptual apparatus into multiple temporal zones, creating a conflicting sensory environment. Potthast describes the first experience of wearing the helmet thus: ‘The first three minutes are just confusing, but then you get a feel for it and you become the director of your own perception. It’s alienating, because you’re experiencing time at a different speed to your own surroundings so you can’t really interact, but it’s also somehow fascinating. People often don’t want to take it off again.’[231] The wearer’s interaction with their environment becomes a fractured feedback system, as their visual and aural

[230] Potthast.
[231] Kit Buchan, ‘Decelerator Helmet: Viewing the World in Slow Motion’, *The Guardian*, 10 June 2014.

senses are situated at different temporal point to the rest of their senses. This conflict interferes with the wearer's vestibular and proprioceptive systems, forcing them to navigate their environment carefully.

The works discussed in the 'Perceptual Field Extenders' section afford their audiences new forms of interaction and control over their perception. Another form of extension is redefining the range of stimuli that we can perceive. Each of our sense modalities have limits to the range of stimuli that they can sense. Our ears can only hear frequencies between 20 Hz and 20 kHz, and the light we see is only a small portion of the electromagnetic spectrum.[232] Although we are unable to directly sense stimuli outside of these ranges, artworks are able to redefine our perceptual range through translating stimuli.

6.2 Perceptual Range Extenders

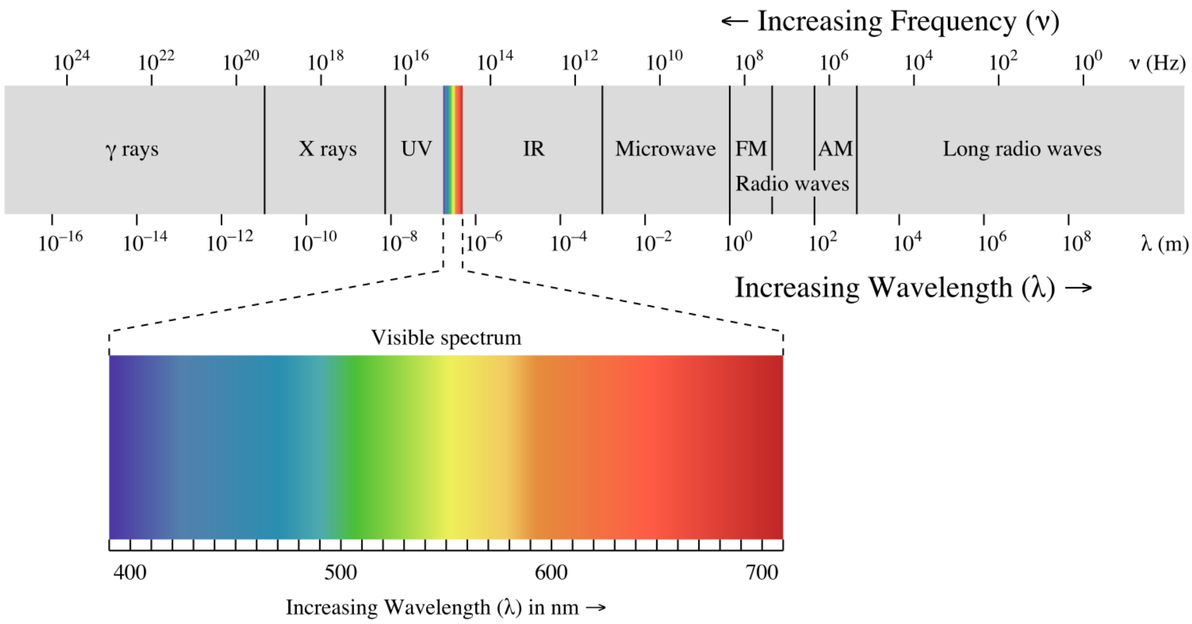


Fig. 40 Electromagnetic spectrum with the visible spectrum expanded below. Image: 'EM spectrum' by Philip Ronan, Gringer is licenced under CC BY 3.0

There are a range of metaperceptual artworks that translate electromagnetic waves into perceivable stimuli. The electromagnetic spectrum contains wavelengths that span from extremely short-wavelength gamma rays (with a wavelength of about 10^{-12} m) to long-wavelength radio waves (with wavelengths of around 10000 m).[233] This vast range, shown in Fig. 40, offers a rich vein of potential for transcending the limits of our perception, allowing us to experience the world in new

232 Mather.
233 Bruce E. Goldstein, *Sensation and Perception*, 8th Edition (Cengage Learning, 1994).

ways. In the following section, I catalogue perceptual range extenders by investigating the bands of the electromagnetic spectrum that have metaperceptual potential.

The X-Ray band (0.01 nm to 10 nm) is predominantly used in medical imaging. The short wavelength and high penetration power of the waves allow them to enter the body, revealing the structure of internal organs and bones. This feature makes the imaging of X-rays a powerful aid in the diagnosis of medical conditions. These imaging techniques have been furthered by various processes such as Computed Tomography (CT scanning), which uses a large series of two-dimensional X-ray images taken from a range of directions to generate a three-dimensional representation.[234] While these technological advancements occurred in the field of medical science, they can also afford artistic explorations.

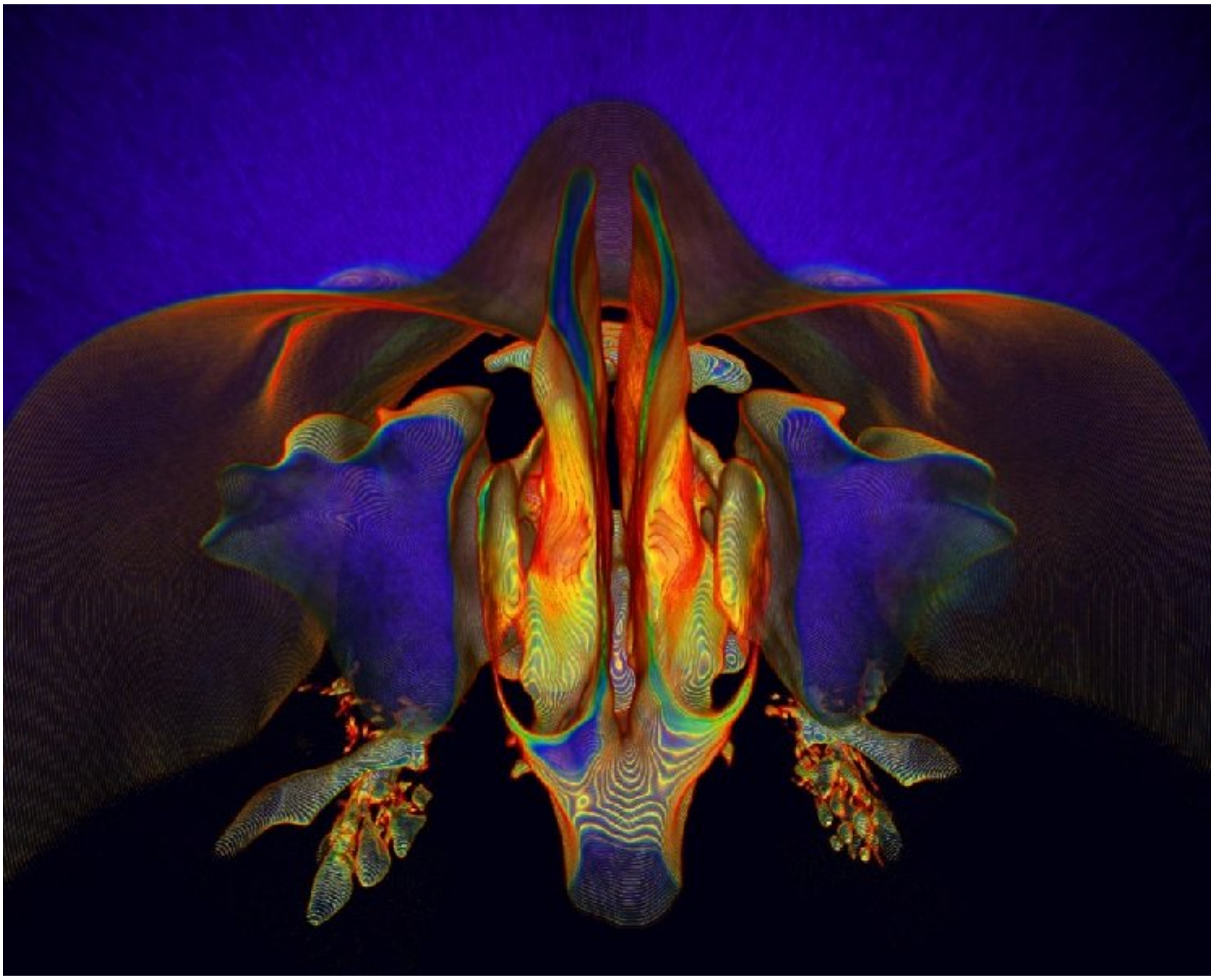


Fig. 41 Kai-hung Fung, What Lies Behind Our Nose. Image provided courtesy of the artist.

While X-ray imaging has been employed by a range of artists, I am unaware of any metaperceptual X-ray explorations. However, as X-rays are able to provide new perspectives on the body, the artworks often share themes with the metaperceptual approach. Dr. Kai-hung Fung is a radiologist

---

[234] Gabor T. Herman, *Fundamentals of Computerized Tomography: Image Reconstruction from Projections* (Springer Science & Business Media, 2009).

who combines his profession with his art practice. By using CT scans, Fung creates visual artworks that show the interior workings of the human body. For instance *What Lies Behind Our Nose* (2007), shown in Fig. 41, uses CT imaging to map the complexities of the human sinuses. Fung has also created his own artistic process of adding colours to create depth to the two-dimensional image, which he has coined the 'rainbow technique.'[235]

Fung's practice uses X-ray imagining as a material to produce static visual works. X-ray imaging has also been used to create interactive works, as in Ikse Maître *Primary Intimacy of Being* (2014). The work is described as a digital mirror, allowing the audience to see themselves, but with their skin stripped away and their bones, organs, and muscles exposed. The work uses a full-body CT scan of the participant that takes up to three-and-a-half hours to create a detailed 3D representation.[236] This long process would be unsuitable to an installation context, so when the work is exhibited, an algorithm identifies the gender of the participant in front of the mirror, which is then used to choose between two pre-scanned forms. This allows for a fast approximation of the audience's body, so that they can immediately engage with the work. The mirror consists of a screen displaying the X-ray imaging, and a Kinect camera that tracks the movement of two dozen different joints. The camera's body-tracking data is used to animate the X-ray model on screen, creating an interactive experience between audience and their approximated X-ray model.

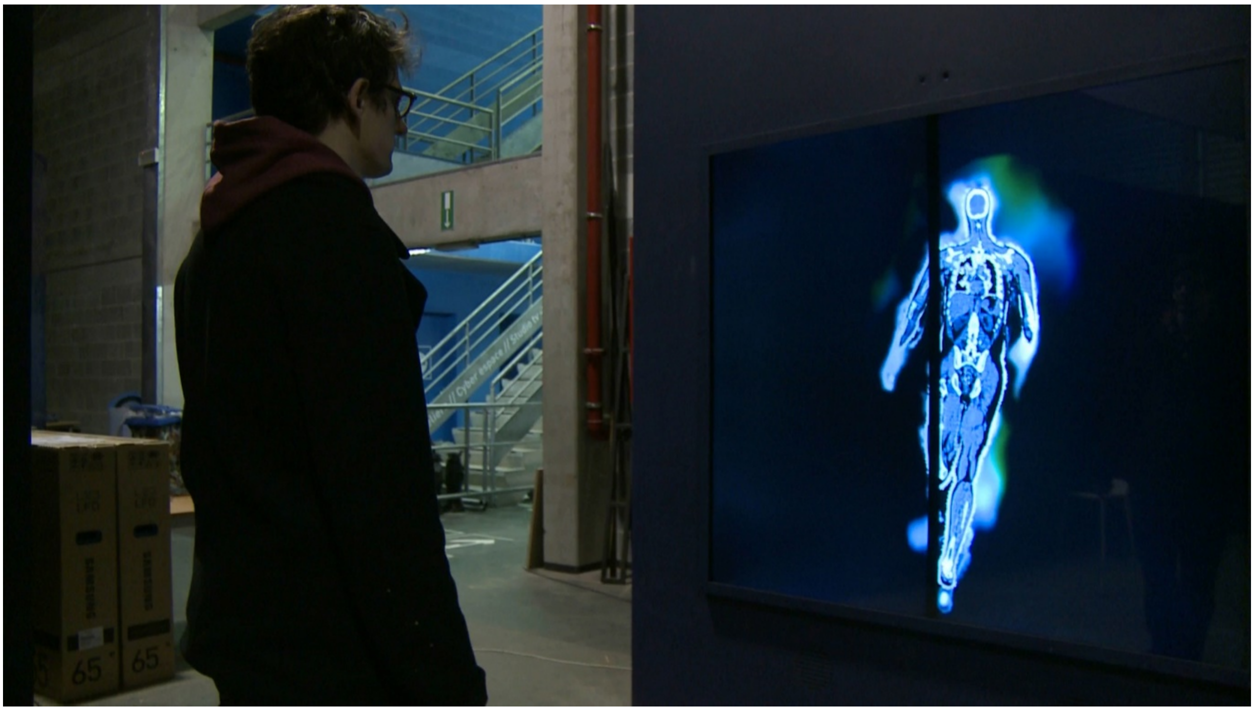


Fig. 42 Ikse Maître, Primary Intimacy of Being. Image provided courtesy of the artist.

[235] Kai-hung Fung, 'The Rainbow Technique: An Innovative Approach to the Artistic Presentation of 3D Computed Tomography', *Leonardo*, 39.2 (2006), 101–101.
[236] Aviva Rutkin, 'Digital Mirror Reveals What Lies under Your Skin', *New Scientist*, 15 April 2014.

The work presents an uncommon, and for some, uncomfortable representation of the self. The artist reports that in an experiment to gauge reactions to the work, he left 30 colleagues alone with the mirror, whereupon 'One-third of people felt uncomfortable in front of the mirror and reluctant to let others see.'[237] The work reveals an uncanny version of the self, one that is always there but rarely seen. In doing so, Maître intends to create a situation in which 'a new intimacy is established with the stranger that is our own body.'[238]

Both Kai-hung Fung and Ikse Maître's works share many themes with the metaperceptual approach. Their thematic materials focus on revealing elements of the body and their method involves translating the X-ray range into the visible spectrum. Where they differ from the metaperceptual approach is in the experience of the audience. Although the works may offer a new perspective of their body, the audience is not able to experience the world through the new perceptual field of X-ray vision. Instead, they are offered an isolated X-ray object. While the audience may have their attention drawn to their own body, this will not be through their perception but through the semantic connections of the visual object. The experience is more closely related to seeing an X-ray of your own body, which may give you a new perspective of your body but is unlikely to provoke the contemplation over the nature of your perception that lies at the core of metaperceptual works.

X-rays are rarely naturally found on Earth, with the most common methods of generating X-rays occurring in highly controlled environments. This limits the potential environments in which X-rays could function as a medium for sight. In contrast with X-rays, the electromagnetic ranges of ultraviolet and infrared are often present. Ultraviolet radiation from sunlight readily penetrates earth's atmosphere, and constitutes about 10% of the total light output of the Sun. Infrared radiation is ubiquitous, as most of the thermal radiation emitted by objects near room temperature is infrared. The following sections explicate the potential for exploring the ultraviolet and infrared spectrums in metaperceptual works.

In a similar vein to X-rays, the infrared and ultraviolet spectra have been explored by a range of visual artists. Richard Mosse has explored the potential for communicating narratives with infrared photography in a range of projects. His series of works, *Infra* (2012), offers a radical rethinking of how to depict a conflict as complex and intractable as that of the ongoing war in the Democratic Republic of Congo. The images utilise Kodak Aerochrome, a now discontinued medium that allows for infrared radiation to be captured on colour film. As infrared radiation is not visible by

[237] Rutkin.
[238] Ikse Maître, 'Primary Intimacy of Being', *Le Pixel Blanc*, 2013.

the human eye, what is captured on film goes through a colouring process. In this case, the film registers live vegetation of the lush Congolese rainforest as a surreal landscape of pinks and reds. The complexity and immensity of the ongoing wars in the Democratic Republic of Congo are difficult to comprehend. Jason Stearns in a review for The Guardian writes 'By representing the conflict with an invisible spectrum of infrared light, he pushes us to see this tragedy in new ways.'[239]

Fig. 43 Richard Mosse, Vintage Violence. Image provided courtesy of the artist.

The vibrant pinks and reds of *Infra* are not the common visual representation of infrared radiation. Traditionally, the information is rendered in monochrome which allows for the thermal information to be precisely and easily read, with colder regions rendered light, and hotter regions rendered dark. Mosse uses this more scientific rendering in another series, *Heat Maps* (2017). The work captures 'the harsh struggle for survival lived daily by millions of refugees and migrants, seen but overlooked, and ignored by many.'[240] One image captures an incident in which a refugee boat with more than 300 passengers started to sink in the waters off the coast of one of the refugee camps. Rescuers struggled to save the passengers from the freezing waters, getting them on shore

[239] Jason Stearns, 'Shocking Pink', *The Guardian*, 2011.
[240] Richard Mosse, 'Heat Maps', *Heat Maps*.

and attempting to warm the bodies of the survivors. The thermal imaging of the cameras revealed the shocking struggle of the victims, with the warm hands of the rescuers rendered dark in contrast to the marble whites of the victims' bodies. [241] In many of the images of *Heat Maps*, Mosse uses the infrared camera to reveal elements of the world which are usually invisible to us, giving us a chilling insight to the struggle of the refugees.

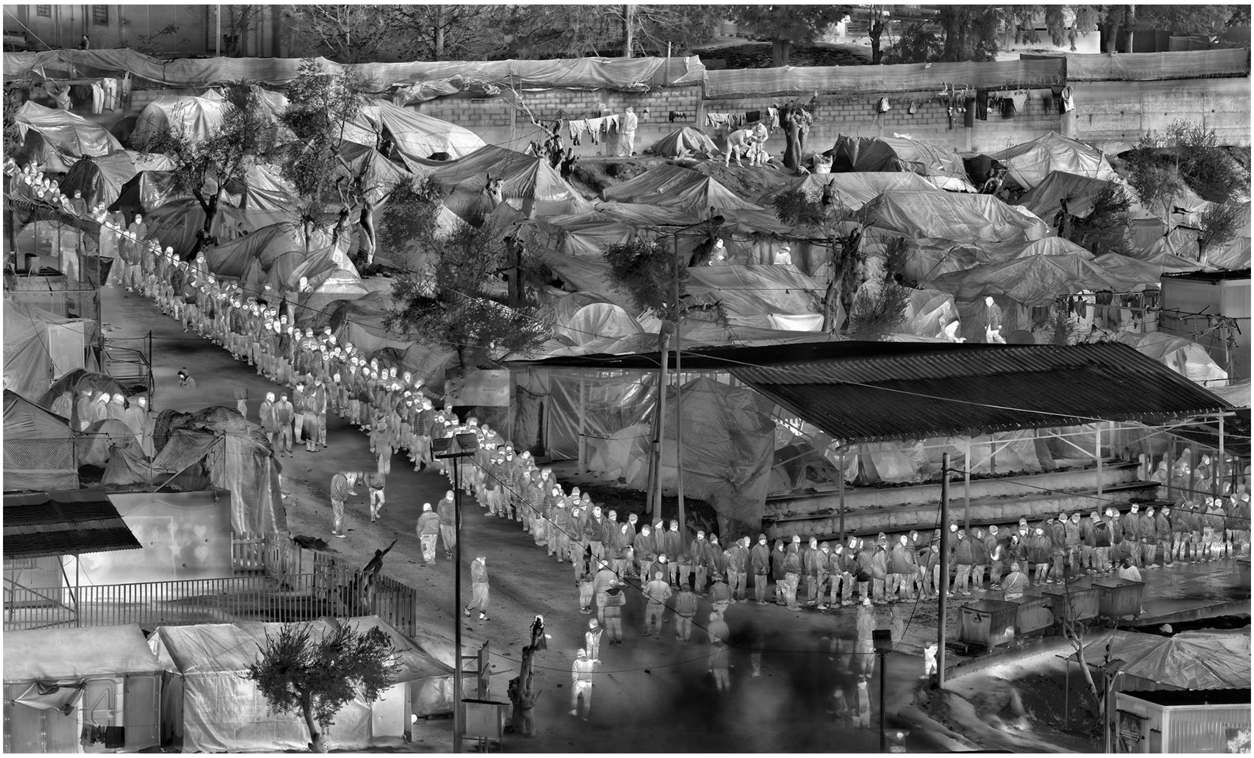


Fig. 44 Richard Mosse, Moria in Snow. Image provided courtesy of the artist.

Richard Mosse's use of the infrared spectrum allows him to communicate elements of narratives that are invisible to the eye. While this is a powerful revelation, the unveiling is directed towards an event or place, rather than the viewer's own perception. Nonetheless, the ability to unveil the hidden elements of our environment and let the viewer see the invisible has a strong potential for future metaperceptual works. As with many works in the perceptual range extender section, these works can create metaperceptual experiences through transcending the limitations of the perceptual apparatus. This not only allows for a new perspective of the world, but also for the limits of human perception to become apparent.

While the infrared range shows a new layer of thermal radiation information for the visual sense, ultraviolet radiation can reveal a hidden world of stimuli that is undetected by any of our senses. There are two main forms of translating the ultraviolet range into the visible spectrum. Reflected ultraviolet photography involves capturing subjects directly illuminated by ultraviolet radiation, either by ultraviolet-emitting lamps or by strong sunlight. A filter is used to block out all visible

[241] Paris Photo, Richard Mosse, 2017.

and infrared light, leaving just the ultraviolet radiation to pass through to the sensor. This method has widespread applications in forensic science, as the ultraviolet spectrum can reveal hidden details and offer a new understanding of an environment. A characteristic of ultraviolet light is that it is highly absorbed by many organic materials but is reflected by many inorganic materials like stone and metal. This allows for an environment to be seen through a contrast between organic and inorganic, making traces of organic material stand out strongly.[242] Other applications include imaging of bite-marks and other pattern injuries on skin, imaging of shoeprints on surfaces where visible-light contrast is low, and the imaging of fingerprints. The metaperceptual potential of the ultraviolet spectrum is similar to the previously discussed infrared band: it offers new perspectives of the world by transcending the limitations of our perceptual system. Two artworks which utilise the ultraviolet spectrum allow for a discussion of this band's metaperceptual potential.

Fig. 45 A screenshot from Thomas Leveritt, How the Sun Sees You. Image provided courtesy of the artist.

Artist Thomas Leveritt uses the forensic revelation of reflective ultraviolet photography to question our understanding of the damage ultraviolet radiation from the sun can do to our skin. His video project *How the Sun Sees You* (2014) captures people of the streets of New York reacting to seeing themselves in a different light. The ultraviolet radiation reveals the not-yet-visible changes and damage of the viewer's skin, giving them a new, and sometimes disturbing, perspective of themselves. Leveritt reports that 'wary participants were noticeably shocked to find cheeks full of freckles, scars from the past and large patches of sun spots and damage where they might not typically apply sunscreen.'[243] The participants were then offered sunscreen and were

---

[242] Austin Richards and Rachel Leintz, 'Forensic Reflected Ultraviolet Imaging', *Journal of Forensic Identification; Alameda*, 63.1 (2013), 46–69.
[243] Nina Azzarello, 'Thomas Leveritt Highlights Sunscreen's Protective Power with UV Footage', *Designboom*, 15 August 2014.

invited to apply it to their faces. The lotion's inorganic materials turn opaque in the ultraviolet representation, creating a striking visual difference as the normally invisible protective layer that sunscreen provides is rendered in a vivid black. This project functioned as such an effective advertisement for sun protection that sunscreen company Nivea employed Leveritt to create a sequel, promoting their Nivea Sun product.

Fig. 46 Craig Burrow, Jade Plant Flower (2017). Image provided courtesy of artist.

Ultraviolet-induced fluorescence photography is the other main method of capturing the spectrum. This method collects the visible light that is caused when ultraviolet radiation generates fluorescence. Under dark conditions, materials which are fluorescent glow, as they absorb electromagnetic radiation and emit visible light. This method can reveal special characteristics of some materials, and in the case of the photography of Craig Burrow, a secret language. Burrow uses ultraviolet-induced visible fluorescence photography to capture the fluorescence of plants, revealing glowing hidden patterns that form on the petals. Flowers create ultraviolet patterns on their petals that function as orientation cues for bees,[244] attracting the bees to their nectar and in turn spreading their pollen. Burrow's works reveal a captivating new perspective of a form of communication between plants and bees, as the fluorescent patterns act as beacons of light to attract bees.

---

[244] C. Eugene Jones and Stephen L. Buchmann, 'Ultraviolet Floral Patterns as Functional Orientation Cues in Hymenopterous Pollination Systems', *Animal Behaviour*, 22.2 (1974), 481–85.

Similar to infrared electromagnetic radiation, experiencing the world through the ultraviolet range has potential to be explored in new metaperceptual works. The effect of expanding the perceptual range into the ultraviolet spectrum reveals a new layer of stimuli that is previously unperceived, and can change the perceptual dynamics of how the viewer sees by contrasting organic and inorganic materials. Both Craig Burrow's ultraviolet flowers and Thomas Levitt's *How the Sun Sees You* are not directly focused on the perception of the audience. While Levitt's work is closest to exploring metaperceptuality, the work is more aligned with the X-ray rendering of the audience's body in Ikse Maître *Primary Intimacy of Being,* discussed earlier in this section. It presents a new perception of the self as an isolated object, rather than a medium through which to see the world.

The last section of the electromagnetic radiation spectrum that we experience, although not directly, is radio waves. While the infrared and ultraviolet ranges border on the visible spectrum, radio waves are much longer in wavelength, allowing for them to radiate out of line-of-sight and through visibly opaque media. Naturally occurring radio waves are a rarity, only being generated by lightning or by astronomical objects. Contrastingly, artificial radio waves are now abundant, as they have been used to transmit information since 1887.[245] While radio waves are the only section of the electromagnetic spectrum that is regularly translated into sound, our experience of them is not usually metaperceptual. While infrared and ultraviolet bands can offer us a new perspective on our environment, radio waves are usually used as a carrier of information. This means that when we are experiencing the translation of radio waves into perceivable stimuli, our attention is usually drawn to the information rather than our own perception of it.

While most of our experiences of radio waves are not metaperceptual, Christina Kubisch seeks to translate radio waves, and other electromagnetic radiation, into perceivable stimuli to reveal the qualities of the radiation itself, rather than information it contains. Kubisch has designed a wearable headset for her *Electrical Walk* (2004) series that uses electromagnetic induction, allowing the wearer to listen to the electromagnetic waves that are constantly present in our environment. The electromagnetic induction acts as a translator of stimuli, converting a range of electromagnetic waves into sound waves. The works guide the wearer through the streets of cities and towns, equipped with a specially designed headset that translates the electrical hums and buzzes into perceivable sound. The piece is enacted by the wearer, as they have the option to either follow a route that is prescribed by Kubisch, or they can explore the city as they wish.

[245] W. C. Brown, 'The History of Power Transmission by Radio Waves', *IEEE Transactions on Microwave Theory and Techniques*, 32.9 (1984), 1230–42.

Fig. 47 Christina Kubisch, Electrical Walks

Electrical Walks reveals the torrent of electromagnetic fields that surround us, and offers a new perspective on our sensory environment. Kubisch describes the experiential effect thus: 'the perception of everyday reality changes when one listens to the electromagnetic fields; what is accustomed appears in a different context. Nothing looks the way it sounds. And nothing sounds the way it looks.'[246] By revealing this range of stimuli, the wearer is able to experience a world of stimuli that usually exists beyond the limits of their perception, making the invisible and inaudible perceivable. In contrast to other metaperceptual works in this section that use a band of the electromagnetic spectrum as a medium through which to experience the world, *Electrical Walks* creates metaperceptual experiences by allowing the wearer to experience the radiation itself. This brings attention to the barrage of stimuli that is present, but goes undetected, due to the limitations of our perceptual systems.

The works discussed so far have focussed on the electromagnetic spectrum, and just as we see light only within a narrow band of electromagnetic wavelengths called the visible spectrum, we hear sound only within a specific range of frequencies and loudness. The human auditory system has limitations in both the loudness and frequency domains. The loudness threshold of hearing has

[246] Christina Kubisch, 'Electrical Walks', *Electromagnetic Investigations in the City*.

been measured as low as 20 micropascals of RMS sound pressure, or roughly -9 dB SPL.[247] This is frequency dependent, as our hearing threshold is not a constant across the spectrum, with the range between 2 kHz and 5 kHz being the most sensitive. In this domain, the use of microphones and amplifiers can act as a technologically mediated perceptual extender. As in the field recording practices of Chris Watson and in Rebecca Kleinberger's perceptual field extender *PHOX Ears,* the threshold of hearing is expanded to quieter sounds than we can normally hear.

In the frequency domain, the audible range is between 20 Hz and 20 kHz. This is dependent on the age of the person and their previous exposure to sound at loud volumes as the health of the auditory system effects its range.[248] In comparison to other animals, elephants can hear stimuli below 20 Hz, and at the other end of the range, dogs can hear frequencies above 40 kHz, cats above 50 kHz, and dolphins as high as 150 kHz.[249] There are multiple ways in which technology can transform ultrasonic stimuli into the hearing range. As with Craig Burrow's UV photography of flowers, this can reveal a new layer of stimuli that exists outside of the limitations of the human perceptual system.

The technological basis for the translation of these ultrasonic frequencies into the audible range can be found in bat detectors. The technology innovations, detailed in the following paragraph, can serve as a platform for artworks to explore this translation in an aesthetic context. Bats generate ultrasonic frequencies between 12 kHz and 160 kHz to use as spatial cues through echolocation. By translating parts of the ultrasonic spectrum into the audible range, we are able to identify the presence and type of bats. There are three types of real-time bat detectors in common use, each using different methods to translate the ultrasonic stimuli into the audible range. Heterodyne detectors are the most commonly used and act as a simple pitch-shifter, moving all the ultrasound frequencies downward by a fixed amount. The user has control over the amount of pitch shift, and can tune into different strata in the ultrasonic frequency spectrum. Frequency-division bat detectors synthesise sound based on dividing the frequency content of the ultrasonic spectrum. There are a number of methods to perform this synthesis, with the most common one using the zero crossings of ultrasonic signals to control a synthesised square wave. The wave's zero-crossings are generated at one-tenth of the original, effectively dividing the frequency content by ten. The last method is time expansion, which involves recording bat calls at a high sampling rate on to a digital medium. The high sampling rate allows for the ultrasonic sounds to be captured and then slowed down, which effectively pitch shifts the bat calls into the audible range. Although

---

[247] Stanley A. Gelfand and Stanley Gelfand, *Hearing: An Introduction to Psychological and Physiological Acoustics, Fourth Edition* (Taylor & Francis, 2004).
[248] Takeda and others.
[249] Mather.

these bat detectors are often advertised as 'real-time', to monitor using this method there is an inevitable delay as the sound is slowed down.

While each method has its own capabilities and limitations for detecting bats, the *time expansion* method has been most frequently used for artistic purposes. Capturing the ultrasonic frequencies at a high sampling rate allows for a superior level of fidelity, as little audio information is lost in comparison to the other two methods. Artworks that have used this translation method include Natasha Barrett's *Crush-2* (2010), which allows the audience to explore the microscopic forces released during the process of crushing rock. The installation allows the listener to move through a virtual, immersive space, experiencing the dynamics of deformation from 'inside' the rock. To capture the full range of forces that are released, a large number of ultrasonic transducers were distributed evenly over the deformed rocks, allowing for the sound of fracturing bonds within the rock structure to be recorded. The ultrasonic recordings are then transposed into the audible range through tape transposition, slowing down the speed of the recordings and therefore lowering their pitch.

Crush-2 presents a new mode of experiencing the interesting physical phenomena of rocks being crushed. Other artistic investigations of the ultrasonic range include unveiling the unheard sounds that common instruments produce. Andreas Bergsland and Trond Engum's research project 'Unheard Sounds: The Aesthetics of Inaudible Sounds Made Audible' presents a thorough investigation of recording methods for capturing sounds just outside of the audible spectrum, often transposing instrumental sounds down by two or three octaves.[250] While this research shows the availability of methods for translating the inaudible into the audible, as of yet, the metaperceptual implications of this translation are underexplored. While *Crush-2* presents previously unheard sonic detail, and Bergsland and Engum's research project details methods for capturing this band of stimuli, their explorations do not draw attention to transcending the limitations of the listener's perceptual apparatus. Instead they focus on new interpretations of existing objects. There is a strong potential for new metaperceptual sound artworks that expand the listener's perceptual range into the ultrasonic, allowing them to experience a stratum of stimuli that is normally inaudible.

The 'Perceptual Field Extenders' category of artworks detailed in this chapter focuses on transcending the limitations of our perceptual apparatus by offering us new ways of perceiving the world. The 'Perceptual Field Extenders' change the shape and size of our perceptual fields. By making the perceptual field dynamic and alterable, the modes in which we usually perceive the

[250] Andreas Bergsland and Trond Engum, 'Unheard Sounds: The Aesthetics of Inaudible Sounds Made Audible', *Journal on The Art of Record Production*, 2015.

world become the object of inquiry. The uniformity of the passing of time becomes fluid in *The Deaccelerating Helmet*; the omnidirectional sphere of our aural field becomes a malleable form in *PHOX Ears*; and our ability to tune out background noise and focus on one stratum of stimuli is enhanced in *Eidos Audio*. Each of these works transcend the boundaries of a facet of the perceptual apparatus which in turn reveals its normal limitations. This allows for metaperceptual experiences as the audience's attention is drawn to their own perceptual apparatus.

The 'Perceptual Range Expanders' have the ability to reveal a world of stimuli that is normally invisible or inaudible. The expansion of our vision into other ranges of the electromagnetic spectrum and our hearing into the ultrasonic reveal new perspectives of the world around us. The vibrancy of the electromagnetic spectrum allows for a range of new visual perspectives: the secret communication between flowers and bees is illuminated in the ultraviolet spectrum; warm bodies struggling against the cold are revealed in infrared; and the interiority of our bodies are shown in the X-ray spectrum. In the aural domain, hearing ultrasonic frequencies provides a new perspective on the communication and sounds of other animals.

By transcending the limitations of our perceptual apparatus, the constant filtration of stimuli in our environment is revealed. The common view of the human perceptual system is that it is a neutral medium through which we perceive the world. The elucidation of the limits and idiosyncrasies of our perceptual system reveals this to be false, thus creating metaperceptual experiences. The 'Perceptual Extenders' allow the audience to have new perspectives of the world, and interact with their own perceptual apparatus in previously impossible ways.

The following chapter details works that rearrange the perceptual apparatus of their audiences in order to mimic another animal. In doing so, they seek to allow the audience to experience as the animal does, approaching Nagel's question by providing a lens to experience the world through.

Chapter Seven

Perceptual Translation: Perceptual Mimesis

The limitations of the human perceptual system are unique to itself, as other animals have their own set of limitations and idiosyncrasies. The 'Perceptual Extenders' chapter contained works that look to transcend these limitations, with some taking cues from the modes in which other animals experience. This 'Perceptual Mimesis' chapter contains works that are directly influenced by the perceptual apparatus of other animals. They translate the perceptual apparatus of their audiences in order to mimic another animal, seeking to allow the audience to experience the world as the animal does.

This examination, exploration, and exploitation of the structure and organization of other animals for problem-solving and design innovation is described as biomimetics.[251] The term was first developed in 1950s by Otto Schmitt, who modelled his invention, the 'Schmitt Trigger', on the squid's nervous system.[252] The 'Schmitt Trigger' is an electronic circuit which, like the squid's nervous system, allows signals to reach a controller only when they exceed a certain threshold level, below which the signals are mostly noise. The mimicry of natural mechanisms in technological innovations predates Schmitt's coining of the word. Leonardo da Vinci's famous flying machines were directly influenced by his observations of birds in flight,[253]. Biomimetics has now become the study of nature and natural phenomena to understand the principles of underlying mechanisms, and the application of these ideas in science, engineering, medicine, and other fields. More modern examples of biomimetic studies include fluid-drag reduction swimsuits inspired by the structure of a shark's skin, Velcro fasteners modelled on burrs, and stable building structures copied from the backbone of turban shells.[254]

Biomimetics has also had influence on architecture and art, where natural forms have been used as the basis for organisational structures. The Nakagin Capsule Tower, designed by Kisho Kurokawa, is a rare remaining example of the Metabolism movement in post-war Japan. The

---

[251] Julian F. V. Vincent and others, 'Biomimetics: Its Practice and Theory', *Journal of The Royal Society Interface*, 3.9 (2006), 471–82.
[252] Thomas J. Misa and Robert W. Seidel, *College of Science and Engineering: The Institute of Technology Years (1935-2010)* (Lulu Press, Inc., 2011).
[253] August Raspet, 'Biophysics of Bird Flight', *Science*, 132.3421 (1960), 191–200.
[254] Jangsun Hwang and others, 'Biomimetics: Forecasting the Future of Science, Engineering, and Medicine', *International Journal of Nanomedicine*, 10 (2015), 5701–13.

Metabolism movement used cellular discoveries of the time to reduce the essential living requirements to discrete, interconnected blocks suitable for rapid growth and expansion.[255] The Metabolists were heavily influenced by the images of metabolic and cellular organisations, incorporating the ideas of cellular replication, organisation, and efficiency of function into their architectural designs. The Nakagin Capsule Tower, shown in Fig. 48, was designed by scaling these forms up to human size, creating nearly identical individual pods or cells. Replicating the modularity of the cell, each of these pods was attached independently and cantilevered from a central shaft, so that any capsule could be removed easily without affecting the others. The resulting architecture is a radically different structure than most residential housing and, although this building is now mostly abandoned, the concept of a capsule hotel is now widespread in Japan.

Fig. 48 Nakagin Capsule Tower designed by Kisho Kurokawa

Where Nakagin Capsule Tower takes its formal organisation from nature, other designs and artworks have been inspired by the complex movements of communities of animals. The power of these systems for the application in art is that by mimicking the simple interactions of the individuals in communities, complex behaviours can emerge. One prevalent example of this behavioural mimesis is of the movement of birds flocking. This complex behaviour is of particular interest in the artificial intelligence and robotics fields as an example of the collective behaviour

---

[255] Bharat Bhushan, *Biomimetics: Bioinspired Hierarchical-Structured Surfaces for Green Science and Technology* (Springer, 2016).

of decentralized, self-organized systems.[256] Murmuration can be a mesmerising sight, as each bird's intricate choreographed movements work together, making a wave or cloud of small black particles. This movement is the inspiration for *Diffusion Choir* (2016), shown in Fig. 49. The work is a permanent kinetic sculpture, consisting of a mechanical array of origami-like structures. Each component can assume a wide range of shapes, as small embedded motors retract and expand the umbrella-like forms. Suspended in a three-dimensional grid, the components all work together to create complex forms in the atrium space. The movements are informed by a flocking simulation, and perpetually evolve over the course of each hour. Through the shrinking and expanding of each component, the sculpture creates complex forms in 3D space, as parts of it appear and disappear. While *Diffusion Choir* is an elegant exemplar of biomimetics in an artwork, the mimesis element is manifested in the formal elements of the work. For a metaperceptual exploration of biomimetics, the mimesis needs to allow for the audience to approximate the experience of another creature. This form of mimesis is discussed in the following section.

Fig. 49 Diffusion Choir by Sosolimited, Hypersonic, Plebian. Image provided courtesy of the artists.

The 'Perceptual Mimesis' chapter of metaperceptual works are informed by a specific form of biomimetics. These works seek to mimic the perceptual systems of other animals, allowing their audiences to experience the world through an approximation of the animal's perspective. A number of animals' perceptual systems are presented below, followed by an exploration of the means by which inspiration may be drawn from them in the creation of new metaperceptual works.

[256] Eric Bonabeau, Marco Dorigo, and Guy Theraulaz, *Swarm Intelligence: From Natural to Artificial Systems* (OUP USA, 1999).

The animal kingdom is full of diverse perceptual systems, including ones that have sensory modes outside of the human range. Some of these sensory ranges have been discussed in the 'Perceptual Extender' chapter. The ultraviolet vision of bees, which allows them to see patterns on petals that help them navigate to find nectar is found in Craig Burrow's photography. Snakes have a sense that is similar to seeing in the infrared spectrum, as explored in the work of Richard Mosse. A range of snakes possess thermal radiation receptors, the facial pits, which allow them to detect modest temperature fluctuations within their environments.[257] This aids them in detecting prey and can help them find cooler areas for thermoregulation of their bodies. Lastly, echolocation allows bats to find prey and navigate in pitch darkness, using ultrasonic sound to map an environment. This stratum of stimuli is explored in Natasha Barrett's *Crush-2,* discussed in section 6.2.

Other senses that lie outside of the human perceptual realm include electroreception and magnetoreception. A range of aquatic animals possess electroreception, or the ability to detect electrical stimuli. All sharks are electrosensory through electroreceptor cells on their snouts and other zones of their head.[258] Any muscular movement made by the shark's prey creates a small amount of electrical activity, which the shark can perceive and use to locate their position. Magnetoreception is a sense which allows an organism to detect a magnetic field to perceive direction, altitude or location, and is used by a range of animals. Homing pigeons and migratory birds are notable for their ability to traverse long distances and navigate to a known point. They use magnetic fields as part of their complex navigation system. These sense modalities that the human perceptual system does not contain offer avenues for new metaperceptual works to explore through perceptual biomimesis.

7.1 Visual Mimesis

'Perceptual Mimesis' also includes different forms and organisations of the sense modalities that humans do possess. Writing on the history and evolution of eyes in the animal kingdom, Michael Land states 'Evolution has exploited nearly every optical principle known to physics, and produced eyes of many different designs, from camera-type eyes, to compound eyes, and eyes that use mirrors.'[259] The differences in environment and evolutionary pressures between animals means that their adaptations are varied, creating a rich range of perceptual apparatuses. This makes the

---

[257] Aaron R. Krochmal, George S. Bakken, and Travis J. LaDuc, 'Heat in Evolution's Kitchen: Evolutionary Perspectives on the Functions and Origin of the Facial Pit of Pitvipers (Viperidae: Crotalinae)', *Journal of Experimental Biology*, 207.24 (2004), 4231–38.
[258] Theodore Holmes Bullock, Carl D. Hopkins, and Richard R. Fay, *Electroreception* (Springer Science & Business Media, 2006).
[259] Michael F. Land and Dan-Eric Nilsson, *Animal Eyes* (Oxford University Press, 2002).

field of perceptual mimesis diverse and rich with a potential for a vast array of different organisations of the perceptual apparatus.

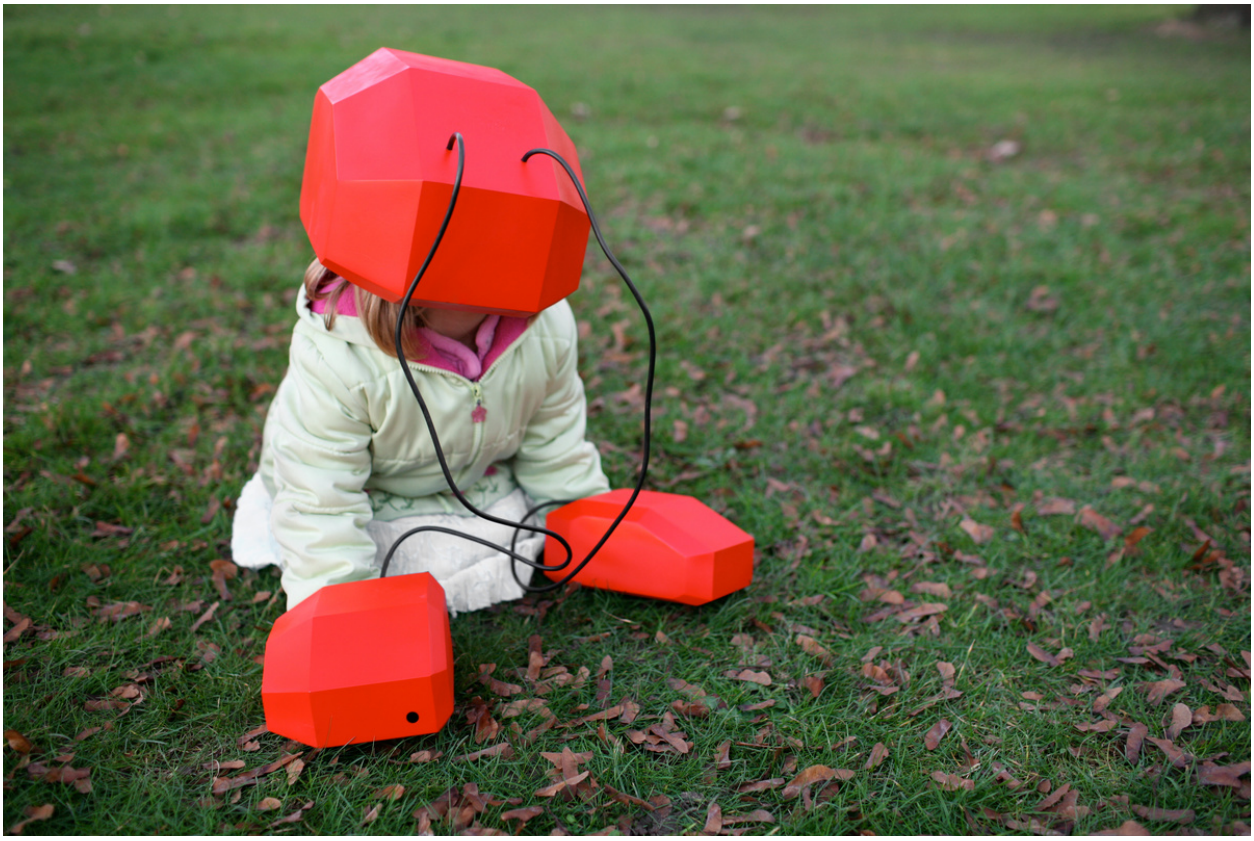


Fig. 50 Chris Woebken and Kenichi Okada, The Ant Apparatus. Image provided courtesy of the artists.

Chris Woebken and Kenichi Okada have produced a series of works entitled *Animal Superpowers* (2008) that examine natural systems and biomimetics. They contend that mimesis can inform our understanding of technology and its relationship to the environment.[260] The series consists of three wearable works that are designed as sensory enhancements for children to experience. The *Ant Apparatus* seeks to offer the perspective of being a minute bug, exploring the relatively large blades of grass in a field. The work shares themes with both the 'Perspective Shifters' and 'Perceptual Extenders'. It consists of a headset that houses virtual reality goggles, and large gloves that have an embedded microscope. The apparatus shifts the perspective of the wearer down to ground level and into the grass through a microscope in the glove. This allows the wearer to see the world at the scale that an ant does, magnifying their vision to 50 times its original size. Art reporter Geoff Manaugh observed that the effect of wearing the headset was that it 'made every move of even a fraction of an inch feel like several feet; users would slow down, crawling barely a centimetre at a time, exploring every crack and divot in the ground or table top, reduced to the scale (and speed) of an ant.'[261] The works creates a metaperceptual experience for the wearer as it forces them to renegotiate their senses by allowing them to see the world as an ant does.

[260] Chris Woebken, 'Animal Superpowers — Chris Woebken'.
[261] Geoff Manaugh, 'Make It A Cross-Species Halloween', *Gizmodo Australia*, 2013.

In contrast to the *Ant Apparatus*, the *Giraffe Device* shifts the visual perspective of the wearer upwards, allowing them to the world from a higher vantage point. The work uses a periscope to raise the viewer's perception by 30 cm. This mirrors the physiology of the giraffe, with their large necks allowing them to tower over other animals. As this work is aimed at children, the artists describe the work as a child-to-adult converter. To enhance the feeling of transformation, they include a voice changer which lowers the wearers voice down an octave well. While this modification moves the experience away from purely attempting to translate the giraffe's perceptual apparatus onto the wearers, it does draw the attention of the wearer onto their perception of self. This work could fit into the 'Perspective Shifter' category, as it seeks to allow the wearer to experience the world as an older person.

Fig. 51 Chris Woebken and Kenichi Okada, Animal Superpowers Series. From Left: Giraffe, Bird Device, and Ant Apparatus. Image provided courtesy of the artists.

The *Bird Device* attempts to give the wearer the magnetoreception sense that birds use as a part of their complex navigation system. The wearable headband can detect direction through GPS, and gives the wearer feedback through vibration. Tiny motors in the device create a haptic sensation on the skin when aligned with a predetermined place or path. The *Bird Device* seeks to translate magnetoreception into a tactile sense, which has its own set of limitations. The implementation is designed to give children a sense of orientation through touch, rather than truly attempt to simulate the sense of magnetoreception. Accordingly, the work may be described as bioinspired, rather than biomimetic. The artists write that 'rather than translating the sense of geomagnetic fields literally, we designed a device that can be set to basic children's needs, sensing the direction of home, ice cream shops or your friends.'[262] The artist's intent, as well as the degree of translation that is involved in the work, means that although the work has metaperceptual themes, it may not elicit metaperceptual experiences as strongly as other works in the *Animal Superpowers* series.

Fig. 52 Leaping Rabbit, Jim Rokos. Image provided courtesy of Jim Rokos and Public Works (Kathrin Bohm and Andreas Lang).

In a similar vein to the *Animal Superpowers,* Jim Rokos's *Leaping Rabbit* (2004) device seeks to alter the user's perception by giving them the sensation of being a rabbit. The work uses a pair of periscopes which are attached, off-centre, to a wheel. The user looks down the length of the

[262] Regine, 'Animal Superpowers', *We Make Money Not Art*, 2008.

periscope which lowers their view to ground level, similar to the *Ant Apparatus.* Where the *Ant Apparatus* changes the magnification of the user's visual perception, the *Leaping Rabbit* changes the orientation of the user's vision. The periscopes face outwards, mimicking the orientation of a rabbit's eyes, drastically changing the visual field. As the periscopes are mounted off-centre, when the user pushes the wheel forward, the periscope's vertical positions rise and fall in a manner akin to a rabbit leaping. The device also includes ears and a tail, which the artist included 'so that onlookers can also understand the product's purpose, avoiding any misunderstanding and the possibility of the user feeling self-conscious.'[263]

Both *Animal Superpowers* and *Leaping Rabbit* are recent works which are predated by the pioneering works of Haus-Rucker-Co. Formed in 1967 by Laurids Ortner, Günther Zamp Kelp, and Klaus Pinter, Haus-Rucker-Co's designs for inflatable structures, prosthetic devices, and interventions in public spaces questioned the limits of architecture, design, and the experience of space.[264] Their perceptual mimesis work *Flyhead* (1968)*,* shown in Fig. 53, is a visually striking helmet made from transparent green plastic that resembles the large bulbous eyes of the fly. The helmet fractures the visual perspective of the wearer through a split prism in front of each eye, creating a mosaic of images. This fracturing mirrors the compound vision of the fly, with its visual perception consisting of a large number of ommatidium.[265] As our visual perception works through integrating two visual streams from our eyes, the presentation instead of tens of different images in *Flyhead* causes the wearer to renegotiate their perceptual apparatus. *Flyhead* is a work in a series entitled *Environment Transformers,* which 'are appliances that change sensory impressions for a limited time in a visual and acoustic way. The processes of seeing and hearing are drawn out of their habitual apathy, separated into their individual functions and put together again as special experiences.'[266] The revelation of habitual apathy in *Flyhead* is created through the perceptual mimesis of the fly, creating a metaperceptual experience of reinvestigating our normal modes of sight in contrast to the ways that other animals experience the world.

---

263 Jim Rokos, 'Jim Rokos Design - Leaping Rabbit', *Leaping Rabbit*.
264 Regine, 'Inner World / Innen Welt: The Projects of Haus-Rucker-Co., 1967-1992', *We Make Money Not Art*, 2012.
265 Land and Nilsson.
266 Ingrid Ortner, 'Architekturbüro O&O Baukunst', *BAUKUNST*.

Fig. 53 Haus-Rucker-Co, Flyhead

7.2 Visual and Aural Mimesis

While *Flyhead* imposes the perceptual apparatus of an animal through the ‘analogue’ technology of split prisms and translucent green plastic, a recent VR work uses an arsenal of digital technology to allow their audience to experience the world as a range of forest animals. The work *In the Eyes of the Animal* (2015), by creative collective Marshmallow Laser Feast, is an artistic interpretation of the sensory perspectives of four species that inhabit British forests. The wearer’s perception is transformed into a mosquito, then a dragonfly, and then from a frog into an owl. As the work is a rare example of a metaperceptual VR work, it presents a paradigm of using the experiential affordances of VR technology to explore metaperceptual themes. As the work also contains a large number of bio-inspired and biomimetic elements, a detailed inspection of the artwork allows for a thorough discussion of biomimetic metaperceptual works.

Fig. 54 Marshmallow Laser Feast, In the Eyes of the Animal

The experience of *In the Eyes of the Animal* is based on Grizedale Forest in England, which was analysed and captured using a range of different techniques. A comprehensive 3D model of the forest was made using Lidar, a surveying method that uses lasers to measure distances. This visual and physical information then was combined with binaural recordings to form a comprehensive study of the environment. Data from this analysis was used to recreate the environment in the virtual domain, with alterations based on the perceptual apparatus of each animal. The artists devised a narrative for their audience, in which the perceptual journey starts with a mosquito, progressing up the food chain as each animal meet their demise. The audience experience the work through a VR helmet that has been encased in a grass-covered pod, integrating it into the flora of the woodland. While they are free to look around, they are carried along a predetermined flight path through the forest, matching the animal that they are mimicking. Audience members also wear a SubPac, a commercial tactile audio vest that uses sound transducers to vibrate the body. This allows for the wearer to feel the dragonfly's wings and the embodiment of the frog's croak, expanding the virtual reality experience into the tactile domain as well. By experiencing this virtual representation of the forest while also being in the forest, the audience's sense of smell, heat, and humidity enhance their sensorium during the work.

While the artistic interpretation in *In the Eyes of the Animal* is informed by the different ways that woodland animals experience the world, some elements of the work are more bioinspired than biomimetic. The Lidar analysis turns the visual domain into data points, allowing the artists to create point-clouds of coloured dots. The visual result can be seen in Fig. 55, with vibrant clouds of individual points representing the forest. These recreations are inspired by the visual experience of each animal. The mosquito's vision is similar to the fly's, with their compound eyes consisting of hundreds of ommatidia. The clarity of their vision is poor compared to humans, as the compound eye would have to be 20 metres in diameter to match the resolution of the human visual sense.[267] Instead, each ommatidium acts as a detector that measures the average brightness of a small region of space, typically about 1° across.[268] This means that their visual experience is radically different to ours, making this artistic interpretation of clouds of coloured dots more inspired by, than representative of, the mosquito.

vision in the dark. This is reinforced by text that the wearer is presented with as they transform

---

[267] A. Mallock, 'I. Insect Sight and the Defining Power of Composite Eyes', *Proceedings of the Royal Society of London*, 55.331–335 (1894), 85–90.
[268] Land and Nilsson.

into the owl: 'At night, eyes open wide, I see forever through tubes of light. Full beam, straight ahead. My breakneck body is under their command. I see you clearly, but you don't see me.'[269]

copyrighted material

Fig. 56 The visuals while being an owl in Marshmallow Laser Feast's In the Eyes of the Animal

Although the fidelity of the visual mimesis in *In the Eyes of the Animal* is lower than possible manifestations, the content of the work is explicitly focused towards experiencing the world as another animal. Accordingly, this may create powerful metaperceptual experiences for the audience. The work also presents a platform for new works using virtual reality to translate the perceptual apparatus of another animal onto the wearer.

In comparison to the high-tech approach of Marshmallow Laser Feast's *In the Eyes of the Animal*, art duo Clearly Connolly use mirrors and bespoke helmets to explore the visual perception of animals, in a series of works entitled *The Meta-Perceptual Helmets* (2014).[270] As discussed throughout this document, my usage of the term 'metaperceptual' denotes artworks that use the perception of the audience as their core material, redirecting the audience's attention back onto their own perceptual apparatus and the particularities of their own subjective experience. While I do not claim Clearly Connolly are using precisely the same definition of 'metaperceptual', there is a strong similarity in the themes found throughout their artworks and writing.

The least radical transformation in their *Meta-Perceptual Helmets* series is *Giraffe*, which is similar to Chris Woebken and Kenichi Okada's work of the same name, discussed earlier in this chapter. This helmet could also be classified as a 'Perspective Shifter', as it raises the origin of sight for the viewer, while leaving its general organisation intact. The artists write that this 'will help point out the strong dependence of our senses on our bodily disposition. The modification of

---

[269] Marshmallow Laser Feast, 'In the Eyes of the Animal', *Experiences | Oculus*.
[270] These works were developed independently of my research

the height of our eyes—leaving our frontal stereovision otherwise intact—may transform our sensorimotor perception of the world more than we would expect, especially in a human-designed world that assumes we are all between 1.5 and 2 metres tall.'[271] The work creates metaperceptual experiences by disrupting the normal harmony of our senses, forcing the wearer to negotiate the new organisation of their sensory apparatus.

Fig. 57 Cleary Connolly, Giraffe. Image provided courtesy of the artists.

The *Hammerhead Helmet* changes the way the wearer perceives depth. The same effect of this helmet is described in a low-tech implementation by neurologist and author Oliver Sacks in his book *The Mind's Eye.*[272] He writes 'I made a hyperstereoscope, using a cardboard tube about a yard long with four little mirrors. With this I could turn myself, in effect, into a creature with eyes a yard apart. I could look through the hyperstereoscope at a very distant object, like the dome of St. Paul's Cathedral, which normally appeared as a flat semicircle on the horizon, and see it in its full rotundity, projecting towards me.'[273] The *Hammerhead Helmet,* presented in Fig. 58, produces the same effect through mimicking the perceptual apparatus of the hammerhead shark, creating a large distance between the eyes. The work creates metaperceptual experiences by exposing the depth mechanisms afforded by the bifocal nature of our vision.

[271] Denis Connolly, Anne Cleary, and Neil McKenzie, 'Meta-Perceptual Helmets for the Dead Zoo' (unpublished Talk, National Museum of Ireland - Natural History, 2015).
[272] Oliver Sacks, *The Mind's Eye*, 1 edition (New York: Alfred A. Knopf, 2010).
[273] Sacks.

Fig. 58 Clearly Connolly, Hammerhead Helmet. Image provided courtesy of the artists.

The horse's perceptual apparatus affords them a wide peripheral field, enabling them to see 350° of their visual field. The *Horsehead Helmet* mimics the horse's perceptual apparatus, translating the eyes so they face outwards, diametrically opposed to each another. This breaks the stereoscopy of our vision in favour of a more panoramic orientation. The work creates metaperceptual experiences by exploring the implications of altering the wearer's perceptual apparatus. The artists write that the translation that the *Horsehead Helmet* gives the wearer 'would be radical: we would be abandoning the singleness of vision offered by our front-set eyes, and with it the stereopsis that gives our vision its depth. But the panoramic vision of equine eyes would offer us a generous and global perspective of the world we are moving through. It would perhaps render unnecessary the continuous head-turning, darting glances and 'saccades' that we use to scan our environment. Might this afford us a calmer perceptive experience?'[274]

[274] Connolly, Cleary, and McKenzie, p. .

Fig. 59 Clearly Connolly, Horsehead. Image provided courtesy of the artists.

Where *Horsehead* expands the visual field by turning both eyes outwards, the *Chameleon* does the same by turning one eye around. The chameleon's visual perception has a range of unique features. One of these is the extreme mobility of their turret-like eye, allowing them to rotate their eyes independently.[275] This mobility allows for the chameleon to have a full 360° visual field, helping them detect predators and prey. *Chameleon* mimics one of the extreme organisations afforded by the chameleon's eyes, pointing one straight forward and one straight back. This radical rearrangement creates metaperceptual experiences by breaking the fusion of the wearer's vision, forcing them to renegotiate their visual sense.

The last work in Clearly Connolly's *Metaperceptual Helmets* series is not a strict example of biomimetics, but explores the conflict between the perceptual apparatuses of predators and prey. Cleary Connolly state that 'the general zoological rule is that predators have frontal binocular vision to help them to chase prey who will mostly have more peripheral vision to help them to spot said predators.'[276] The *Cheshire Cat* helmet explores whether we could adapt to having peripheral vision in one eye, and frontal vision in the other.

[275] Land and Nilsson.
[276] Connolly, Cleary, and McKenzie.

Fig. 60 Clearly Connolly, Chameleon. Image provided courtesy of the artists.

The name and design of the helmet is based on an interesting visual phenomenon coined 'The Cheshire Cat effect' by Sally Duensing and Bob Miller.[277] The effect occurs under conditions of binocular rivalry, where each eye receives conflicting stimuli. In this situation, motion in the field of one eye can trigger suppression of the other visual field as a whole, or in parts. Sally Duensing and Bob Miller discovered that this was particularly pertinent when looking at faces, as certain features of the face would disappear, while others would persist. They write 'if the viewer looked at the smile of the face while the motion occurred in the visual field of the other eye, the face would completely disappear leaving only the smile. This image would remain for as long as 5s. Spontaneously four or five viewers said, "Oh, just like the Cheshire Cat", thus giving us a name for this effect.'[278]

Clearly Connolly's *Cheshire Cat* helmet recreates the conditions for this binocular rivalry, by placing a 45° mirror over one eye, rotating the view 90°, while leaving the other eye's vision unimpeded. In this way, one eye mimics the forward-facing orientation of most predators, while the other mimics the peripheral vision of prey. This work is an interesting combination of 'Perceptual Mimesis' and 'Perceptual Hacking', which is discussed in Chapters Nine, Ten, and Eleven. The exploration and revelation of our underlying perceptual processes through creating extraordinary experiences are at the heart of both this work and those within the Perceptual Hacking category. They create metaperceptual experiences by making the artefacts of our

[277] Sally Duensing and Bob Miller, 'The Cheshire Cat Effect', *Perception*, 8.3 (1979), 269–73.
[278] Duensing and Miller.

perceptual apparatus the core artistic force, allowing for the audience to explore their own perceptual system.

Fig. 61 Clearly Connolly, Cheshire Cat. Image provided courtesy of the artists.

7.3 Aural Mimesis

While the survey of approaches presented in the 'Perceptual Mimesis' category is dominated by visual-based artworks, this survey is still instrumental for the provocation of new sound-based artworks, as the approaches used in these works are not necessarily visually specific. This survey reveals how underexplored the field of perceptual mimesis in the aural domain is, suggesting great potential for a range of new works. As previously discussed, the animal kingdom boasts a diverse range of perceptual apparatuses, each with its own features and limitations. The previous chapter, Perceptual Extenders, presented a range of different ways in which the human perceptual apparatus could be expanded to perceive invisible and inaudible strata of stimuli. By mimicking the perception of animals like bats and dolphins, the limitations of audience's aural perception could be expanded. The perceptual mimesis used in *Hammerhead* and *Giraffe* could also have aural analogues. While these works effectively move the eyes of the wearer, other works could move the ears, changing the way we hear and localise sounds. This experiential effect may be similar, as the underlying perceptual processes are disrupted, causing the wearer to renegotiate their aural sense.

There may be a range of factors which influence the dominance of visual works in the field. The *Metaperceptual Helmet* series are a range of passive mediators which use mirrors and lenses to radically rearrange the perceptual apparatus of the wearer. Due to the omnidirectional propagation of sound, the realisation of a passive aural equivalent is more difficult, if not impossible. This matches the current state of perceptual aids, where electronics are used to correct the hearing of their wearers. It may be necessary for works that intend to mimic the aural perception of other animals to integrate electronics in their mediation as well. This technical challenge in itself may be a barrier for some artists to create the works. Another factor, which is relevant to all of the surveys conducted in this framework, is that the sound art discipline is smaller than its visual counterparts. This means that more artists are exploring the visual sense compared to the aural sense. As discussed previously, this makes the exploration of metaperceptual themes across a variety of media more salient, as the range of different approaches have potential for aural analogues.

The 'Perceptual Mimesis' category of works rearrange the perceptual apparatus of the audience to mimic the organisation of other animals. This rearrangement of perceptual organisation has been extended into completely new schemes, creating radically different modes through which to perceive the world. The last chapter focused on the 'Perceptual Translation' category explores works that rearrange the perceptual apparatus into new forms.

Chapter Eight

Perceptual Translation: Perceptual Rearrangers

The ‘Perceptual Rearrangers’ category of metaperceptual artworks manipulate the perceptual apparatus of the audience into new organisations. As in the ‘Perceptual Mimesis’ category, the rearrangement of the perceptual apparatus disrupts its normal functioning and reveals the underlying perceptual processes that are often ignored or undetected. The following chapter discusses works that offer the audience new organisation schemes through which to experience the world.

The *Metaperceptual Helmets* discussed in the previous chapter are inspired by psychologist George Malcolm Stratton’s pioneering perceptual experiments.[279] Stratton’s experiments are one of the most often cited studies of adaptation to visual rearrangement. His experiments were intended to test the then-current theories that upright spatial vision required the human eye to invert the incoming image onto the retina.[280] In the experiments, Stratton wore a monocular device that he devised to rotate his visual field by 180°, effectively inverting his vision on the horizontal axis.[281] Stratton posited that if, while wearing his inverting goggles, he eventually came to see the world as upright again, he would thereby have disconfirmed the necessity of the retinal image being inverted.

In the longer of the two studies, Stratton wore the inverting goggles for eight days, blindfolding himself immediately after removing the device at night and before going to bed. He reports that when first donning the goggles, his experience was of a drastic disturbance in his visuomotor coordination, a nauseating illusory motion of the visual field when he moved his head, and an inverted picture of the world.[282] He continued with his normal daily activities and after several days he found that both the disturbance to his visuomotor coordination, and the nauseating illusory motion of his visual field had dissipated. While these two features revealed the power of the human perceptual system to adapt to new organisations, the hypothesis of the experiment was not satisfactorily answered. Stratton reported that during the latter stages of the experiment, the visual

---

[279] Connolly, Cleary, and McKenzie, p. .
[280] George M. Stratton, ‘Some Preliminary Experiments on Vision without Inversion of the Retinal Image.’, *Psychological Review*, 3.6 (1896), 611.
[281] Robert B. Welch, *Perceptual Modification: Adapting to Altered Sensory Environments* (Elsevier, 2013).
[282] Welch.

field occasionally appeared upright, but primarily when he was engrossed in some activity or otherwise not critically comparing his visual experience to his memory of the normal appearance of things.[283]

Stratton's experiment is one in a rich history of perceptual studies that modify the perceptual apparatus in order to reveal the underlying processes that allow it to function. Robert Welch writes that 'Like a perfectly running automobile, human perception is both taken for granted and poorly understood; it has often required a severe malfunction or obstruction of its performance to reveal its workings.'[284] Physiologist Paul Weiss has identified three classes of interference experiments that can be applied to the field of perceptual adaptation to provide insights into how artworks that rearrange the perceptual apparatus create metaperceptual experiences.[285,286] *Defect* experiments remove or incapacitate a component of perception in order to analyse its role. The assumption is that when one component of the perceptual apparatus is removed, the remaining components will function normally, allowing for any change to be attributed to the normal role of the removed component. Complementary to the defect experiments, *Isolation* experiments block or stop the functioning of all but one component of the perceptual apparatus. The resulting behaviour is attributed to the role of the remaining part. As with the defect experiments, isolation experiments assume that this allows for the normal functioning of a component in the perceptual apparatus to be exposed. The defects in both classes of interference experiments led Weiss to suggest that the third class would be superior. *Recombination* experiments do not inhibit a component of the perceptual apparatus, but instead alter the relationship between parts. Rather than creating a deficit in behaviour, recombination of the perceptual apparatus often produces a malfunction; the response to which can create metaperceptual experiences by offering insights into the normal operation of the perceptual system. Stratton's inversion of the visual field is a key example of this, as it alters the relationship between the visual field and the rest of the participant's sensorium, forcing them to adapt to the new organisation.

Weiss's three categories for interference experiments are closely aligned with some of the metaperceptual methods. Both the defect and isolation methods share similarities with the deprivation category of works. Both classes employ the same perceptual alteration as the artworks which block or occlude one of the sense modalities, discussed in Section 3.3, with the isolation

---

[283] Welch.
[284] Welch.
[285] These classes were originally devised for the experiments on the Central Nervous System, but can be aptly applied to the perceptual apparatus.
[286] Paul Weiss, 'Autonomous versus Reflexogenous Activity of the Central Nervous System', *Proceedings of the American Philosophical Society*, 84.1 (1941), 53–64.

experiments employing them to a more extreme degree. The recombination class is directly related to the 'Perceptual Rearrangers' which are discussed in this chapter. As with Stratton's experiments, the reorganisation of the perceptual apparatus can be extremely disruptive and reveal the overlooked and unconscious processes of our perception.

8.1 Visual Rearrangers

As a direct homage to Stratton's inverting goggles, Carsten Höller's *Upside-Down Goggles* (2015) allow for the gallery audience to experience this reorganisation of the perceptual apparatus. Since 1994, Höller has devised at least six increasingly refined versions of the *Upside-Down Goggles.*[287] He regularly offers them to viewers for use when touring his exhibitions or participating in special outdoor expeditions. The goggles sometime combine with other works that play with the audience's perception, as with his *Upside-Down Mushroom Room.* The perceptual result is a doubt-inducing experience of orientation, as the goggles invert the mushrooms which are suspended upside-down from the ceiling, and show them to be right-side up. Höller has also arranged elaborate performances, modelled after Stratton's studies, during which participants wear the goggles in a controlled environment for up to eight consecutive days, testing their ability to adapt to the new rearrangement or perception.

Fig. 62 Carsten Höller, Upside-Down Goggles

[287] Carsten Höller, *Experience / Carsten Höller ; [Director's Foreword by Lisa Phillips ; Introduction by Massimiliano Gioni ; Curated by Massimiliano Gioni, with Gary Carrion-Murayari and Jenny Moore.]* (New York, N.Y: Skira Rizzoli in association with New Museum, 2011).

An aural equivalent of the inversion found in Stratton's experiments and Höller's artwork is explored in my own work, *Your Localisation Exposed.* The work inverts the position of the ears, making left right, and right left, and is further discussed in Chapter Eleven.

The 'Perceptual Mimesis' works of Cleary Connolly are precursors to a new series, the *Para-Perceptual Helmets* (2015), which look to push the organisation of the perceptual apparatus into new territories. They write: 'The *Meta-perceptual helmets* were concerned with the position of the eyes in the head, mostly exploring arrangements that we already find in the natural world. The *Para-perceptual helmets* will explore more complex and less natural arrangements. If we are still exploring the science of vision, it is to make these objects-for-looking as pertinent and engaging as possible.'[288] The artists are also developing another new series entitled *Exo-Perceptual* (2015) which 'are more concerned with the poetry of looking than with the science of seeing. They are a poetic complement to the previous helmets, providing opportunities to explore some extraordinary processes, as well as creating highly aesthetic art objects.'[289] Both new series feature some realised works, as well as some speculations for future helmets.

Fig. 63 Cleary Connolly, Cyclops. Image provided courtesy of the artists.

[288] Cleary Connolly, 'Future Helmets'.
[289] Connolly.

One of the realised works is the *Cyclops* helmet, which shares themes with the perceptual adaptation of Stratton's experiments and the binocular rivalry that their *Cheshire Cat* helmet creates. Cleary Connolly write 'Our two eyes always look in the same direction and focus on the same object. But today we are often obliged to focus on task and environment simultaneously, as when we text while walking down the street.' The *Cyclops* helmet rearranges the perceptual apparatus of the wearer to provide a solution for multi-taskers. The helmet has a large central eye that creates a wide-angle view, and a second smaller eye which focuses diagonally downwards. This could be at a point where the wearer's hands are occupied with a task. The *Cyclops* helmet breaks the stereoscopy of the wearer's vision in a similar vein to many of the *Meta-perceptual* Helmets. Additionally, the *Cyclops* helmet also creates a new hierarchy in the perceptual apparatus, as the front-facing central eye dominates the smaller, downward-facing eye. This creates binocular rivalry not only through presenting each with a different image, but also through a difference in the importance of the information received in navigating the world.

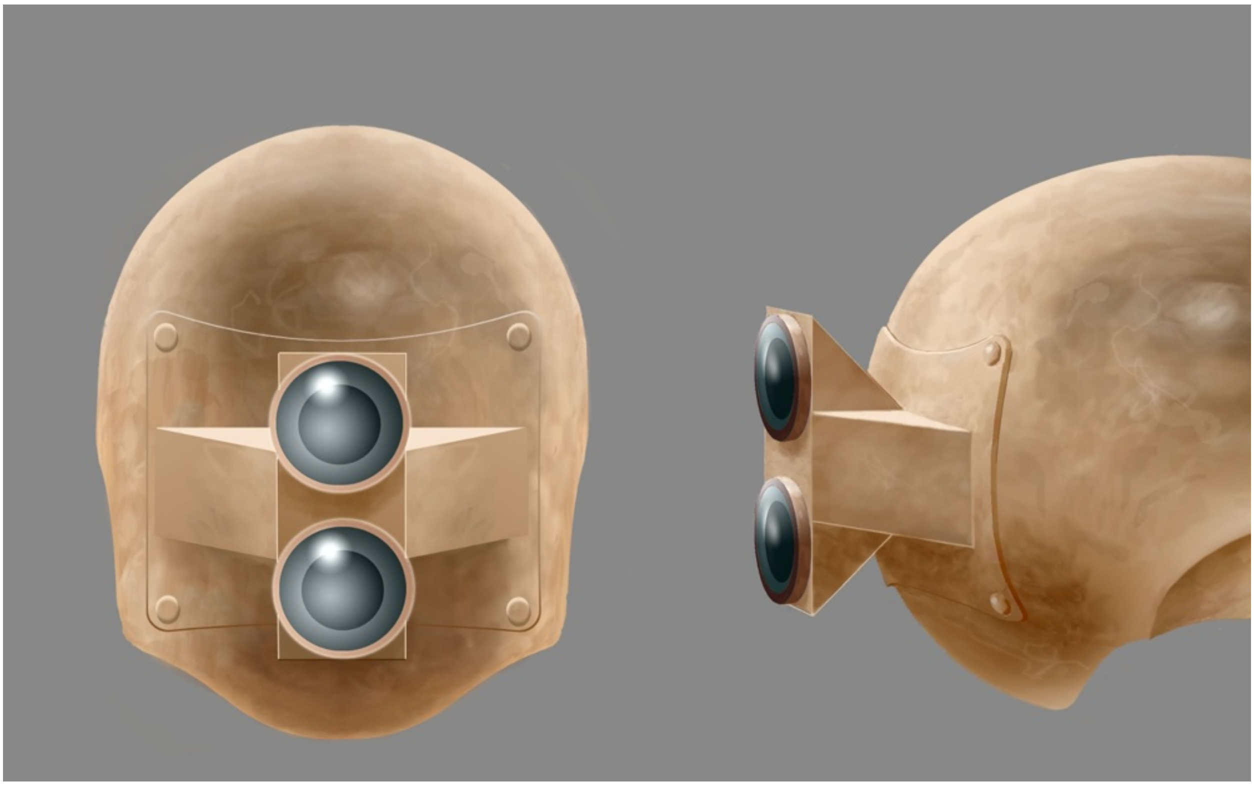


Fig. 64 Cleary Connolly, Gecko Helmet drawing. Image provided courtesy of the artists.

Cleary Connolly have a range of work-in-progress helmets that, like *Cyclops*, rearrange the perceptual apparatus of the wearer into new forms. The *Slit Eye* helmet mimics the vertical-slit pupils of cats and horizontal-slit pupils of goats. The helmet presents both concurrently, separating the two eyes in order to question how the orientation of the slit-pupil changes the perceiver's vision. The *Cross-Eyed* helmet forces the eyes of the wearer to converge, turning the point of focus of each eye in on themselves by 45°. The extreme convergence of the two eyes forces the wearer to adapt to the new relationship between the two images perceived, and renegotiate the unity of their visual sense. Lastly, the *Gecko* helmet, shown in Fig. 64, both moves the location of the two eyes and rotates them 90°. The eyes are arranged in a vertical line, and as the image is rotated by 90°, the effect can be likened to the wearer turning their head to the side.

Cleary Connolly's *Para-Perceptual helmets* create non-natural arrangements of the wearer's visual sense, forcing them to attempt to adapt. While Stratton's experiments were conducted over multiple days to allow him to fully adapt to the change in perceptual organisation, these works are presented to an audience for a much shorter amount of time. This means that the experiential effect is much more of a Gestalt change, rather than a lived-in experience that changes over the course of multiple days. Where Stratton was able to renegotiate the relationship between his vision and control over his body towards the end of the trial, audiences of these works are much more likely to only experience the incapacitation of their sense. This in itself can create powerful metaperceptual experiences, as the normal relationships between the senses is severed and rearranged, revealing its normal processes. This idea is implemented in my new metaperceptual artwork, *Your Localisation Exposed*, discussed in Chapter Twelve.

This intent to disrupt the functioning of the perceptual apparatus in order to reveal its underlying workings is at the heart of Alfons Schilling's *Sehmaschinen* (1997). He writes, 'Optical phenomena concern me, if at all in that I aim to unmask them.'[290] Translating as 'vision machines', his *Sehmaschinen* are a range of wearable visual rearrangers that are intended to 'investigate more closely into and to impeach the process of seeing itself.'[291] The most emblematic of this intent are his works *Kleines Rad* (1978) and *Antelope* (1984). *Kleines Rad* inverts left and right, and front and back, creating a disorienting experience where the wearer can move through the world only by seeing what they have left behind. *Antelope* intensifies this idea by additionally making distant objects near, while also implementing the *Kleines Rad*'s inversions.

[290] Peter Weibel, *Beyond Art: A Third Culture: A Comparative Study in Cultures, Art and Science in 20th Century Austria and Hungary* (Springer Science & Business Media, 2005).
[291] Weibel.

Fig. 65 Alfons Schilling, Antelope. Image provided courtesy of the artist.

8.2 Aural Rearrangers

The works surveyed in this 'Perceptual Rearrangement' section disrupt the normal functioning of the perceptual apparatus in order to reveal the underlying processes that are often ignored or undetected. The pioneering perceptual adaptation experiments of George Stratton have had a strong influence on many artists, as can be seen in many of the works that invert the visual perspective. There is a lack of exploration of perceptual rearrangement in the aural domain. As previously discussed in Chapter Seven, this could potentially be due to the differences between the visual and aural sense. As the visual field is much narrower than the omni-directional aural field, altering the location and direction of the eyes may ostensibly be a more radical intrusion to the normal functioning of the perceptual system. The rearrangement of the ears, however, still disrupts many of the underlying perceptual processes that rely on precise differences between the stimuli in each ear. My new work *Your Localisation Exposed,* discussed in Chapter Twelve, is one exploration of the rearrangement of the aural apparatus. In addition to the new works presented in subsequent chapters, there is the potential for many new works that explore other reorganisations of the aural perceptual apparatus.

8.3 Perceptual Translation as an Artistic Material

The 'Perceptual Translation' category offers a diverse range of approaches to creating new metaperceptual works. The 'Perspective Shifters' category is the least radical in its alteration of the perceptual apparatus, as it keeps most of the organisation of the senses intact. One of the strongest potentials for this method is its ability to create deeply empathetic experiences. The gestalt effect of the shift in perspective is focused on the location of the new origin and the implications of this translation, rather than a reorganisation of the perceptual apparatus. Due to the minimal change in the organisation of the perceptual apparatus, these experiences can show the differences between subjectivity and allow for a meditation on the audience's own perception and how it filters the way they perceive the world. My new metaperceptual work *Your Hearing Them,* discussed in Chapter Twelve, explores these themes.

'Perceptual Extenders' create powerful metaperceptual experience by transcending the limitations of the human perceptual range. The allure of many of these works lies in their affordance of completely new experiences, revealing a layer of stimuli that is invisible and inaudible. The bifurcation of the section shows two different approaches to extending the perceptual apparatus. The 'Perceptual Field Extenders' alter and extend the shape of the perceptual field. While these alterations may be less radical than experiencing ultrasonic frequencies or infrared radiation, they can reveal subtleties in the limits of the size of the perceptual field. This includes the interaction between different sense modalities, as each organ has different limits and shapes to its perceptual field. The 'Perceptual Range Extenders' have the potential to give their audience access to previously unexplored environments, allowing them to experience the world through a new filter. Expanding the perceptual field can reveal a rich range of stimuli that is constantly in our environment but goes undetected, as it is imperceptible through our perceptual apparatus.

The focus on the limitations of the perceptual apparatus through extending its boundaries is also present in the 'Perceptual Mimesis' chapter. The mimicry of other animal's perceptual apparatuses allows the audience to approximate their experience. This includes some works that change the perceptual field, as in the *Horsehead* helmet of Cleary Connolly and the *Ant Apparatus* of Chris Woebken and Kenichi Okada and other works that extend the perceptual range, mimicking the extra perceptual abilities that many animals possess. These works are explicitly informed by other animal's perception, with many of the works having the name of an animal in their title. This semantic level of the work frames the expectation of the audiences, and may help to produce metaperceptual experiences as their attention is drawn to their own perceptual apparatus.

The reorganisation of the perceptual apparatus that many of the 'Perceptual Mimesis' works employ is pushed to its limits in the 'Perceptual Rearrangers' chapter. These works impose new organisations on the perceptual apparatus of the audience and force them to attempt to adapt. The breaking of perceptual processes reveals them, making the audience aware of often unconscious elements of their perception. While the Gestalt effect of many of the 'Perceptual Rearrangers' is of disorientation and confusion, the process of trying to adapt to this rearrangement can produce powerful metaperceptual experiences. My new metaperceptual work *Your Localisation Exposed*, discussed in Chapter Twelve, explores this approach.

A final category of metaperceptual works builds directly on some of the ideas presented in this chapter. The 'Perceptual Hacking' category of artworks explores oddities and artefacts that are caused by the perceptual system. The artworks creatively misuse facets of the perceptual apparatus and perceptual processes to create metaperceptual experiences. I discuss and catalogue the methods of Perceptual Hacking in the next chapter.

Chapter Nine

Perceptual Hacking: Physical Artefacts

Though some in the field used the term "hacker" as a form of derision, implying that hackers were either nerdy social outcasts or "unprofessional" programmers who wrote dirty, "nonstandard" computer code, I found them quite different. Beneath their often-unimposing exteriors, they were adventurers, visionaries, risk-takers, artists . . . and the ones who most clearly saw why the computer was a truly revolutionary tool. Among themselves, they knew how far one could go by immersion into the deep concentration of the hacking mind-set: one could go infinitely far. I came to understand why true hackers consider the term an appellation of honor rather than a pejorative.

—Steven Levey

9.1 Perceptual Hacking Preface

The term 'Perceptual Hacking' has been coined in this document to describe a metaperceptual approach to creating artworks that creatively misuse facets of the perceptual apparatus and perceptual processes. Perceptual hacking has similarities with other forms of hacking. The term *hacking* and its root *hack,* has gone through multiple transformations, with it now being used as a fluid term to denote a range of things. Perceptual Hacking involves creating normally undesirable artefacts in the audience's perceptual system. By revealing the imperfect nature of our perception, these works draw attention to its constant mediation and filtration of our experience.

This chapter examines works that use perceptual oddities as their artistic materials. A metaperceptual analysis of these works involves both an understanding of their audience's phenomenology, as well as, a discussion of the perceptual processes that are being creatively misused. In doing so, I use the discussion of core perceptual processes from Section 2.2 as a foundation from which to build upon.

As with all of the metaperceptual categories, the use of a certain perceptual phenomenon does not necessarily create a metaperceptual experience. The key element is the effects the phenomenon has on the audience, and its ability to redirect the attention of the observer back onto their perceptual apparatus. One perceptual oddity, the Zwicker tone, is an exemplar of this difference. In the following paragraphs, I examine the creation of the Zwicker tone and discuss the experience of the artefact through a metaperceptual lens.

The Zwicker tone, illustrated in Fig. 66, is an auditory aftereffect, produced in response to extended exposure to a certain type of noise. First discovered in 1964 by Eberhard Zwicker, he found that 'if a white noise with a half-octave-band suppression placed anywhere from 300 to 7000Hz is presented at an overall sound-pressure level of about 60dB for 1 min and then switched off, a decaying, poststimulatory sound similar to a pure tone is heard for about 10 sec. The pitch of the post-stimulatory tone corresponds to a frequency within the suppressed band.'[292] This is an interesting case of non-linearity in the auditory system. The Zwicker tone occurs once the noise is turned off, and is therefore not caused by external stimuli. This means that the auditory system creates an experience that is not due to a direct input.

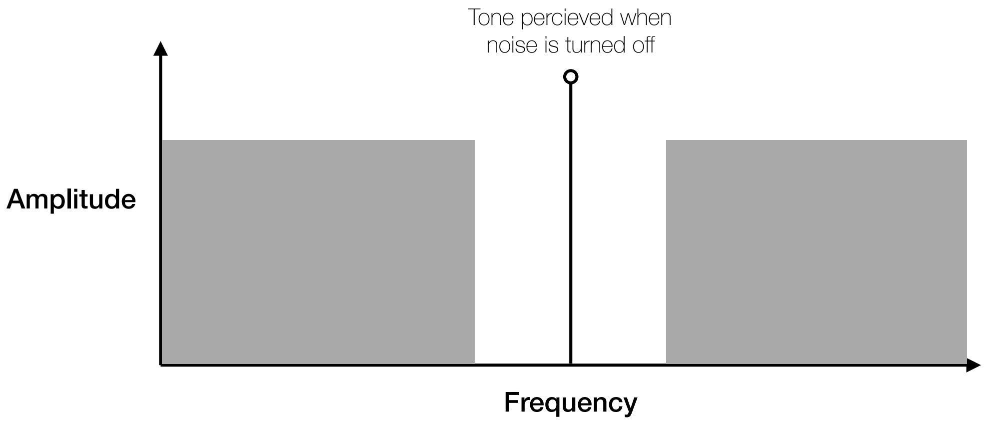


Fig. 66 A diagram of the stimulus that provokes the Zwicker tone

To understand why and how the Zwicker tone is created, an in-depth understanding of the neural model of the auditory system is needed, which is outside the scope of this document. The leading theory is that the Zwicker tone is caused by an artefact of the interaction between a neural noise reduction mechanism and the asymmetric inhibition of the neurons responsible for pitch perception.[293]

The Zwicker tone is an example of an artefact of the perceptual process which is borne out of the particularities of our perceptual mechanisms. While this experience may be uncommon, one could experience the Zwicker tone and not be cognisant of the strangeness of this perceptual oddity, or of it at all. It is a very subtle experience, and is similar to tinnitus, which many people experience regularly. The ringing in the listener's ears may cause them to wonder if something has gone wrong with their perception, a theme that the deprivation metaperceptual works often explore, but no more so than many other common experiences of minor malfunctions. This means that the creation

---

[292] Eberhard Zwicker, '"Negative Afterimage" in Hearing', *The Journal of the Acoustical Society of America*, 36.12 (1964), 2413–2415.
[293] Jan-Moritz P. Franosch and others, 'Zwicker Tone Illusion and Noise Reduction in the Auditory System', *Physical Review Letters*, 90.17 (2003), 178103.

of the Zwicker tone alone may not be sufficient to create a metaperceptual experience. The Zwicker tone has not, to my knowledge, been explored in sound art yet. The extended exposure to loud noise that is necessary for the artefact to occur may hinder potential creative usages and the unclear link between the stimulus and effect may make this artefact ill-suited to creating metaperceptual artworks.

The 'Perceptual Hacking' chapter looks at artworks that use perceptual oddities and artefacts as their core materials to create metaperceptual experiences for their audience. While a large number of the works contains 'illusions' of various types, the term 'illusion' does not pertain to all of the perceptual oddities that are explored in the 'Perceptual Hacking' category. The Oxford English Dictionary defines *illusion* as:

1. An instance of a wrong or misinterpreted perception of a sensory experience.
2. A deceptive appearance or impression.
3. A false idea or belief.[294]

These definitions do not account for some perceptual oddities, including afterimages and oto-acoustic emissions, which will be discussed in this chapter.

While the term 'illusion' does not apply to all perceptual oddities in the following chapters, the attempts to organise illusions into types offers a helpful system for classifying the 'Perceptual Hacking' approach. British cognitive psychologist Richard Gregory believed that 'cognitive illusions reveal knowledge and assumptions for vision, and perhaps take us close to "brain language", but they must be understood and also classified.'[295] Over multiple articles and books, Gregory devised different classification approaches for illusions. While the 'Perceptual Hacking' category does not solely contain illusions, the classification systems devised by Gregory are useful organisational structures that help to group the different artefacts and show commonalities between them.

---

[294] Oxford Dictionaries, *Oxford English Dictionary*, 7 edition (Oxford: Oxford University Press, 2013).

[295] Richard L. Gregory, 'Knowledge in Perception and Illusion', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 352.1358 (1997), 1121–1127.

Kinds and classes of visual illusions

Kinds of visual illusions	Classes of visual illusions		
	Physical	*Physiological*	*Cognitive*
Ambiguities	mist shadows	size – distance for a single stationary eye real – apparent motion	Necker cube Jasrow's duck-rabbit Rubin's vases
Distortions	(of space) stick in water (of velocity) stroboscope (of colour) filters refraction diffraction scattering	(of space) adaptations to length or tilt or curvature Café wall (of brightness and colour) simultaneous and sequential contrast	Ponzo Poggendorff Orbison Hering Müller-Lyer Zöllner figures
Paradoxes	mirrors (eg seeing oneself in the wrong place, and duplicated)	when visual channels disagree aftereffect of motion: moving yet not changing position or size	Penrose impossible objects Escher's pictures
Fictions	rainbows Moiré patterns	afterimages autokinetic effect migraine patterns	Kanizsa's triangle filling-in of the blind spot and scotomas

Fig. 67 Richard Gregory's 'Kinds and classes of visual illusions'[296]

In an article entitled 'Putting illusions in their place', Gregory devises three conceptual classes: *Physical*, *Physiological*, and *Cognitive*. Within these classes, he devises four different kinds of visual illusions: *Ambiguities*, *Distortions*, *Paradoxes*, and *Fictions.* Gregory populates a matrix using these classifiers with known illusions and environmental conditions that effect perception, presented above in Fig. 67. The classes describe 'supposed causes, or origins of the illusions'[297], whereas the types order the illusions by their perceptual effect.

The most applicable element of Gregory's organisation to the Perceptual Hacking approach is his classification of three classes: *Physical*, *Physiological*, and *Cognitive.* The 'physical' category covers extraordinary stimuli that create perceptual confusion due to their departure from normality. A common physical illusion is the 'bent stick', where a stick that is partially submerged in water will appear bent due to water refracting light. The 'physiological' category examines artefacts that are created at the sense organ level. These oddities are by-products of the perceptual system, created by its stimulation in a particular manner that it does not process well. Lastly, the 'cognitive' category contains oddities borne out of the processing of stimuli by the brain. Gregory argues that

296 Richard L. Gregory.
297 Richard L. Gregory.

these cognitive artefacts are 'due to (mis)use of assumptions or knowledge, or to rule-following leading perception astray.'[298]

The origin of an illusion or artefact may result from several different elements. The three components of stimuli, perceptual apparatus, and perceptual processing are all necessarily active to create our experience, and are thus never fully independent or isolated. While Gregory acknowledges that this causes difficulties for categorisation, it does not render these categories futile. They offer a clear guiding principle for organising the illusions and the 'Perceptual Hacking' category.

In Chapter Nine, Ten, and Eleven, I use the three classes as a guiding principle to organise the perceptual artefacts that are explored by the Perceptual Hacking artworks. As each sense modality has their own range of perceptual oddities, these chapter are ordered into both visual and aural subsections, the outline is shown in Fig. 68. While the visual artefacts will not always have aural equivalents, the discussion of their exploration through artworks allows for a broad overview of the terrain of artistic affordances. The discussion of these visual works also contextualises the existing aural works in the wider art canon. As Gregory's classification does not include aural artefacts, the inclusion of aural artefacts expands existing frameworks. Furthermore, a discussion of the relationship between visual and aural artefacts and their exploration in artworks allows for artists and movements to be connected by their implicit themes.

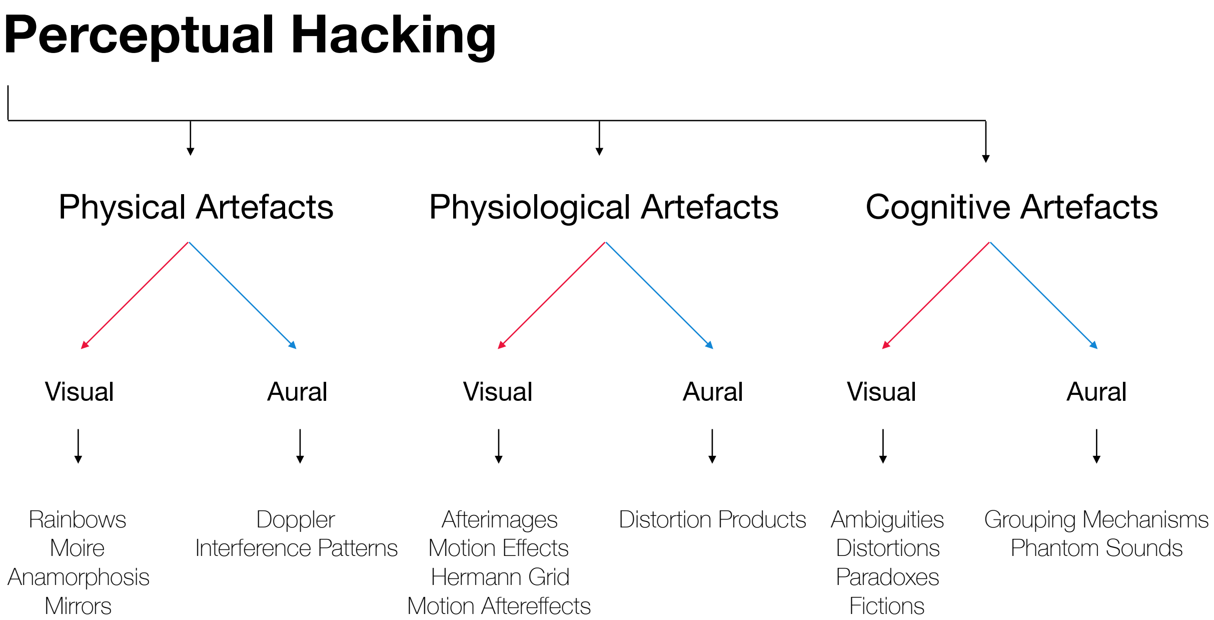


Fig. 68 Overview of Perceptual Hacking approach

[298] Richard L. Gregory.

9.2 Physical Artefacts

Physical artefacts are created when the physical properties of an environment cause stimuli to behave in extraordinary ways. These artefacts occur in the physical world, rather than being merely a by-product of the perceptual apparatus or perceptual processing. These artefacts confront our expectations, as they break the normal rules by which stimuli usually behave. This confrontation is subject to an understanding of the normal modes by which light, sound and other stimuli, usually behave. Gregory presents a wide range of physical illusions from different stimuli. He states that 'Physical includes many kinds of distortion, loss, and additions to patterns of energy (stimuli) accepted as evidence of objects.'[299] His examples range from mist and shadows to mirrors, rainbows, and bent sticks, as presented in Fig. 67. Given that the term 'illusion' is difficult to define, and the fact that these physical illusions are dependent on the concept of them being extraordinary, a clear distinction of what counts as a physical artefact and what does not is difficult to define. Additionally, this means that awareness of these irregularities may go unnoticed, as the observer may not have the relevant knowledge of normal behaviours. Metaperceptual experiences occur when the attention of the observer is drawn to their perception and, therefore, physical artefacts that can easily go unnoticed may not be well-suited for metaperceptual artworks. The commonly known 'Doppler effect' is one such artefact whose behaviour and inappropriateness for metaperceptual use are discussed in the following paragraphs.

First observed in 1842 by physicist Christian Doppler, the effect was hypothesised to explain the different colours of binary stars in space.[300] Doppler posited that it was the movement of the stars in our galaxy and beyond that cause their perceived colour to change. The electromagnetic radiation emitted by stars moving away from the earth are shifted down in frequency towards red wavelengths. Stars moving towards the earth are shifted up in frequency towards the blue wavelengths.[301] This effect not only applies to electromagnetic waves but to sound waves as well, and is often encountered in our everyday experiences. The 'Doppler effect' occurs when a sound source is moving at speed relative to the observer, as each successive wave crest is emitted from a different position, causing the perception of its pitch to shift. A common producer of the effect is the sound of an emergency horn as it passes an observer. As the vehicle moves towards the observer, the pitch of the horn rises and then falls as the vehicle recedes.

---

[299] Richard L Gregory, 'Putting Illusions in Their Place', *Perception*, 20.1 (1991), 1–4.
[300] Christian Doppler, *Über Das Farbige Licht Der Doppelsterne Und Einiger Anderer Gestirne Des Himmels* (Calve, 1842).
[301] Robert J. Trumpler, 'Observational Evidence of a Relativity Red Shift in Class O Stars', *Publications of the Astronomical Society of the Pacific*, 47.279 (1935), 249–56.

The Doppler effect highlights the subjectivity of our experience, a key metaperceptual theme. The horn of an emergency vehicle driving around a busy crowd will be heard by most people, but their experiences will differ depending on their physical location. This is not due to the horn changing in pitch, as it remains static, but the relative movement between sound source and observer creating a physical oddity. While this subjectivity of experience is revealed to the informed observer, this awareness is dependent on previous knowledge. Many people experience the Doppler effect without having their attention drawn towards the way that waves propagate through air with respect to a moving source and its effect on perceived pitch.

One of the reasons that the Doppler effect may be ill-suited for metaperceptual works is that it is difficult to investigate the reality of their experience. Hermann von Helmholtz described visual perceptions as unconscious inferences from sensory data and knowledge that are derived from the past. Psychologically projected into external space, our perception is accepted as our most immediate reality.[302] This acceptance of perception as reality is what causes the physical artefacts to be extraordinary, as they depart from our expectations and lead us to question the validity of the experience. In the case of the Doppler effect, an observer could easily believe that there is no challenge to the validity of their experience, as many other reasons could be given for the rising and falling of pitch. For an artwork to create metaperceptual experiences by creating the Doppler effect, the artist would need to afford an audience interaction with the effect that would allow them to investigate the extraordinariness of the phenomenon.

The reality of other artefacts can be more easily investigated, which makes them more appropriate materials for metaperceptual artworks. In the next section, I survey the visual illusions that Gregory provides in his classification, and explore possible aural physical artefacts, considering their potential for metaperceptual works.

9.3 Visual Physical Artefacts

While Gregory classifies a range of visual illusions in the physical class, the 'Fictions' type is likely to be the most useful in metaperceptual works. In this type, Gregory includes rainbows and Moiré patterns. A rainbow is created by the refraction, reflection, and dispersion of light in water droplets causing a colourful arc in space.[303] To observe a rainbow, the viewer's back must be to

[302] Hermann von Helmholtz and James Powell Cocke Southall, *Treatise on Physiological Optics* (Courier Corporation, 2005).
[303] R. J. D. Tilley, *Colour and the Optical Properties of Materials: An Exploration of the Relationship between Light, the Optical Properties of Materials and Colour / Richard J.D.Tilley.*, 2nd ed.. (Hoboken, N.J.: Wiley, 2011).

the light source as they look towards a region of the atmosphere with suspended droplets of water or mist. The rainbow appears to be a physical object at a specific distance from the observer, and one might be fooled into thinking that other observers will see the same rainbow. However, the perception of a rainbow is unique to the observer themselves, and no two observers ever see the exact same rainbow.[304] Furthermore, the illusory nature of the rainbow means that it is an elusive object, as it can never be reached even when approached.

Fig. 69 Olafur Eliasson, Beauty, 1993, Installation view: Long Museum, Shanghai, 2016, Photo: Anders Sune Berg ©

Olafur Eliasson recreates the physical conditions needed for rainbows to appear in his work *Beauty* (1993), shown in Fig. 69. The artwork's description reads 'A punctured hose sprays a curtain of fine mist from the ceiling of a darkened space through the beam projected by a spotlight. From certain perspectives, a rainbow can be seen in the falling water; it shifts in intensity or disappears as the viewer approaches or moves away.'[305] The work presents the physical oddity in a controlled environment, providing the audience with the allure of catching the elusive object. While the rainbow now appears within reach, the work cannot change the reality of the illusion, and as the audience move the rainbows vanish. The dynamic behaviour of the colours brings attention to the positionality of the observer, revealing that rainbows are not just objects in the world, but objects of perception as well.

---

304 Tilley.
305 Jonathan Crary and Olafur Eliasson, *Olafur Eliasson: The Curious Garden: Kunsthalle Basel: 8/1997* (Schwabe & Co. AG Verlag , Basel, 1997).

The environment that *Beauty* creates is not only visual, but also physical. Art critic Elizabeth Sims writes 'Visitors cluster around the walls, breathing in the moist air and watching the fine spray of water as it falls in waves to the floor. From a classically Minimalist perspective, *Beauty* brings the viewer into the present. Awareness of breath, of skin, and of the permeability of body and environment are heightened. Encouraged by this generous presence, a few visitors approach the work. Some dip a hand into its concentrated body, while others dare to walk through it completely. Desire is roused and liberated at once.'[306] The extraordinariness of the work lies not only in the creation of rainbows in an unusual environment, but also in the playful transgression of museum expectation through the simulation of an external atmospheric event (mist) within the sterile confines of a gallery space.

Many metaperceptual themes are implicitly explored in *Beauty.* Unlike the aforementioned Doppler effect, the ability for the audience to interact with the physical illusion in *Beauty* gives them a degree of autonomy over their experience, allowing them to question the reality of their perception. Additionally, an understanding of sound and light's normal behaviour is needed to appreciate the extraordinariness of the Doppler effect. The interaction in *Beauty* involves no prior understanding of physics or optics, the disappearance of the rainbow and movement of its colours is not dependant on previous knowledge, as it is perceived regardless. This allows for an immediate perceptual exploration of the work, framing the audience's awareness towards their own subjective perception. While this element of the work is not contingent on the audience's knowledge, other facets of the work are heavily affected by it. The extraordinariness of a rainbow, and indeed all other physical artefacts in this category, is dependent on the observer's understanding and previous exposure to the phenomenon. An observer who has never encountered a rainbow before would have a vastly different experience of *Beauty* than someone who has seen many. To the new observer, the colourful light show would be truly extraordinary, a colourful seemingly ephemeral object that disappears as one tries to approach it. To an observer who has encountered rainbows often, the experience may draw their attention more to the recreation of a physical oddity in an unusual environment rather than their own perception. This is a shared facet of the all the physical artefacts. As the artefact is caused by irregularities of behaviour in the outside world, the awareness and attention of an observer may be drawn more to the external oddities rather than internal perceptual oddities.

This is the case in another of Olafur Eliasson's works, in which he explores the visibility of light. In *Your Making Things Explicit* (2009)*,* shown in Fig. 70, a powerful beam is cast across a room that is filled with a light fog. The beam passes through a glass cuboid, temporarily disappearing as

[306] Elizabeth Sims, 'Take Your Time: Olafur Eliasson', *X-TRA*, 11.1 (2008).

it travels through the air in the glass structure. The work presents the interesting interaction of light and different materials, and its effect on our ability to perceive it. In comparison to *Beauty*, *Your Making Things Explicit* draws attention to the irregularities of the physical world more so than the audience's perception, and therefore is unlikely to create metaperceptual experiences.

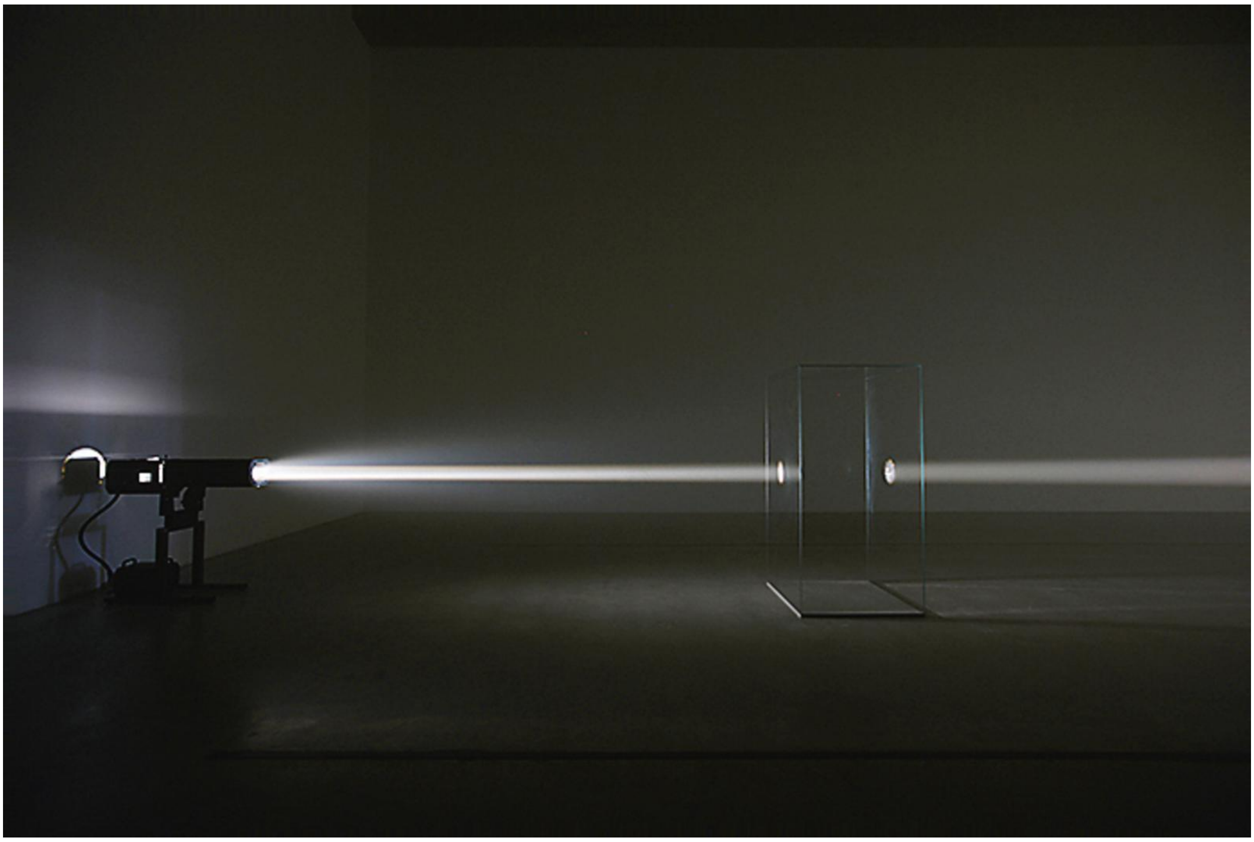


Fig. 70 Olafur Eliasson, Your Making Things Explicit, HMI lamp, tripod, glass, fog machine, wood, Installation view: 21st Century Museum of Contemporary Art, Kanazawa, Japan, 2009-10, Photo: Olafur Eliasson, © 2009 Olafur Eliasson.

The other physical illusion that Gregory gives for the fiction type is moiré patterns, which are produced when two regular and repetitive geometrical patterns are superimposed, slightly out of alignment.[307] The term derives from the fabric *moiré antique* or 'watered silk', which has a pronounced parallel weave that, when superimposed 'small differences in spatial frequency, orientation, and speed are magnified', [308] creating vivid complex shapes from the interference. The distinction of these complex shapes from the patterns is caused by simultaneous contrast: the effect of the black areas where there is maximum overlap appearing darker than those with minimal overlap.[309] In this way, the effect is a combination between the physical stimuli and the cognitive processing.

[307] Nicholas Wade, 'Moiré and Motion', in *Art and Illusionists*, Vision, Illusion and Perception (Springer, Cham, 2016), pp. 311–34.
[308] Lothar Spillmann, 'The Perception of Movement and Depth in Moiré Patterns', *Perception*, 22 (2016), 287–308.
[309] Nicholas Wade.

Moiré patterns have been employed by many artists to create complex designs from simple materials. An early exploration can be found in Ludwig Wilding's *Augenmotiv* (1965), shown in Fig. 71, which uses two sets of black lines to create complex curved patterns. The work was installed in the 1965 exhibition 'The Responsive Eye', which was held at the Museum of Modern Art in New York City and showcased the emerging Op Art movement. It was one of the first artworks which separated the two components generating the moiré fringes; this had a dramatic effect on the perception of the observer. As the audience moved around, the work became interactive, as every movement of the observer yielded a dynamic transformation of the moiré fringes.

Fig. 71 Ludwig Wilding, Augenmotiv

More recent artworks have expanded on this dynamic interactivity, by making the works themselves move. Larry Akers combines moiré patterns with turntable mechanics in *The Wheel* (2013), shown in Fig. 72, allowing the viewer to spin the components and alter the interference patterns. Akers appears to be implicitly exploring metaperceptual themes, as he writes: ‘The beauty is perhaps not so much in the pieces themselves, but rather in the way we perceive them. When considered in the context of our physical, neural, and cognitive processing of images, the overall experience is both introspective and splendidly sensual.’[310]

copyrighted material

Fig. 72 Larry Akers, The Wheel

Outside of the ‘fictions’ type, Gregory includes mirrors as part of the ‘paradoxes’ category. As physical artefacts are defined by their departure from normal behaviour of stimuli, the commonness of the experience of seeing a mirror’s reflection makes them unlikely to gain the

[310] Larry Akers, ‘Mixed Media Moire Animations’, *Eye Play Studio -- Artwork by Larry Akers*.

attention of an observer in the way that an extraordinariness of a moiré pattern does. In order for mirrors to create extraordinary physical behaviour, they need to be presented in such a way that they create unusual perceptions. Anamorphosis artworks often employ mirrors in such a way that they transform distorted images to reveal a hidden order. An early example of this can be found in a secret portrait of Bonnie Prince Charlie, made around 1750, which is now held at the West Highland Museum in Scotland. The work, shown in Fig. 73, is an example of using anamorphosis to conceal a hidden figure. This had a pragmatic purpose, as to possess an image of the prince at time would have been seen as treason in the aftermath of the Battle of Culloden in 1746.[311] A tray with smudges of colour stretched in a semicircle transforms into a portrait of the prince by a polished cylinder which is placed at its centre. The cylinder acts as a mirror, transforming the seemingly chaotic colour smudges into a recognisable order.

Fig. 73 Artist unknown, Secret portrait of Bonnie Prince Charlie

[311] M. Pittock, *Material Culture and Sedition, 1688-1760: Treacherous Objects, Secret Places* (Springer, 2013).

Mirrors can also be used to seemingly break the rules of physics, as in the work *Dalston House* (2013) by Leandro Erlich, shown in Fig. 74. The work consists of a platform that mimics the façade of one of the nineteenth-century Victorian terraces that line many of London's streets, with a large mirror positioned above it at a 45° angle. Visitors are invited to walk and lie on the platform, and observe themselves in the mirror above, which creates confusing relationships that seem to defy gravity. Art journalist Amy Frearson explains 'As a person walks over the surface of the house, the mirror reflects their image and creates the illusion that they are walking up the walls. Similarly, visitors can make it look like they are balancing over the cornices or dangling from the windows.'[312]

Fig. 74 Leandro Elrich, Dalston House, 2013. Barbican Art Center, London. © Gar Powell-Evans for the Barbican Art Center

While both of these works create extraordinary behaviours of stimuli through bending light, they are unlikely to create metaperceptual experiences. This may be due to the ubiquity of mirrors, as most audiences will not be provoked into investigating how the work's illusion is created. As physical artefacts are dependent on the extraordinariness of stimuli, the commonness of mirrors may not redirect the attention of audiences back onto their own perception, but instead to the qualities of the external stimuli. For an artwork to be metaperceptual using physical artefacts, these artefacts must be sufficiently extraordinary to draw the audience's attention back on to themselves.

[312] Amy Frearson, 'Dalston House by Leandro Erlich', *Dezeen*, 2013.

While Gregory's classification of illusions is explicitly focused only on the visual domain, the rich range of aural illusions and artefacts are important to consider for metaperceptual artworks. The Doppler effect has been discussed, with the difficulty of assessing its veracity causing it to be ill-suited for creating metaperceptual experiences. In the following section, I discuss aural physical artefacts that are better suited for exploration through the metaperceptual framework.

9.4 Aural Physical Artefacts

In the sound domain, physical artefacts similar to the Moiré pattern include interference and phasing effects. When two sound waves superimpose, the amplitudes combine to make a resultant wave. Constructive interference occurs when the peaks of two sound waves coincide, causing an increase of amplitude, whereas destructive interference occurs when the combination of the two waves causes a reduction of amplitude. If two sound waves are perfectly out-of-phase with each other, the destructive interference can result in no sound at all, as the waves sum to cancel each other out. Both constructive and destructive interference are illustrated below in Fig. 75.

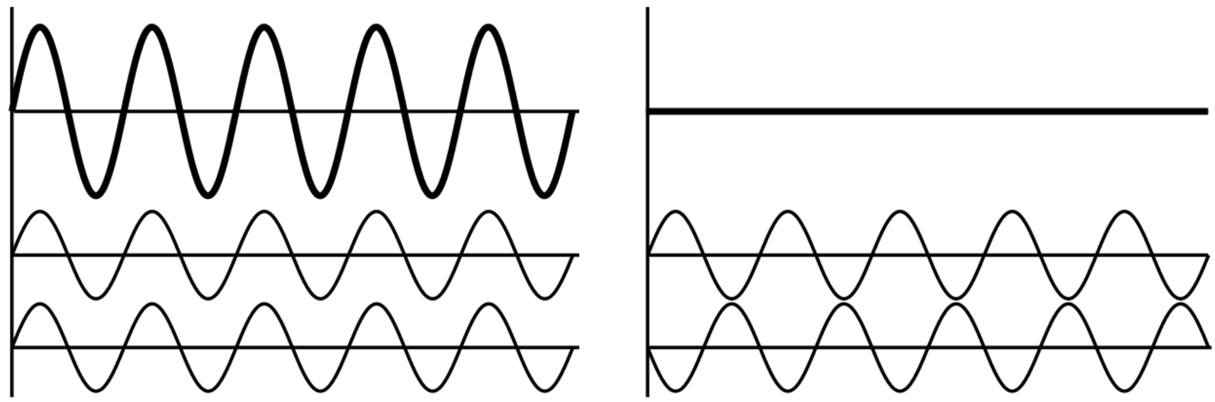


Fig. 75 Left: Constructive interference of the bottom two waves increases amplitude of resultant wave on top; Right: Destructive interference of bottom two waves decreases amplitude of resultant wave on top, effectively silencing it. Image 'Interference of two waves' by Haade licensed under CC BY 3.0

When two waves of slightly different frequencies are combined, a phenomenon called a beat frequency is perceived. The amplitude of the perceived sound fluctuates at the rate of the difference between the two frequencies. This effect is often used to tune string instruments, as the beating between two closely related tones provides the performer a clear cue when the two strings are close to each other in frequency.[313] It also gives certain instruments their distinctive timbre, as with many of the melodic gamelan instruments of Indonesia, which are tuned to produce beat frequencies.[314]

---

[313] Neville H. Fletcher and Thomas D. Rossing, *The Physics of Musical Instruments* (Springer Science & Business Media, 2012).
[314] Edward C. Carterette and Roger A. Kendall, 'On the Tuning and Stretched Octave of Javanese Gamelans', *Leonardo Music Journal*, 4 (1994), 59–68.

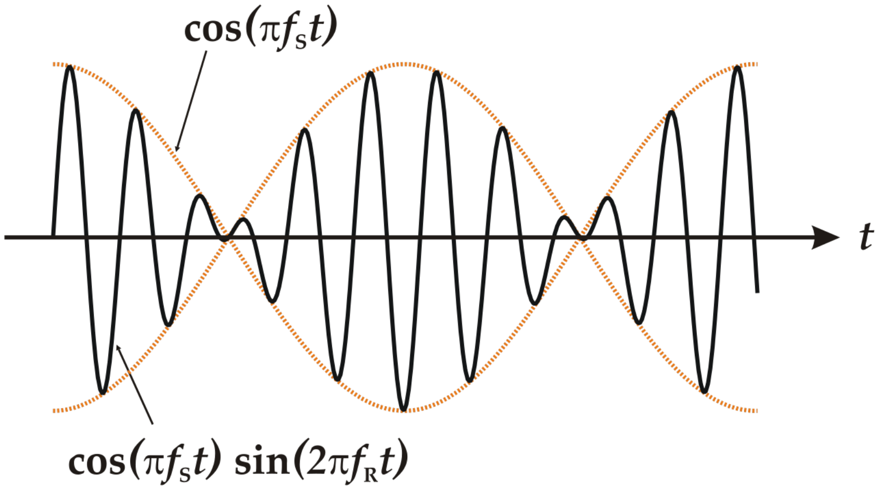


Fig. 76 A beat frequency created by two similar frequencies being superimposed. The orange line shows the resulting wave. Image: 'Beating of two frequencies' by Ansgar Hellwig licensed under CC BY 3.0

Various composers have focused on this phenomenon, most notably by Alvin Lucier in his 1990 album *Crossings.*[315] The series of three works are a bare presentation of beating frequencies, combining classical instruments and sine tone oscillators. Lucier presents the two pitches in long held notes, with no change in amplitude or articulation. Over the course of the long pieces, the lack of any other musical development draws attention to the beating between the two pitches, as each combination has slight differences in their relationship. This austere presentation inspired music reviewer Tim Perkis to write 'The impact of these pieces is physiological: the unrelenting sine waves cause a strong trance effect. The combination tones, beatings and other interferences between the sine tone and the players form the heart of this music. At a certain point, the difference between changes in the music and changes caused by the listener swallowing, moving his or her head or moving across the room become indistinguishable. The sound has the remarkable property of seeming to happen right in the ear and, certainly, some of the perceptible effects are caused by breakdowns and hallucinations in the brain's sound localization apparatus. The effect is unlike anything one is likely to have heard in normal life or in normal music.'[316]

The stark presentation of the two tones through easily discernible sources allows for the audience to have a similar interaction as in Olafur Eliasson's *Your Making Things Explicit.* The audience is able to discern the veracity of the perceptual effects in both of these works, as there is no mystery in the creation of the materials, and in some senses, they are even able to interact with the phenomena. If an audience member slightly moves their head while listening to Lucier's *Crossings*, the precise blend of amplitudes between the sounds changes the perceivable result. This interaction allows for metaperceptual experiences, as the audience are left to question how the

---

[315] Thomas Ridenour, *Alvin Lucier: Crossings* (Lovely Music, Ltd., 1990).
[316] Tim Perkis, review of *Review of Crossings*, by Alvin Lucier and Emanuel Dimas de Melo Pimenta, *Leonardo Music Journal*, 1.1 (1991), 112–112.

interaction between the stimulus and their perception are creating perceptual effects that are 'unlike anything one is likely to have heard in normal life or in normal music.'[317]

Perkis notes the different forms of aural oddities that the two notes create which includes 'combination tones, beatings, and other interferences.'[318] The closely related phenomena of combination tones and binaural beats are also caused by the relationship between two tones, and their origins also lie in the cognitive processing of the sound, which I will discuss further in the Cognitive Artefacts chapter. These perceptual artefacts form the artistic materials in my own metaperceptual work *Destructive Passages One & Two*, discussed in Part III.

While Alvin Lucier's use of interference patterns in sound is bound to the musical performance context, other artists have created inhabitable physical and spatial environments using interference patterns. Carsten Nicolai's work *invertone* (2007), shown in Fig. 77, explores destructive interference through carefully distributing its effect in space, creating what could be described as a sound sculpture. The work consists of two large loudspeakers, precisely spaced apart and facing each other. Ideally, the work should be installed in an anechoic chamber, as any reflections created by the room will corrupt the delicate balance that Nicolai seeks. The two speakers emit white noise, and as he explains: 'all over the room the sound is evenly present except at the centre point right in the middle between the speakers. Here the waveforms face themselves directly and thereby (ideally) erase each other totally.'[319]

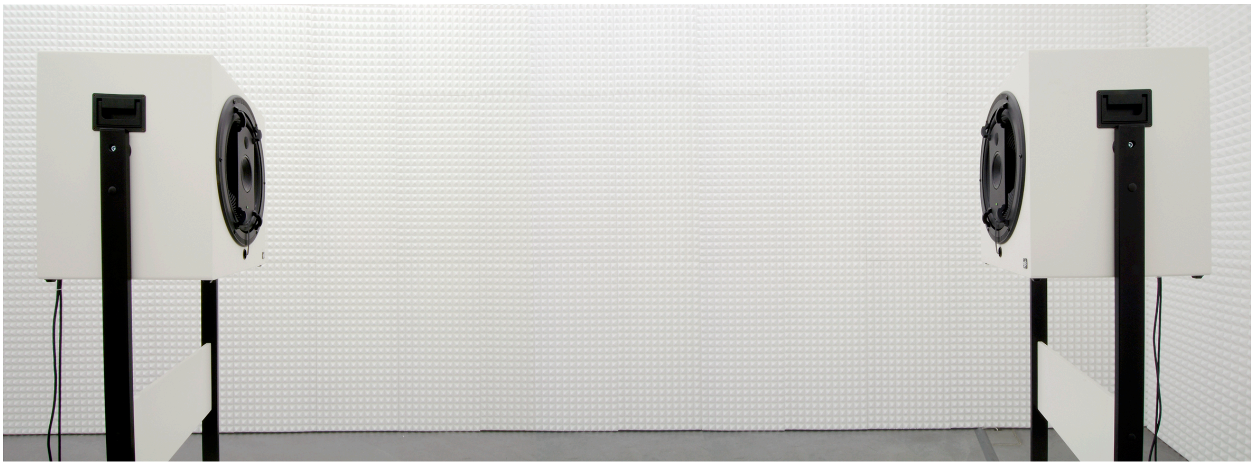


Fig. 77 Carsten Nicolai, invertone, 2007, two loudspeakers, sound, pedestals, modular foam acoustic panels. Photo: Uwe Walter, Courtesy Galerie EIGEN + ART Leipzig/Berlin and Pace Gallery.

invertone pursues a physical ideal of the complete cancellation of sound caused by destructive interference. The reality of the work will never quite reach this ideal however, as the reflections

[317] Perkis.
[318] Perkis.
[319] Telekom, '"In Terms of Freedom, More Was Possible": Hans Ulrich Obrist Talks to Carsten Nicolai', *Telekom Electronic Beats*, 2012.

from the room and even the presence of a listener, and the way their body filters sound, will create slight differences in the sound waves. In this way, the active presence of the audience obstructs the purity of the physical environment, making the utopian ideal unobservable. This parallels John Cage's experience of silence in an anechoic chamber, as his active presence made the experience of pure silence unattainable. Regardless of the purity of the wave interference, the physical artefact of a prominent reduction in volume at this isolated point in space is nevertheless extraordinary in itself.

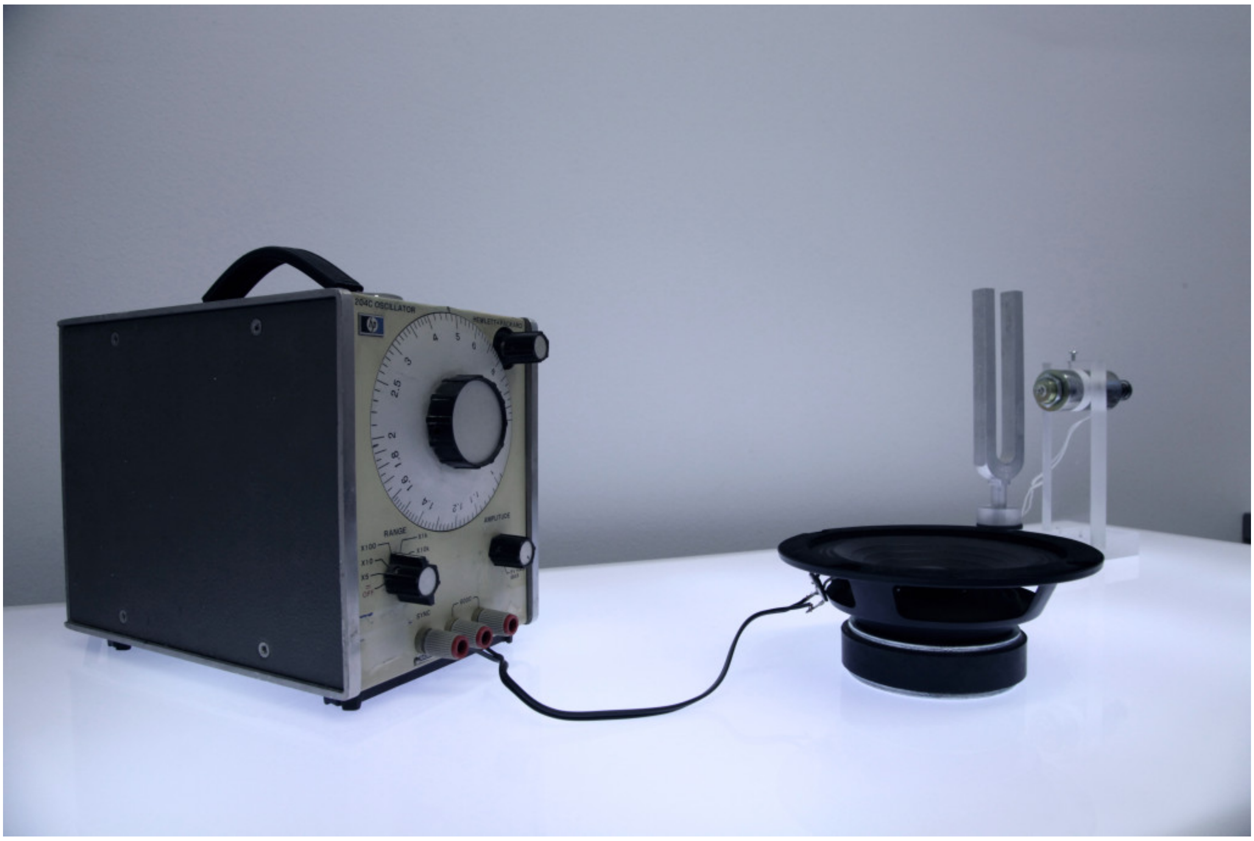


Fig. 78 Nicolas Bernier, Frequencies (A / Friction). Image provided courtesy of the artist.

While the experience of *invertone* may be a complex investigation of finding nodes of constructive and destructive interference, Nicolas Bernier's *Frequencies (A / Friction)* (2015), shown in Fig. 78, draws the audience's attention to the interaction between two pure tones. The work consists of a tone oscillator connected to a speaker, and a 480 Hz tuning fork. The oscillator frequency is stable at 476 Hz, which means that when the tuning fork is struck by the solenoid, a beating pattern appears. The refined and austere presentation of interference patterns in *Frequencies (A / Friction)* reveals how the physical artefact is created, and draws the audience's attention to the oddity of the beating between the two pure tones. By striking the tuning fork intermittently, while the tone oscillator's presence is constant, the beating effect is constructed and deconstructed at different points. This reinforces interaction between the pure tones, and the extraordinary artefact it creates. This work was particularly influential for my new metaperceptual work *Destructive Passages One*

& Two, presented in Chapter Thirteen. The work also uses solenoids to actuate tuning forks to explore interference patterns and binaural beating.

The exploration of interference patterns by distributing them in space in Nicolai's and Bernier's works, rather than in time as in Alvin Lucier's *Crossings*, allows for a different form of audience interaction. As the sonic effect remains a static spatial entity, the audience is able to explore the physical artefact by moving through the space. Similar to Olafur Eliasson's *Beauty*, this allows the audience to investigate the veracity of their experience. While the listener's first reaction to moving into the point of interference may be to assume that the stimuli has changed, the ability to then carefully move one head and experience the subtle effects allows for the audience to understand the reality of their perception. Their experience is dependent on where they are in the space, which allows them to experience the oddity of sound seemingly frozen in space as a sculptural form. The work provokes the audience into actively investigating their own perception, thus creating a strong metaperceptual experience.

invertone is characteristic of many of the physical artefact works, in that metaperceptual themes form only part of the work's artistic materials. These works are often investigations of interesting physical phenomena, rather than being exclusively focused on the perception of the audience. Accordingly, physical artefact works are likely to draw the audience's attention to both extraordinary physical phenomena, as well as create extraordinary perceptual spaces and experiences. While the metaperceptual framework does not exhaust all interpretations of these physical artefact works, it does provide a lens through which to analyse the ability of these works to direct their audience's intentionality back on to themselves.

The interference behaviour explored in the works of Lucier, Nicolai, and Bernier, is at the wavelength level. A similar concept at a higher temporal level has been evidenced in the minimalist and phase works of many composers such as Steve Reich and Terry Riley. By superimposing multiple versions of a phrase at different tempi, these works create complex melodic materials borne out of simple materials. This process has similarities to Moiré patterns, as the superimposition of simple patterns bear new complex perceptual objects. As with Carsten Nicolai's exploration of interference patterns, the phase works of Steve Reich or Terry Riley may not be explicitly intended to create metaperceptual experiences. The beating effects that occur through the phasing of melodic lines is one part of the interesting musical world that the works create. Accordingly, the metaperceptual framework offers one means by which we can analyse the work, but does not exhaust the possible and applicable interpretations.

The works in this ‘Physical Artefact’ category produce extraordinary physical stimuli that can in turn create extraordinary perceptual experiences for their audiences. This quality of *extraordinariness* is what can provoke metaperceptual experiences, as the audience has their attention drawn to the act of perceiving itself due to the departure from normality. As the extraordinariness of an experience is subjective to the audience member, the extent to which each work is considered metaperceptual is, to some degree, dependent on the audience. Future metaperceptual explorations of physical artefacts may consider the audience interaction with the work to further guide the audience’s attention to their own perception. The ability for the audience to investigate the veracity of the physical artefact is an important perceptual framer, drawing the audience’s attention to whether or not what they are perceiving is ‘real’. Physical artefacts, such as the Doppler effect and the Zwicker tone, that are harder to investigate in this way are ill-suited for metaperceptual artworks, relying on a thorough understanding of the physics of light and sound rather than a perceptual exploration.

Chapter Ten

Perceptual Hacking: Physiological Artefacts

The physical artefacts discussed in the previous chapter are created when the physical properties of an environment cause stimuli to behave in extraordinary ways. Physiological artefacts, on the other hand, occur in the perceptual apparatus itself when the sense organs create by-products as a result of processing stimuli, or from abnormal functioning. Gregory states that 'Physiological illusions include all manner of neural losses and interactions producing degenerated or distorted neural signals, and sometimes bizarre fictions including those of drugs.'[320] These physical artefacts manifest in various forms, and can be caused by the malfunctioning of a sense organ, or the miscommunication between multiple sense organs. As with many of the other metaperceptual approaches, the malfunctioning of the senses can draw attention to the perceptual apparatus itself, revealing the ways in which it mediates our experience.

The malfunctioning of a sense organ is sometimes due to damage of the perceptual apparatus rather than due to extraordinary stimuli. The Zwicker tone, discussed at the beginning of this chapter, is closely related in experience to tinnitus, a 'phantom auditory perception without corresponding acoustic or mechanical correlates in the cochlea.'[321] The two most common causes of tinnitus, acoustic trauma and aging, are typically associated with impaired cochlear function.[322]

While the experience of the Zwicker tone and tinnitus are very similar, the origin of the tone is vastly different. The Zwicker tone presents an interesting case in which, in response to a non-damaging stimulus, the audience may have a similar experience to their perceptual apparatus malfunctioning due to damage. There are similarities between this and some of the works in the Deprivation category including Anish Kapoor's *L'origine du monde* and *Descent into Limbo.* Through an understanding of our visual processes, Kapoor creates the illusion of nothingness by using materials that almost completely absorb light, provoking the audience to question their perception and whether it is malfunctioning. Accordingly, these works could be classified as explorations of both Deprivation and Perceptual Hacking approaches.

---

[320] Richard L Gregory.

[321] Byung In Han and others, 'Tinnitus: Characteristics, Causes, Mechanisms, and Treatments', *Journal of Clinical Neurology (Seoul, Korea)*, 5.1 (2009), 11–19.

[322] Carol A. Bauer, Thomas J. Brozoski, and Kristin Myers, 'Primary Afferent Dendrite Degeneration as a Cause of Tinnitus', *Journal of Neuroscience Research*, 85.7 (2007), 1489–98.

As causing damage to the perceptual apparatus of the audience is not a viable approach for artists, only those physiological artefacts that are produced by extraordinary stimuli will be the focus of this category. The Zwicker tone is an example of a single sense organ's neural organisation creating a perceptual artefact. In this case, the interaction between the noise-detection neurons and the asymmetric lateral inhibition behaviour of the output neurons causes the Zwicker tone to appear. These neural components in the organisation auditory system fulfil different roles, and in normal contexts work efficiently to allow us to make sense of the milieu of sonic stimuli around us. The presentation of broadband noise with a notch removed for an extended period causes this normally functioning system to produce an unusual artefact.

Physiological artefacts can also be caused when the communication between multiple sense organs is conflicting. Gregory gives the example of double vision, which can 'have physiological origins, such as loss of convergence of the eyes as by-effects of alcohol.'[323] George Mather's comprehensive text, *On the Foundations of Sensation and Perception*[324] explains a similar effect of alcohol. Postural alcohol nystagmus, or the effect of the world appearing to spin, occurs when a person has acute alcohol intoxication. This effect originates in part of the vestibular organ called the semi-circular canals, which senses information about orientation, rotation, and acceleration, allowing us balance and co-ordinate our movements. The system integrates information from the vestibular organs and other streams of sensory input including vision. The ampullary cupula in the canals houses hair cells suspended in gelatinous mass. As alcohol diffuses into the ampullary cupula, it makes a layer of the mass lighter and more buoyant, resulting in dysfunction. When the intoxicated person lies down, the cupula moves and triggers eye movements, causing nausea and the apparent movement of the worlds.[325] This is an example of a miscommunication between the senses caused by a change in the perceptual apparatus on the physiological level. This disagreement between senses is explored in my work *Your Localisation Exposed* (presented in Chapter Twelve), which rearranges an audience member's perceptual apparatus, causing their visual and aural sense to be in conflict.

In this chapter, I organise a range of different physiological artefacts and analyse their exploration in artworks. As in the physical artefact chapter, these artefacts will be ordered into visual and aural groups, and the suitability for using these artefacts in metaperceptual works is analysed. Some physiological artefacts are better suited for creating metaperceptual experiences, and the reasons for this will be explored throughout.

---

323 Richard L Gregory.
324 Mather.
325 Thomas Brandt and Robert B. Daroff, 'The Multisensory Physiological and Pathological Vertigo Syndromes', *Annals of Neurology*, 7.3 (1980), 195–203.

10.1 Visual Physiological Artefacts

'Every impression is preserved for a time in its sensitive object [in this case the eye]…and the impression is that of a blow, so the brightness of the sun or other luminous body remains in the eye for some time after been seen.'[326]

—Leonardo da Vinci

Gregory includes a range of visual physiological illusions including afterimages, autokinetic effect, and aftereffects of motion. Of these illusions, the afterimage has been most thoroughly explored in visual art. An afterimage is a 'visual experience caused by a previously seen stimulus, when that stimulus itself is no longer present.'[327] There are two main types of afterimages: *Positive Afterimages*, also known as visual persistence,[328] in which the colours of the original stimuli are maintained, and *Negative Afterimages,* in which the colours are inverted from the original stimuli. The Zwicker tone was first described in his paper titled 'Negative Afterimage in Hearing',[329] due to the similarities between it and the visual phenomenon. As the pitch of the Zwicker tone is not in the stimulus that provokes it, it is defined as a negative afterimage, rather than positive.

10.1.1 Afterimages

Positive and negative afterimages are caused by different experiential conditions, but appear to be the result of similar physiological processes. Positive afterimages often occur when the visual sense has adapted to a lack of stimulation, usually from a dark environment or because the eyes have been blocked. When briefly presented with an intense visual stimulus, the image will persist for a time after the stimulus has been removed. In this case, the colours remain the same as in the stimulus. Negative afterimages occur after prolonged exposure to a stimulus, and is most effective if the stimulus contains intense contrasts of colour. The visual system adapts to the visual stimulus over time, and when the stimulus is removed, an inverted image of complementary colours is perceived. This is often experienced when looking at a bright stimulus, such as the sun, for a period

---

[326] Kenneth D. Keele, *Leonardo Da Vinci's Elements of the Science of Man* (Academic Press, 2014).
[327] G. Thomson and Fiona Macpherson, 'Negative Afterimages', *The Illusions Index*, 2017.
[328] The term 'persistence of vision' is extensively discussed in regards to film, as it was once thought to be the reason for the apparent continuation and motion that we perceive when watching film. This has since been debunked by many researchers, for a meta-analysis see Joseph Anderson and Barbara Anderson, 'The Myth of Persistence of Vision Revisted', *Journal of Film and Video*, 45.1 (1993), 3–12.
[329] Zwicker.

of time, and then looking away. Leonardo da Vinci noticed this effect, writing the 'brightness of the sun or other luminous body remains in the eye for some time after [having] been seen.'[330]

The exact cause of positive afterimages is still the subject of debate. In 1985, Gerald Long wrote that 'despite impressive empirical effort, there is at present no generally accepted model of visual persistence.'[331] The effect has been attributed to sluggish photoreceptor functioning,[332] continuing photoreceptor or retinal neuron activity,[333] and more recently to persistence of a visual representation in the absence of evidence that the world has changed.[334] While the cause of positive afterimages is not currently fully understood, the phenomenon has been explored in art in a range of contexts.

One of the first and most famous explorations of the persistence of vision effect is Marcel Duchamp's *Rotative plaques verre, optique de precision* (1920), shown in Fig. 79. The work consists of five glass arms or propellers with black and white arcs painted on them. The arms fan out from a centre axle, which is attached to a motor. When this is rotated rapidly, a set of concentric circles becomes visible. Wade explains that 'The circles are seen because of the recurrent stimulation of the retina by the arcs; the effects of each stimulation persist until the next one. The fact that the effect can be photographed indicates that the exposure duration of the camera exceeded the time required for rotation through 180 deg (as the glass arms are separated by 180 deg).'[335] As the glass arms are separated in space, the viewer will see a different combination of the concentric circles depending on their perspectival position. Moving around the machine allows for a demystification of the perceptual artefact, as the viewer can see the different parts that move to make the circles. The ability to investigate the veracity of their perception can allow for the audience to have metaperceptual experience. A development of this work creates a moving spiral instead of concentric rings, which will be discussed in the Motion Aftereffect section.

---

[330] Keele.

[331] Gerald M. Long, 'Duration and Resolution Effects on Visual Persistence (Positive Afterimages)', *Bulletin of the Psychonomic Society*, 23.4 (1985), 409–12.

[332] Barbara Sakitt, 'Iconic Memory.', *Psychological Review*, 83.4 (1976), 257; Barbara Sakitt and Gerald M. Long, 'Relative Rod and Cone Contributions in Iconic Storage', *Perception & Psychophysics*, 23.6 (1978), 527–536; Barbara Sakitt and Gerald M. Long, 'Cones Determine Subjective Offset of a Stimulus but Rods Determine Total Persistence', *Vision Research*, 19.12 (1979), 1439–1441.

[333] H. B. Barlow and J. M. B. Sparrock, 'The Role of Afterimages in Dark Adaptation', *Science*, 144.3624 (1964), 1309–14.

[334] Alex O. Holcombe, Donald I. A. MacLeod, and Scott T. Mitten, 'Positive Afterimages Caused by a Filled-in Representation', *Journal of Vision*, 4.8 (2004), 485–485.

[335] Nicholas J. Wade, 'Op Art and Visual Perception', *Perception*, 7.1 (1978), 21–46.

copyrighted material

Fig. 79 Marcel Duchamp, Rotative plaques verre, optique de precision, in motion showing the effects of the persistence of vision

A modern exploration of persistence of vision can be found in the LED works of Teddy Lo. *Positive Void* (2009), shown in Fig. 80, consists of a rectangular array of LEDs that creates hidden images through persistence of vision. By rapidly displaying a sliver of the image on each side of the rectangle, the persistence of vision effect allows for the audience to move their head, causing the image to smear in space. Fig. 80 shows the perceptual result of the persistence of vision in this work.

copyrighted material

Fig. 80 Teddy Lo, Positive Void

Positive Void connects the visual phenomenon of persistence of vision to the omnipresence and insidiousness of advertising campaigns. Lo writes 'Billboards, web advertisements, viral marketing, social media—advertising is an inescapable presence in the contemporary society to the point where it has become an expected, practically ignored part of the modern landscape.'[336] By embedding secret images in the work through persistence of vision, Lo explores the autonomy of perception and exposure to advertising materials. The audience are in control of whether they see the full images, or just the frame of an LED rectangle. In doing so, the work 'seeks to co-opt and undermine this pervasive force.'[337]

The audience's interaction with the work creates metaperceptual experiences in a similar way to other works such as Olafur Eliasson's *Beauty*, discussed in this chapter. In both works, the audience's attention is drawn to their own perception through their movement. In *Beauty*, this movement in their spatial position in the room, with certain points in space allowing the audience to see the vibrant rainbows in the mist. In *Positive Void*, the movement is of the perceptual apparatus itself, with the movement of the head smearing the light across space, revealing the hidden images embedded in the artwork. This autonomy of interaction with the artwork allows for a metaperceptual experience, as the audience's attention is drawn to their own perceptual apparatus and the perceptual oddity of the persistence of vision. While many of the physical artefacts

[336] Teddy Lo, 'Positive Void', *Teddy Lo Studio - A LEDARTIST SUBSIDIARY*, 2014.
[337] Lo.

discussed in the previous chapter require an understanding of the normal behaviour of light and sound for an appreciation of their extraordinariness, the persistence of vision phenomenon is not predicated on this knowledge. The experience is immediate, and, because it is caused by the movement of the perceptual apparatus, offers a captivating metaperceptual exploration.

Negative afterimages have received more attention from researchers, as the peculiar inversion of colour provides insights into our perception of colour. An understanding of the physiological mechanisms behind negative afterimages requires a brief discussion of the photoreceptive rods and cones that reside in the retina. Each cone belongs to one of three types depending on the particular kind of light-sensitive photopigment molecule it contains. The short-wavelength pigment absorbs light best around 419 nm; the medium-wavelength pigment absorbs light best around 531 nm; and the long-wavelength pigment absorbs light best around 558 nm.[338] The relative intensities of the cones' response to light stimuli combine, allowing us to perceive colour.

Negative afterimages are thought to be caused by adaptation and bleaching in the rods and cones.[339] Bleaching occurs when the molecules in the cones and rods are struck by light, causing them to lower their future rate of absorption.[340] Adaptation is caused when the retina is exposed to light for a long period of time, resulting in the sensitivity of the activated photoreceptors in that particular region to decrease. If the visual system is subjected to an intense stimulus of light consisting of mainly short-wavelengths for an extended period, the short-wavelength cones will adapt and bleach over time. Once this stimulus is removed, these cones will be less sensitive relative to the two other types of cones in that area of the retina. If the eye is presented with a uniform white stimulus (that is all cones are stimulated), then that part of the retina will perceive the complementary colour, as the reduction in sensitivity in the short-wavelength cones will bias the mix towards the other cones. Thus a red stimulus will produce a green afterimage (and vice versa), a blue stimulus will produce a yellow afterimage (and vice versa) and a white stimulus will produce a black afterimage and so on.[341]

Mo H. Zareei's work explores both positive and negative afterimages in a sound art performance context. *Rasper* is a mechatronic sound and light sculpture that produces rich noise timbres and

[338] Bruce E. Goldstein.
[339] Peter H. Schiller and Edward J. Tehovnik, *Vision and the Visual System* (Oxford University Press, 2015).
[340] Tôru Yoshizawa and George Wald, 'Pre-Lumirhodopsin and the Bleaching of Visual Pigments', *Nature*, 197.4874 (1963), 1279–86.
[341] Bruce E. Goldstein.

bursts of white light.[342] Zareei uses the instrument to extend glitch music into the acoustic, physical, and audiovisual realm by creating grid-based rhythmic materials from mechanically sonic by-products that are complemented by pure light aesthetics. In *Rasping Music,* Zareei controls an array of four *Raspers* to create simple rhythmic units of noise and light. The work is influenced by Minimalist approaches, with its name a homage to Steve Reich's *Clapping Music* (1989). Through the technique of phasing, previously discussed in Steve Reich's *Piano Phase*, the simple rhythmic ideas evolve into complex patterns as their distribution throughout the ensemble changes over time.

Fig. 81 Mo H. Zareei's Rasper sound sculptures. Image provided courtesy of the artist.

The bright flashes of white light create positive afterimages in the beginning of the work and, as the audience's visual perception goes through the process of adaptation and bleaching, eventually creates negative afterimages by the end of the work. My own experience of *Rasping Music* was preceded by a period of silence and darkness, during which my eyes adjusted to the low level of light and became highly sensitive. This period framed my experience, as the work begins with the powerful gesture of all four *Rasper* units creating a sharp attack of noise and light in unison. Sitting in a line, spaced equally apart, the *Raspers* bombarded my eyes with an instantaneous flood of white light, illuminating the room for a fraction of a second. While I could hear the sharp attack of noise complimented by an equally sharp disappearance, my eyes lagged behind, the light fading

342 Mo Zareei, Ajay Kapur, and Dale A. Carnegie, 'Rasper: A Mechatronic Noise-Intoner.', in *NIME*, 2014, pp. 473–478.

over time. In this sense, my eyes behave like capacitors discharging, the sharp rectangular beams of light slowly fading into vague milky objects. This residual impression is the positive afterimage effect: the intensity of light causes my eyes to see the afterimage in the same colour as the stimulus.

The rhythmic phrase articulated in unison at beginning of the work eventually disintegrates as the phrase is articulated by each *Rasper* at different delay times. The effect is that new patterns of light and sound appear in the ensemble, causing my visual focus to shift between different *Rasper* units. These small, rapid eye movements are called saccades,[343] and their effect on my perception is that the afterimages start to be distributed in space. As the work progresses, my eyes undergo the process of adaptation and bleaching, changing the once-white positive afterimage into a deep blue negative afterimage. The change in colour is particularly arresting, as it slowly develops throughout the work until there is a vibrant contrast between the stimulus of the white *Rasper* lights, and the blue afterimages that are scattered around the ensemble in my vision.

While *Rasping Music* (2013) offers an interesting metaperceptual experience through the evolution of afterimages, a metaperceptual analysis only investigates one element of the work. *Rasper* is one of three sound and light sculptures (that form his *Brutalist Noise Ensemble*)[344], *Rippler*[345] and *Mutor*[346] completing the trio. Zareei uses the ensemble to create sound-based artworks that connect to the aesthetic sensibilities of Brutalist architecture. Zareei contextualises this sound-based Brutalism with contemporary practitioners, identifying an emergent trend in the aesthetic principles of artists including Ryoji Ikeda, Alva Noto, Pan Sonic, Martin Messier, and Nicolas Bernier.[347] While a metaperceptual analysis does not exhaust all of the artistic materials in Zareei's work, it can offer a new insight into the experience of the work, adding to the totality of interpretations and understandings.

While Zareei's creation of afterimages in *Rasping Music* is a facet of the overall experience of the work, Olafur Eliasson's *Your blue afterimage exposed* (2000) places the effect at the thematic crux of the work. The work, shown in Fig. 82, is a pure exploration of metaperceptuality through perceptual hacking. It consists of two parts: the first involves a spotlight that projects an intense orange square of light into one wall. After about ten seconds, the light is turned off, leaving the

---

[343] Bruce E. Goldstein.
[344] Mo H. Zareei, Dale A. Carnegie, and Ajay Kapur, 'Physical Glitch Music: A Brutalist Noise Ensemble', *Leonardo Music Journal*, 2015, 63–67.
[345] Mo H. Zareei, Dale A. Carnegie, Dugal McKinnon, and others, 'Rippler: A Mechatronic Sound-Sculpture', *Journal of Comparative Media Arts*, 1 (2015).
[346] Mo H. Zareei, Dale A. Carnegie, Ajay Kapur, and others, 'Mutor: Drone Chorus of Metrically Muted Motors', in *ICMC*, 2014.
[347] Zareei, Carnegie, and Kapur.

viewer in darkness. When the stimulus is removed, the viewer perceives a blue rectangular afterimage where the stimulus once was. The second part of the work presents the opposite effect, as a blue square of light is projected onto a wall in a separate space. This time, the afterimage is orange, linking the complementary relationship between the two experiences.

Fig. 82 Olafur Eliasson, Your blue afterimage exposed, 2000. Spotlight, dimmer, tripod, colour filter foil. Installation view: Masataka Hayakawa Gallery, Tokyo. © 2000 Olafur Eliasson

Writing about the effect of the after-image in his work, Eliasson says 'for a moment you've been turned into a projector. This is how the piece can look back at us, create something in us. I like the idea of us being the light projector, projecting the piece onto the space.'[348] This role of the audience as projector or co-creator is a key element of many of Olafur Eliasson's works, as it is in the metaperceptual approach. He continues: 'the reason I think it's important to exercise this double-perspective is that our ability to see ourselves seeing—or to see ourselves in the third person, practically to step out of ourselves and see the whole set-up of the artefact, the subject and the object—that particular quality also gives us the ability to criticize ourselves. I think this is the final

[348] Madeleine Grynsztejn and others, *Olafur Eliasson*, Revised & Expanded ed. edition (London ; New York, NY: Phaidon Press, 2002).

aim: giving the subject a critical position, or the ability to criticize one's own position in this perspective.'[349]

While *Your blue afterimage* presents an isolated area of intense stimulus, his work *Room for one colour* (1997) creates an immersive environment exploring the afterimage effect and other perceptual colour artefacts. The work, shown in Fig. 83, consists of an empty room with white walls and no natural light. Mounted on the ceiling is an array of sodium-based yellow mono-frequency lamps that bathe the audience in pure light, saturating their visual system and causing extraordinary perceptual artefacts. Art critic Marcella Beccaria writes that 'in the case of *Room for one colour*, they [the lamps] shine on an empty space in which the visitors become protagonists, with their individual reactions constituting the real subject of the work. Some people experience apparent changes in perception as they spend more time in the room, since the human brain tends to call up memories of missing colours in order to compensate for the lack of retinal information. For others, the condition of 'hypervisibility' offered by the installation provides an opportunity to observe details that would otherwise be neglected. In most cases, in reaction to the yellow environment, viewers momentarily perceive a bluish after-image.'[350]

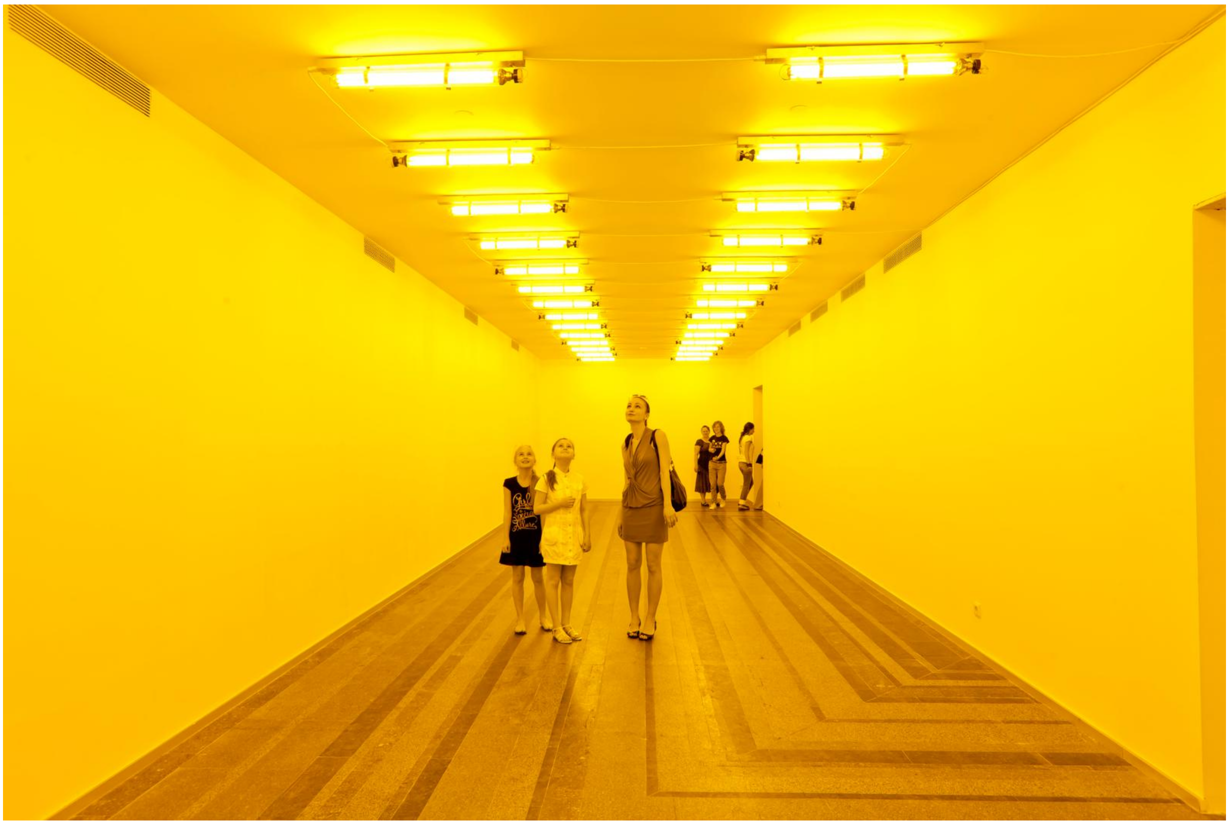


Fig. 83 Olafur Eliasson, Room for one colour, 1997. Monofrequency lamps. Installation view: Moderna Museet, Stockholm 2015. Photo: Anders Sune Berg. Courtesy: the artist; neugerriemschneider, Berlin; Tanya Bonakdar Gallery, New York. © 1997 Olafur Eliasson

[349] Grynsztejn and others.
[350] Marcella Beccaria, *Tate Modern Artists: Olafur Eliasson* (London : New York: Tate, 2013).

Beccaria describes not only the afterimage effect, but also 'hypervisibility' and 'memories of missing colours.'[351] The hypervisibility may be due to the work mostly reducing the palette of colour to a continuum between yellow and black. Eliasson explains the effect of this by using an analogy of what happens when we look at the same picture in black and white and in colour: 'we have the impression that the former is easier to interpret than the latter.'[352] This hypervisibility can persist temporarily outside the exhibition space, further drawing the audience's attention to their own perception and the core role as protagonist that they play in the artwork. The 'memories of missing colours' may share similarities to the works discussed in the 'Uniformity of Stimulus' from the deprivation chapter. Areas of this monochromatic environment may produce a lack of differentiation for the viewer, with their eyes potentially creating hallucinatory colours. This could also be caused by the afterimage effect: as the viewer's visual perception adapts and becomes bleached, the complimentary blue colour may start to appear. Art critic Adrian Searle writes of his experience in the space: 'the shocking light saturates your eyeballs and shuts down your capacity to read colour, until you stumble out and experience a moment of visual hypersensitivity. It made me feel kinda blue.'[353]

Olafur Eliasson is one of the key artists exploring metaperceptual themes and approaches. His works are often environments that co-create experiences with the audience, with their perception the core artistic material. He implicitly discusses many of the metaperceptual themes in interviews and in his writings, such as in his entry in the exhibition catalogue *Monochrome: Painting in Black and White*, where he writes of *Room for one colour*: 'the experience of being in a monochrome space of course varies with each visitor, but the most obvious impact of the yellow light is the realisation that perception is acquired. The representational filter, or the sudden feeling that our vision simply is not objective, is brought to our awareness and with that our ability to see ourselves in a different light.'[354] The new works presented in Part III attempt to explore these themes in the aural domain. They focus on the subjectivity of our experience and the way in which our perceptual apparatus and processes mediate our experience of the world.

10.1.2 Motion Effects

As part of the physiological illusions, Richard Gregory also includes the autokinetic effect, a visual illusion of movement in a static image or environment. The effect is a known problem for pilots

[351] Beccaria.
[352] Beccaria.
[353] Adrian Searle, 'Monochrome Review – White Stripes, Shocking Yellow and 500 Shades of Grey', *The Guardian*, 2017.
[354] Lelia Packer and Jennifer Sliwka, *Monochrome: Painting in Black and White* (New Haven, CT: National Gallery London, 2017).

who, when flying at night, may encounter the impression that a light in the distance—often a ground light or star in the sky—is moving in front of the airplane's path.[355] The illusion can cause a misperception that an object is on a collision course with the aircraft, causing evasive manoeuvres.

The cause of the autokinetic effect has been argued by Gregory as a 'loss of calibration'[356] in the visual system that occurs when the muscles in the eye and neck start to fatigue. He writes 'fatigue of the eye muscles requires abnormal command signals to hold the eyes' fixation on the light, but these are the same as the signals which normally move the eyes when they follow a moving object. We thus see movement when the muscles are fatigued, although neither the eyes nor the image on the retinas are moving. The wandering illusory movements of the autokinetic effect seem to be due to the command signals maintaining fixation in spite of slight spontaneous fluctuations in the efficiency of the muscles, which tend to make the eyes wander. It is not the eyes moving, but the correcting signals applied to prevent them moving which cause the spot of light to wander in the dark.'[357]

The illusory movement that the autokinetic effect produces is related to the movement that observers perceive in many of the works from the Op Art movement, previously discussed in Chapter Two. While the cause of the movement may not be due to the autokinetic effect, the perceptual result is similar. Bridget Riley's work *Current* (1964) shown in Fig. 84, creates extraordinary movement from a static image. The work is a mass of undulating black and white lines that appear to vibrate and form three-dimensional depressions that quiver on the painting's surface. In the middle of centre of work, the dense curves also give the illusion of depth, as they recede past the frontal plane of the painting. As the viewer gazes across the painting, the fringes of their perception appear to distort, provoking the audience to direct their intentionality towards this space of movement. As they chase this illusory movement around the canvas, the viewer can end up in a perceptual game of hide and seek, as the movement can never be caught in the focus of their visual perception.

---

[355] Fred H. Previc and William R. Ercoline, *Spatial Disorientation in Aviation* (Reston, United States: American Institute of Aeronautics and Astronautics, 2000).
[356] Richard Langton Gregory, *Eye and Brain: The Psychology of Seeing* (McGraw-Hill, 1978).
[357] Richard Langton Gregory.

copyrighted material

Fig. 84 Bridget Riley, Current

This interaction between the artwork and the audience's perceptual apparatus can produce metaperceptual experiences. Art critic Paul Moorhouse writes 'Riley's early paintings radically reversed the traditional relationship between the work of art and the viewer. The conventional assumption is that a painting is an essentially passive thing: an inert, unchanging image over which the viewer's gaze roams freely. Her work shattered this expectation.'[358] This activation of the audience is a key element in metaperceptual works, as they require the experience of the audience for their materials to be fully materialised. Writing on a similar work by Riley, Moorhouse continues: 'Looking at *Blaze 1* (1962), for example, involves being drawn, instantly, into a dynamic relationship with a work of art. In that relationship, the painting does not exist simply as an arrangement of shapes which undergo disinterested inspection. Instead, the process of looking 'activates' the painting. Its formal structure is catalysed and destabilized by the viewer's gaze. As the mind struggles to interpret the sensory information with which it is presented, it veers from one visual hypothesis to another, vainly trying to fix the image. This state of flux generates vivid perceptual experiences of movement and light.'[359]

[358] Paul Moorhouse, *Bridget Riley*, 1st edition (London : New York: Tate, 2003).
[359] Moorhouse.

The perceptual artefacts created by *Current* may be caused by a range of physiological features of the perceptual system. Psychologist Nicolas Wade's analysis of *Current* posits that 'several visual effects seem to be involved when these paintings are viewed, which probably account for their particular success.'[360] He argues that the motion effects encountered in *Current* are most likely caused by asymmetry of the eye that varies with accommodation. When the eye focuses on an object, it goes through the process of accommodation where the ciliary muscles change the shape of the lens within the eye to adjust its optical power and its focusing distance. Helmholtz's perceptual studies show evidence of small irregular fluctuations of lens curvature during changes in accommodation which may cause the distortions of space when viewing *Current*.[361] As the audience looks over the work, the ambiguity of depth causes their eyes to rapidly accommodate, creating fluctuations of lens curvature and distortions in space.

While *Current,* and many of her artworks from the 1960s, only use black and white, another perceptual artefact can cause colours to seemingly appear. When looking at *Current,* hints of yellow, blue, purple and red may start to appear in the white spaces between lines. The cause of these subjective colours is still contentious, as it appears that a range of factors including orientation of lines, shape of lines, and negative space between lines, all effect the appearance of colour. Wade argues that subjective colours are caused by regular astigmatism, which is a refractive error in which the eye does not focus light evenly on the retina. This theory is informed by an experiment by Gordon Stanley and William C. Hoffman[362] in which observers viewed an image of concentric squares with vertical and horizontal sides, shown in Fig. 85. Most subjects reported that the vertical white spaces appeared a desaturated reddish-pink with the horizontal spaces looking pale green. This perceptual artefact is closely related to the McCollough effect.[363] The study indicates that the orientation of the lines and their directions have different effects on the subjective colour perceived. Accordingly, Wade argues that there is 'unequal refraction of light in different meridians which results from irregularities in the curvature of the optical surfaces of the eye.'[364]

While the audience may not know the exact causes of these effects, the phenomenological impact of the work is immediate, as they experience the strange distortions and malfunctioning of their perception. In the aural realm, there are similar cases in which the extraordinariness of an

---

360 Nicholas J. Wade.
361 Hermann Von Helmholtz, *Handbuch Der Physiologischen Optik* (Voss, 1867), IX.
362 Gordon Stanley and William C. Hoffman, 'Orientation-Specific Color Effects without Adaptation', *Bulletin of the Psychonomic Society*, 7.6 (1976), 513–14.
363 Celeste McCollough, 'Color Adaptation of Edge-Detectors in the Human Visual System', *Science*, 149.3688 (1965), 1115–1116.
364 Nicholas J. Wade.

experience is evident, even if the cause of the peculiarity is not. For example, otoacoustic emissions, which are further discussed Section 10.2, create the perception that sounds are emanating from within the skull. While the audience may not understand what is happening in their perception, the extraordinariness of the experience is what makes the artwork metaperceptual, as the audience's attention is turned towards the strange things happening in their senses.

copyrighted material

Fig. 85 The image presented to participants of Stanley and Hoffman's trial

10.1.3 Hermann Grid

Another perceptual artefact that Nicolas Wade identifies as being explored in the Op Art movement is the Hermann grid. The effect was first discovered serendipitously by Ludimar Hermann while reading a book.[365] A figure in the book consisted of a five by eight grid of dark squares, and while Hermann looked at it, dark grey dots appeared at all the intersections other than the one he fixated

[365] Nicholas J. Wade.

on. He attributed these illusory dots to simultaneous contrast, and since then, this illusion has been explained by a range of different theories. The exact cause is still the subject of debate.[366]

Fig. 86 Victor Vasarely, Supernovae

---

[366] G. Baumgartner, 'Indirekte Grössenbestimmung Der Rezeptiven Felder Der Retina Beim Menschen Mittels Der Hermannschen Gittertäuschung', *Pflügers Archiv European Journal of Physiology*, 272.1 (1960), 21–22; Peter H. Schiller and Christina E. Carvey, 'The Hermann Grid Illusion Revisited', *Perception*, 34.11 (2005), 1375–97.

These illusory smudges can be seen in *Supernovae* (1959-61) by Victor Vasarely, shown in Fig. 86. The work is composed of a network of 1,161 small black squares set inside a thin white vertical grid. Embedded in the grid of black squares are a range of different shapes which form intrusions in to the uniformity of the grid. The illusory dots of the Hermann grid are evident when looking at the work, as they appear at the intersections of the squares. As with the movement illusions in Bridget Riley's *Current*, the perceptual oddity occurs in the fringe of the visual field, causing the eye to move around the painting to investigate the veracity of the black smudges. As the audience's eyes move to focus on a smudge, it disappears, with the neighbouring intersections now appearing to have black circles. This creates a dynamic interaction with the work, causing the audience to realise that the dots are an artefact of their own perception, rather than being present in the painting. The intrusion of the other shapes also reveals details of the illusion, as the intensity of the dots is altered by the shape of the intersection. The rows of circles that occupy the lower half of the work increase in size from left to right, changing the shape of the white space between themselves and the surrounding squares. This change in shape and space effects the intensity of the illusory dots, as they are weak where the smallest circle creates a large white space. As the circles increase in size, so do the illusory dots, with the largest circles eventually negating the Hermann grid effect. Similar modulations in intensity of the illusory dots occur where other shapes intrude on the uniformity of the grid.

The Hermann grid illusion is not the only perceptual oddity explored in the work, as art curator Judith Wilkinson writes: '*Supernovae* is designed to appear to visually alter as the viewer moves in front of it. The work plays optical tricks such as seeming to surge or retreat in areas, flip orientation and change in chromatic density depending on the spectator's angle of vision. Motion, the artist explained in 1971, is not implied by depicting the object as moving. Rather, it is "the aggressiveness with which the structures strike the retina."[367] This is idiomatic of many of the Op Art practitioners, as they combine a range of visual artefacts to create works that move, pulse, and interact with the perceptual apparatus.

10.1.4 Motion Aftereffect

The last physiological visual illusion discussed in this section is the motion aftereffect, which shares many characteristics with the other physiological artefacts. The illusion is experienced after extended exposure to motion in the visual field, and results in the illusory motion of static objects in the opposite direction. This effect can often occur in natural environments, as Robert Addams observed in 1834 while looking at the Falls of Foyers waterfall. Addams stared at the waterfall for

[367] Judith Wilkinson, '"Supernovae", Victor Vasarely, 1959-61', *Tate*, 2016.

an extended period of time, and when he shifted his gaze to the surrounding rocks they appeared to move upwards. He reported: 'Having steadfastly looked for a few seconds at a particular part of the cascade, admiring the confluence and decussation of the currents forming the liquid drapery of waters, and then suddenly directed my eyes to the left, to observe the vertical face of the sombre age-worn rocks immediately contiguous to the waterfall, I saw the rocky face as if in motion upwards, and with an apparent velocity equal to that of the descending water'.[368]

The exact cause of this illusion is still the subject of research, as Stuart Anstisa, Frans Verstraten, and George Mather write: 'Even more than 2000 years after Aristotle's report of the MAE (motion aftereffects) it is difficult to make firm statements on the actual nature of this illusion.'[369] They argue for the illusion originating in the visual cortex, and arising from selective adaptation in cells tuned to respond to movement direction. In the case of the Addams looking at the waterfall, the cells in the eye go through the process of adaptation, with the cells responding to the movement of the water. This process causes them to suffer a reduction in responsiveness, so that during competitive interactions between detector outputs, false motion signals arise. The result is the appearance of motion in the opposite direction when one later gazes at the rocks effects provide a form of error-correction or coding optimization, or both.[370]

Motion aftereffects may be experienced in a range of works that involve repetition of movement. Olafur Eliasson recreates the environment of the first noted observation of the effect in his *Waterfall* (2016) series, in which he constructs artificial waterfalls through large scaffolding structures and water pumps. Iterations include in a gallery in Denmark, in urban spaces in the United Kingdom, Canada, and four in the East River in New York, and recently in the Gardens of Versailles, shown in Fig. 87. While the work may create motion aftereffects due to their constant movement, Eliasson is also responding to other cultural and semantic elements that constructing large waterfalls in urban spaces creates. In an interview at the 4th European Conference for Science Journalist, he explains: 'I was reacting very much to the scale of the city. In a city like New York, I have some difficulty feeling my body, placing myself physically. Is that building nearby or is it far away? This is a similar experience to one I had hiking in the Simien Mountains of Ethiopia. I had some trouble judging scale in these mountains because they were new to me. I remember sitting on a cliff with my legs hanging over the edge. There was a waterfall down below, and from

368 Stuart Anstis, Frans A. J Verstraten, and George Mather, 'The Motion Aftereffect', *Trends in Cognitive Sciences*, 2.3 (1998), 111–17.
369 Anstis, Verstraten, and Mather.
370 Anstis, Verstraten, and Mather.

the motion of the water I was suddenly aware of the height of the cliff, aware of my body in the landscape. So for me the waterfalls are a way of putting a sense of scale back into Manhattan.'[371]

Fig. 87 Olafur Eliasson, Waterfall, 2016. Crane tower, water, stainless steel, pump system, hoses, ballast. Installation view: Palace of Versailles, 2016. Photo: Anders Sune Berg. © 2016 Olafur Eliasson

The effect is not only produced by linear motion, but also circular. Gregory writes 'It may be induced most easily by looking steadily, for about half a minute, at the central pivot of a rotating record player. If the turntable is then stopped suddenly it will seem, for several seconds, to be rotating backwards.'[372] The effect can be experienced in the early kinetic works of Duchamp including *Rotative Demisphère, optique de precision* (Rotary Demisphere) (1925), shown in Fig. 88, and Duchamp's sole film, *Anémic Cinéma* (1926). Both *Rotary Demisphere* and *Anémic Cinéma* use rotating disks with spirals drawn on them. The spirals seem to pulse in and out as they rotate, their ambiguous depth creating perceptual confusion and their repetitive rotation causing trance-like effects. The rotational movement can cause motion afterimages after an adaptation period, creating the sensation of the warping of space once the observer averts their gaze from the spinning disks. These works share aesthetic themes with the Op Art movement, with its bold contrast of black and white lines and focus on the perception of their audiences.

---

[371] Anthony King, 'Interview: Olafur Eliasson', *ECSJ2017*, 2017.
[372] Richard Langton Gregory.

Fig. 88 Marcel Duchamp, Rotative Demisphère, optique de précision

Although not strictly a motion aftereffect, one of the most striking explorations of the perception of motion can be found in Vortex tunnels, often installed at haunted attractions, amusement parks, and illusion museums. The National Science and Technology Centre in Canberra, Australia hosts the 'Rototron', shown in Fig. 89. The *Rototron* is a vortex tunnel that uses LEDs installed on the walls to create the illusion that the whole tunnel is slowly spinning. Visitors are invited to walk through the tunnel, and experience the effects that the spinning motion and static walkway has on their perception. As their visual sense adapts to the illusory motion of their tunnel, the balance of the visitor is heavily impaired. Due to our sense of balance synthesising information from the vestibular system and the visual sense to regulate balance, the illusory motion of the tunnel causes a conflict in information. This is an example of perceptual hacking that causes a miscommunication between sense organs. The vestibular system responds to the static ground below, indicating that there is no movement, while the visual sense is informing the visitor that they are in motion. The result is that many visitors find walking in a straight line difficult, as they sway along the pathway, with some visitors having to close their eyes in order to stay upright.

Fig. 89 The Rototron, The National Science and Technology Centre in Canberra, Australia

The rich range of physiological visual artefacts provoke metaperceptual experiences in various ways. In comparison to the physical artefacts, physiological artefacts are caused in the sense organs themselves, which inherently draws the attention of the observer back on themselves to a higher degree than extraordinary external stimuli. As the artefact is caused in the sense organs, the audience often has a degree of autonomy over the appearance of the artefact, as they can look away and interact with the artefact. The chasing of the illusory movement in Bridget Riley's works is emblematic of this interaction, as the audience have the revelation that their perception is the cause of the perceptual oddity.

The potential for creating metaperceptual experiences through visual physiological artefacts is paralleled in the aural domain, which I discuss in the following section. The visual artworks discussed in this section can offer paradigms for creating new metaperceptual sound works. While the artefacts are different between each sense, the modes of interaction and the features of the artwork that allow for metaperceptual experiences transcend this change of modality. I examine and discuss aural physiological artefacts in the following section.

10.2 Aural Physiological Artefacts

'it is said that the human ear is a non-linear device —it receives physical vibrations at the eardrum, but it does not faithfully transduce them into electrical pulses to send on to the brain ... it distorts them en route.'[373]

—Daphne Oram

The previously discussed Zwicker tone is an example of an aural physiological artefact caused by the behaviour of the neural pathways leading from the ear. The experience of the Zwicker tone can be subtle, as many people who experience the tone may not be cognizant of the odd cause of the tone. As metaperceptual experiences are caused when their audience has the attention drawn back onto themselves, the production of the Zwicker tone alone does not necessarily cause metaperceptual experiences. In the following section, I explore aural physiological artefacts that have metaperceptual applications, and catalogue the ways in which they have been used in artworks.

10.2.1 Distortion products

Combination tones and Otoacoustic emissions (OAE) are both perceptual artefacts caused by two real tones interacting with the perceptual apparatus to create a third, illusory tone. The use of these terms and the distinction between them in musical literature, is often vague. In instrumental music, there is a long discourse on combination tones, also known as Tartini tones. In 1714 Giuseppe Tartini, the celebrated Italian violinist and musical composer, discovered that when two notes are simultaneously sounded on the violin with sufficient intensity, they give rise to a third note distinct from both.[374] Tartini would often use this to help correct faulty intonations of double-stops on the violin.[375] By making the third illusory tone consonant with the two real tones, he was guided in finding the intonation of the open strings. Contrastingly, discussion of otoacoustic emissions primarily occur in the medical field, as OAEs provide a simple, efficient and non-invasive objective indicator of healthy cochlear function. Accordingly, OAE screening is widely used in universal new-born hearing screening programmes.[376]

---

[373] Daphne Oram, *An Individual Note: Of Music, Sound and Electronics* (Galliard Ltd, 1972).
[374] John Augustine Zahm, *Sound and Music* (University of Michigan Library, 1892).
[375] Arthur Taber Jones, 'The Discovery of Difference Tones', *American Journal of Physics*, 3.2 (1935), 49–51.
[376] David T. Kemp, 'Otoacoustic Emissions, Their Origin in Cochlear Function, and Use', *British Medical Bulletin*, 63.1 (2002), 223–41.

While the terms are often used in different contexts, the artefacts have a common origin. Music theorist Gary Kendell writes that 'Combination tones are exactly the same as otoacoustic emissions, or, more specifically, distortion product otoacoustic emissions.'[377] His paper 'Sound Synthesis with Auditory Distortion Products' adopts the term 'distortion products' rather than otoacoustic emissions or combination tones for the sake of clarity. While there are slight differences between the combination tones and otoacoustic emissions (which I discuss in the following section), they can both be defined as distortion products.

Distortion products are sounds generated from within the inner ear. They occur as a by-product of the interaction between the basilar membrane and a unique cochlear mechanism known as the 'cochlear amplifier'.[378] Where OAEs differ from combination tones is that they are created when the tympanum receives vibrations transmitted backwards through the middle ear from the cochlea, reversing the normal flow of energy from outside to in, causing the ear to produce sound. These sounds can be detected by recording technology, which allows them to be useful tools in the medical domain to test healthy cochlear functioning. The nuances of the ways in which these metaperceptual pieces explore distortion products require an in-depth examination of the phenomenon, detailed in the following paragraphs.

As discussed in Section 2.2, the basilar membrane is a stiff structural element inside the cochlea partition, shown in Fig. 90. The membrane is deformed by sound when vibration is transferred through the stapes and plays an important role in our perception of pitch. The 'cochlear amplifier' is an effect produced by the outer hair cells which contributes greatly to the sensitivity and discrimination of hearing.[379] The amplification effects of the cochlea are necessary as even healthy ears have a degree of conductive loss when the mechanical pressure waves of sound transition from the low acoustic impedance of air to the high mechanical impedance of the fluid-filled cochlea. The outer hair cells allow for an amplification and sharpening of the deformation wave caused by sound in the basilar membrane. When vibration of the basilar membrane causes the cilia of the outer hair cells to bend in one direction, this causes the entire outer hair cell to elongate, which pushes on the basilar membrane. Bending in the other direction causes the hair cells to contract, which pulls on the basilar membrane. This pushing and pulling increases the motion of the basilar membrane and sharpens its response to specific frequencies.[380]

---

[377] Gary S. Kendall, Christopher Haworth, and Rodrigo F. Cádiz, 'Sound Synthesis with Auditory Distortion Products', *Computer Music Journal*, 38.4 (2014), 5–23.
[378] Kemp.
[379] Kemp.
[380] Bruce E. Goldstein.

Fig. 90 A partially uncoiled cochlea

Distortion products are created by the amplification effects of the outer hair cells. This can cause new tones to be perceived that are not in the stimulus, and in special conditions, OAEs are created when the basilar membrane transfers energy back onto the oval window, making the stapes vibrate. As the bones in the middle ear are vibrated, a feedback loop in the perceptual system is caused, transforming the sensory organ into a producer of sound. Stimuli of slightly differing frequency or spectral composition can give rise to quite different distortion products. There are two main factors that impinge on the quality and loudness of these distortion products. Firstly, the amplifying effects of the outer hair cells are not purely uniform, which causes irregular distortions and interactions in the basilar membrane. Secondly, certain relationships between tones produce stronger distortions to the travelling wave in the basilar membrane. There are known relationships between pure tones which create distortion products. Kendall et al. writes that two types are particularly useful to music and sound synthesis due to the ease with which listeners can hear and recognize them: 'the quadratic difference tone ($f_2 - f_1$), which obeys a square-law distortion and the cubic difference tone ($2f_1 - f_2$), which obeys cubic-law distortion.'[381]

Distortion products are well-suited for creating metaperceptual experiences, as the experience of them differs from normal sounds created outside of the perceptual system. Kendall et al. write 'In order for auditory distortion products to be musically meaningful, the listener must be able to distinguish them from acoustic sounds; otherwise, why not simply use ordinary acoustic

[381] Kendall, Haworth, and Cádiz.

signals?'[382] This distinction is precisely particularly salient to creating metaperceptual experiences, as this difference is what facilitates the audience's attention being drawn back to their own perception. In addition, distortion products are notably ear-catching because of their unusual localisation effects, as they appear much closer than the loudspeakers that generate them, and in some case seem to emanate from inside the head. Kendall et al. explain that 'Distortion product tones are produced within each of the two ears. For localization purposes, it is as if the signals bypass the outer and middle ears and arrive directly in the left and right basilar membranes… By themselves, distortion product tones lack externalization: Their imagery is within or just outside of the head. Far left and far right images are characteristically at the sides of the head.'[383]

As distortion products are borne out of the relationship between two pure tones, their exploration is well-suited to electronic musicians who use technology to carefully control these relationships. British Radiophonic Workshop composer Daphne Oram devotes two chapters of her 1972 book *An Individual Note: Of Music, Sound and Electronics*[384] to the consideration of sum and difference tones. Her writing was influential to later electronic musicians including Maryanne Amacher, whose seminal work *Head Rhythm/Plaything* from her album Sound Characters (Making the Third Ear) (1999)[385] is one of the most notable explorations of distortion products. The work is a flurry of pure-tone arpeggios that create distortion products that move around the head in disorientating patterns. Music critic Mark Richardson responds to the work by writing: 'A swarm of high-pitched beeps—what sounded like sine waves in the 2khz range—created an effect where sound seemed to be starting inside of the head, shooting from of my ears like a fountain of auditory sparks.'[386] The localisation of these sounds produces an interesting contrast between the 'outer' sounds, and 'inner' sounds, forming a complex spatial counterpoint between real tones and generated tones. The extraordinariness of the distortion products creates a powerful metaperceptual experience, as the audience are provoked to question whether this internal tone is generated by them, and if not, how it seemingly emanates from their body.

Amacher explicitly explores the metaperceptual theme of the audience's body as a producer and co-creator of the work. She writes in the liner notes of *Sound Characters*, 'the tones in this music will cause your ears to act as neurophonic instruments that emit sounds that will seem to be issuing directly from your head ... [my audiences] discover they are producing a tonal dimension of the

[382] Kendall, Haworth, and Cádiz.
[383] Kendall, Haworth, and Cádiz.
[384] Oram.
[385] Maryanne Amacher, *Sound Characters*, Composer Series – TZ 7043 (US: Tzadik, 1999), TZ 7043.
[386] Mark Richardson, 'Maryanne Amacher and Stepping Into It', *Pitchfork*, 2009.

music which interacts melodically, rhythmically, and spatially with the tones in the room. Tones "dance" in the immediate space of their body, around them like a sonic wrap, cascade inside ears, and out to space in front of their eyes ... Do not be alarmed! Your ears are not behaving strange or being damaged! ... These virtual tones are a natural and very real physical aspect of auditory perception, similar to the fusing of two images resulting in a third three dimensional image in binocular perception ... I want to release this music which is produced by the listener.'[387] My first experience of *Head Rhythm/Plaything* was heavily influential in the formative stages of producing the metaperceptual framework. My perception was stimulated in radically different ways than other electroacoustic works I had experienced, and this led me to meditate on how some works seem to transcend perception and offer self-reflective experiences.

Distortion products have been used in a range of different contexts since Amacher's pioneering work. There appears to be a recent surge in interest in these phenomena, as a range of technological tools and writings have given composers access to a high degree of control over the perceptual artefact. Kendall et al's paper 'Sound Synthesis with Auditory Distortion Products' provides 'synthesis methods to render these tones more easily audible and lend them the dynamic properties of traditional acoustic sound, thus making auditory distortion a practical domain for sound synthesis.'[388] Preceding Kendall et al's 2014 paper, researcher and composer Alex Chechile developed *The Ear Tone Toolbox*[389], a collection of Max externals, VST plugins, and patches for the hardware OWL synthesiser that offer creative control over distortion products. The toolbox allows the user to input various combinations of evoked distortion products and acoustic primary tones, which are then synthesised in the software. Both Kendall et al's and Chechile's research are exemplars of the perceptual hacking approach. Through a thorough understanding of the physiology of the ear and the by-products that can be caused by the perceptual apparatus, they have developed artistic practices that explore these perceptual artefacts as experiential materials. By developing tools that afford precise control over the perceptual artefacts, they have the potential for fostering a range of new metaperceptual works.

Alex Chechile has used *The Ear Tone Toolbox* in a series of works entitled *On the Sensations of Tone* (2010),[390] the title an homage to Helmholtz's formative book of the same name.[391] The works mix electronic and acoustic sources, using distortion products to invite the listener into an

---

[387] Maryanne Amacher, TZ 7043.
[388] Kendall, Haworth, and Cádiz.
[389] Alex Chechile, 'The Ear Tone Toolbox for Auditory Distortion Product Synthesis', 2016.
[390] Alex Chechile, 'On The Sensations of Tone VIII', *Projects*, 2010.
[391] Hermann von Helmholtz, 'On the Sensations of Tone as a Physiological Basis for the Theory of Music, Trans', *London*, 168 (1885).

exploration of their listening space. Through slight head movement, distortion products will appear, disappear, and change timbre. Chechile discusses concepts of *macroscopic* and *microscopic* listening, which can be achieved by shifting attention between the primary tones and the ear tones.[392] These concepts show the distinctiveness of the otoacoustic emissions, as they can easily be differentiated from the pure tones created by the speakers. The ability of the audience to be cognisant of this difference is essential for metaperceptual experience, as the audience's attention is drawn to the extraordinary perceptual by-product. The blend and intensity of the effects can also be changed and enhanced by cupping hands around one's ears, creating a degree of interaction with the phenomenon.[393]

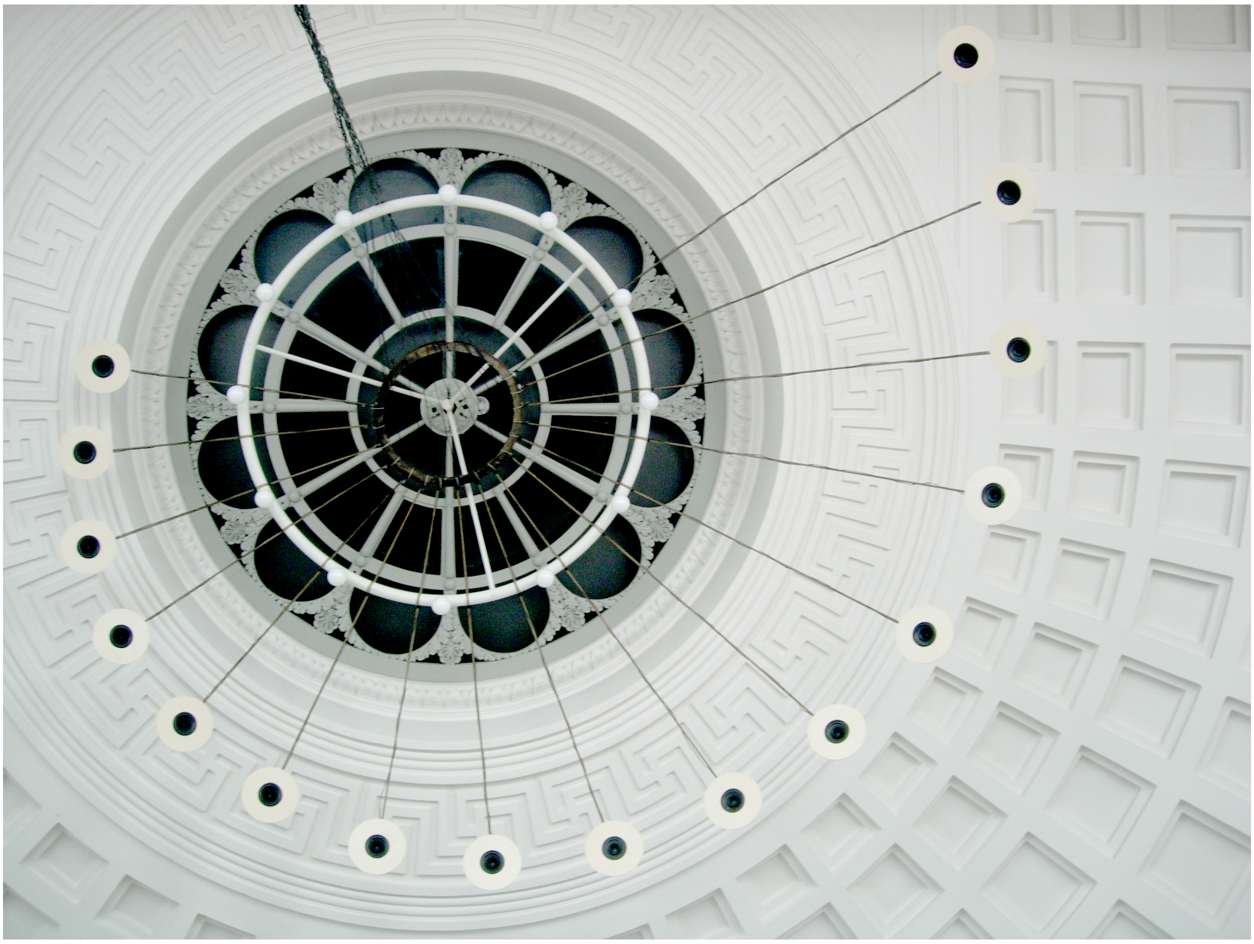


Fig. 91 Jacob Kirkegaard, Labyrinthitis. Image provided courtesy of the artist.

In an installation context, Jacob Kirkegaard has explored distortion products in his work *Labyrinthitis* (2008), shown in Fig. 91. Kirkegaard employed an interesting compositional process, in which he recorded his own OAE and then used these recordings in the work. Two tones were initially played, creating an OAE in Kirkegaard's ear which was recorded. The OAE tone is then played back through the speakers with another new tone, creating a new OAE. This continues on

[392] Alex Chechile, 'Creating Spatial Depth Using Distortion Product Optoacoustic Emissions in Music Composition' (Georgia Institute of Technology, 2015).
[393] Chechile, 'Creating Spatial Depth Using Distortion Product Optoacoustic Emissions in Music Composition'.

throughout the work, creating a cascading series of pure tones and distortion products in the listener's ears. Douglas Kahn writes in the liner notes of the CD release for the work that this cascading relationship 'in effect, creates a situation where the audience hears him hearing and hear themselves hearing.' The parallels between this and the title of this research project, *Listening to Yourself Listen,* are apparent. Kahn continues that 'in this way alone, Kirkegaard has countered Duchamp's dictum, "One can look at seeing, one can't hear hearing."'[394] This is a core principle of the metaperceptual approach: the revelation and experience of the act of perceiving itself.

Labyrinthitis has been presented as both a multi-channel performance and as a sound installation. In the gallery context, Kirkegaard connects the aural elements of the work with the visual and physical elements of the space. The array of loudspeakers is installed on metal rods of varying lengths to create a three-dimensional ascending spiral hanging from a domed ceiling. This mirrors the anatomy of the spiral-shaped cochlea, reinforcing the exploration of the cochlea as the central artistic theme.

Labyrinthitis's exploration of metaperceptual themes is integrated on visual, sonic, experiential, and conceptual levels. The visual elements reinforce the focus on the perceptual apparatus not only as a receiver of sound, but also as a producer of sound. Otoacoustic emissions in particular problematise the normal conception of the ear as a passive sense. Kirkegaard writes 'the human hearing organ—still often perceived as a passive unidirectional medium—does not only receive sounds from the outside, it also generates its own sound from within itself.'[395] The composition and presentation of the work is idiomatic of approaching the perceptual apparatus as an active creator rather than a passive receiver. The use of recordings from Kirkegaard's own OAEs links the conceptual and sonic materials, as these physiological artefacts are subsequently produced in the ears of the audience. As with Maryanne Amacher's *Head Rhythm/Plaything*, the extraordinariness of experiencing distortion products creates metaperceptual experiences, as the perceptual apparatus is stimulated in unique, and for most audiences, radically new ways.

The surge of interest in using distortion products for musical purposes can also be evidenced in the instrumental realm. A rare discussion of combination tones in the nineteenth century comes from Murray Campbell and Clive Greated's analysis of the final section in Jean Sibelius's *Symphony No. 1* (1899). Two flutes enter partially through the final section, playing a series of thirds in their high register. Purity of the flute's timbre and the close intervals create cubic

[394] Douglas Kahn, 'Active Hearing: Jacob Kirkegaard Labyrinthitis', *Labyrinthitis*, 2008.
[395] Jacob Kirkegaard, 'Labyrinthitis', 2008.

distortion products, creating a third illusory tone.[396] Whether or not Sibelius intentionally sought this perceptual artefact is not discussed. A recent doctoral thesis by Ben Hjertmann in 2013 entitled *Combination Tones as Harmonic Material*[397] provides 'methods of deriving harmony, and in some cases melody, from combination tones.'[398]

In an explicit exploration of the perceptual apparatus, Samuel Holloway creates metaperceptual experiences through distortion products in his work *Malleus* (2005). The name refers to one of the three bones in the middle ear that make up the ossicles. Although the malleus does not play a major role in the creation or production of distortion products, the name is evidence for a focus on the perceptual apparatus as a site for artistic exploration. Furthermore, *Malleus* is the second piece in a series of three trios collectively entitled *Middle Ear*.

Malleus is for three clarinets, with one clarinet in standard tuning, and the other two between one half and three quarters of a semitone sharper and lower respectively. Each play the same line which is corrupted through the slight differences in tuning, notated tempo changes, and slight changes in articulation and ornamentation. At different points in the work, these slight differences create strong clashes between the clarinets, as their high register and loud dynamic create powerful distortion products in the ears of the audience. Music reviewer Carolyn Drake responded to the work by writing 'As the trio's languid trajectory continued towards a high-register forte, the nauseating ringing in the ears brought the piece to an almost unbearable apex, yet it was a deft and ingenious execution of the piece's goal.'[399] While Holloway's work is a less precise exploration of distortion products than some of the electroacoustic works which use technology, the perceptual effects of the distortion products are both apparent and attention grabbing.

Distortion products offer a rich range of perceptual effects to be explored in different forms of presentations. The creation of new technology provides composers and artists easier access to the precise control of their creation, fostering the potential for new metaperceptual works. The creation of these technologies also indicates a current interest in the artistic exploration of the phenomenon, as the development of these environments are by and for artists.

[396] Murray Campbell, *The Musician's Guide to Acoustics / Murray Campbell and Clive Greated.* (London: Dent, 1987).
[397] Ben Hjertmann, 'Combination Tones as Harmonic Material' (unpublished Doctor of Music, Northwestern University, 2013).
[398] Hjertmann.
[399] Carolyn Drake, 'Review: Hear|say: Round and Round', *The Listener*, 2015.

Physiological artefacts are well-suited to creating metaperceptual experiences, as they produce extraordinary phenomena that is not contingent on the audience having an understanding of the normal behaviour of light and sound. As physiological artefacts are caused in the sense organs, this inherently draws the attention of the audience back on to themselves. While there are fewer aural physiological artefacts than visual, distortion products can be manifested in various ways, allowing for a rich range of artistic exploration. These distortion products are also strongly related to some of the cognitive artefacts caused by the interaction of two pure tones and the perceptual apparatus. These artefacts, as well as a range of other cognitive artefacts, are discussed in the following chapter.

Chapter Eleven

Perceptual Hacking: Cognitive Artefacts

Whereas physical artefacts occur in the behaviour of stimuli in the outside world, and physiological artefacts occur as by-products of the sensory organs, cognitive artefacts occur higher up the perceptual processing chain in the brain. Gregory writes of cognitive illusions that they 'are the most subtle, and the most controversial for they are difficult to investigate systematically… One has to show that it is due to (mis)use of assumptions or knowledge, or to rule-following leading perception astray.'[400] He continues with a sort of hacking analogy, 'It may be useful to think of operating rules as introduced 'side-ways' (like floppy discs) and producing illusions when their rules (or algorithms) are inappropriate for the task in hand. This concept of inappropriateness is subtle because it can cause errors though there is no malfunctioning of the physiology.'[401]

This rule-following nature of the sensory system has long been exploited by artists, as can be seen in the tradition of *trompe-l'œil,* and more recently *trompe-l'oreille,* discussed in Chapter Two. To exploit the rule-following nature of the sensory system in an artistic context requires a deep understanding of perceptual processes and a strong artistic craft. In this chapter, I categorise and discuss aural cognitive artefacts and their metaperceptual applications.

11.1 Visual Cognitive Artefacts

Richard Gregory's classification of visual illusions includes a large range of cognitive artefacts. The sheer variety of illusions may make this class the most apt for metaperceptual artistic exploration, as many of the artefacts have the ability to draw the observer's attention to the role of their perception as an active mediator. While a full discussion of all the cognitive illusions and their causes is outside the scope of this research, in the following sections I discuss those illusions that are best suited to creating metaperceptual artworks. In the visual domain, these sections are modelled on Gregory's types: ambiguities, distortions, paradoxes, and fictions. In the aural domain, I provide three types for categorising aural cognitive artefacts: Grouping Mechanisms, Paradoxes, and Phantom Sounds.

[400] Richard L Gregory.
[401] Richard L Gregory.

11.1.1 Ambiguities

Gregory includes the Necker Cube, Joseph Jastrow's Rabbit-Duck illusion, and Edgar Rubin's Vase as examples of ambiguous images that induce the phenomenon of *multistable perception:* an image that can provide multiple, albeit stable, perceptions. The perception of these images can spontaneously 'flip', creating a complex interplay between perception and understanding. This is the case in the Necker Cube, which is a simple wire-frame drawing of a cube with no visual cues as to its orientation. This lack of depth information causes our perception of it to flip between having either the lower-left or the upper-right square as its front side.[402] The Rabbit-Duck illusion, shown in Fig. 92, is a black-and-white cartoon which alternates between being perceived as a rabbit or a duck.[403] Lastly, Edgar Rubin's vase is an image that can be perceived as a single vase, or as two faces looking inwards at each other.

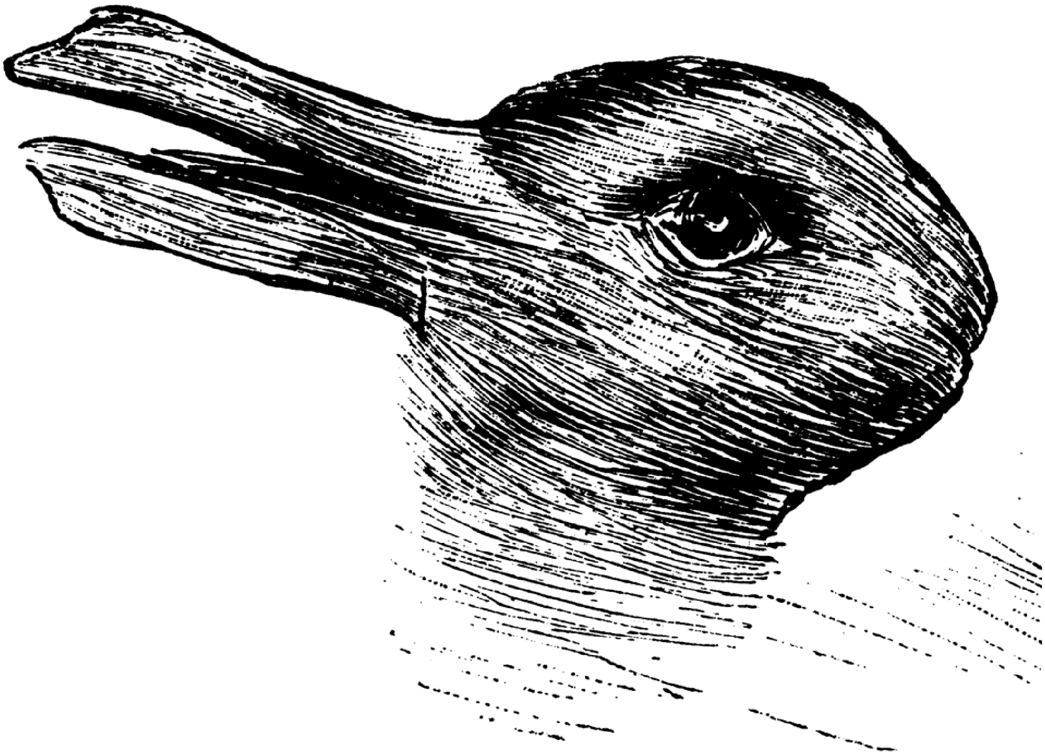


Fig. 92 Joseph Jastrow's Rabbit-Duck illusion.

Ambiguous images have 'played a significant historical part in theories of visual perception and are still widely used today.'[404] It has been argued that their ability to support more than one interpretation provides insights into the sensory, cognitive, and physiological processes that

---

[402] L. A. Necker, 'Observations on Some Remarkable Phenomenon Which Occurs in Viewing a Figure of a Crystal or Geometrical Solid', *London and Edinburgh Philosophical Magazine and Journal of Science*, 3 (1832), 329–337.
[403] Joseph Jastrow, 'The Mind's Eye.', *Popular Science Monthly*, 1899.
[404] 'Vi. Conception and Perception of Ambiguous Figures', *Monographs of the Society for Research in Child Development*, 76.1 (2011), 87–104.

underlie visual perception. The interaction between the observer and image is quite unique, in that the alternation between states is spontaneous, and not dependent of the perspectival position of the observer. These perceptual reversals can be voluntarily triggered, once the observer has become cognisant of multiple interpretations and are greatly affected by mood, attention, and practice.[405] The static nature of the image makes it clear that the change in perspective is solely due to the interpretation of the observer, rather than the stimulus changing itself. The makes the illusion well-suited to creating metaperceptual experiences, as the ambiguity in the image leaves no ambiguity in the cause of the illusion.

copyrighted material

Fig. 93 Salvador Dalí, Slave Market with the Disappearing Bust of Voltaire

Multistable perceptions can be found in a range of visual artworks, in particular in many surrealist paintings. Salvador Dalí's works often blur the distinction between real and imagined, with many employing illusions to challenge the viewer's perception. Susana Martinez-Conde et al.'s article 'Marvels of illusions: illusion and perception in the art of Salvador Dalí'[406] catalogues fourteen of Dalí's artworks that create ambiguous images in different methods and media. *Slave Market with the Disappearing Bust of Voltaire* (1940), shown in Fig. 93, is one example of Dalí's approach, in which the heads of two nuns within a busy scene also constitute the eyes of the bust of Voltaire.

---

405 David A. Leopold and Nikos K. Logothetis, 'Multistable Phenomena: Changing Views in Perception', *Trends in Cognitive Sciences*, 3.7 (1999), 254–64.
406 Susana Martinez-Conde and others, 'Marvels of Illusion: Illusion and Perception in the Art of Salvador Dali', *Frontiers in Human Neuroscience*, 9 (2015).

Slave Market with the Disappearing Bust of Voltaire creates metaperceptual experiences by drawing the viewer's attention to the dynamic mediation that their perception plays in interpreting the work. For most viewers, the slave market scene dominates the initial perception of the work, but once Voltaire's bust is discerned, the observer can flip between the two interpretations, by attending to different details in the work. Lizann Bonnar's study of this work indicates that previous exposure to information that is specific to each percept can cause one interpretation to be seen first.[407] This reveals the information-laden nature of our perception, as well as the perceptual apparatus as a dynamic mediator of stimuli. Dalí himself also frames the audience's attention through the title of the work, making the duplicitous nature of the work explicit.

Dalí's extensive exploration of ambiguous images demonstrates their potential for future metaperceptual works, as there is a rich variety of different methods in creating the cognitive illusion. Gregory's second type of cognitive illusions—distortions—also have the potential to be explored in metaperceptual works. I discuss these distortion illusions in the following section.

11.1.2 Distortions

Gregory includes a large range of cognitive distortion illusions that are mostly due to the misinterpretation of size, shape, or length. He posits that 'these illusions may occur when normally correctly operating perceptual systems are not appropriate to the current situation.'[408] The Ponzo illusion highlights this rule-following behaviour in a non-appropriate situation. The illusion, shown in Fig. 94, consists of two identical horizontal lines that that are enclosed by two converging vertical lines.[409] Gregory gives an alternate name of the 'railway lines illusion', as the two converging vertical lines resembles train-tracks receding away from the viewer. The illusion causes a distortion of the length of the two horizontal lines, as the top horizontal line appears to be longer than the horizontal line below it.

---

[407] Lizann Bonnar, Frédéric Gosselin, and Philippe G. Schyns, 'Understanding Dali's Slave Market with the Disappearing Bust of Voltaire: A Case Study in the Scale Information Driving Perception', *Perception*, 31.6 (2002), 683–91.
[408] Richard L Gregory.
[409] Mario Ponzo, *Intorno Ad Alcune Illusioni Nel Campo Delle Sensazioni Tattili, Sull'illusione Di Aristotele e Fenomeni Analoghi* (Wilhelm Engelmann, 1910).

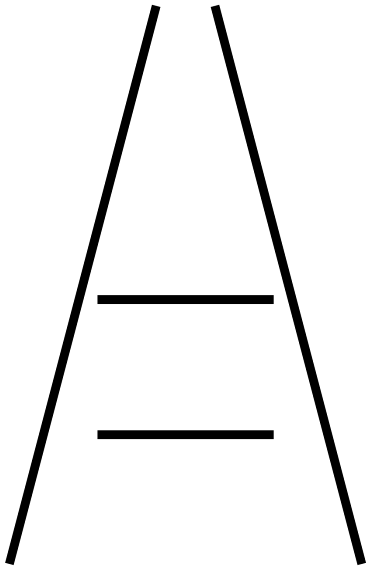


Fig. 94 Ponzo Illusion. Image: 'Ponzo Illusion' by Timjarrett, licenced under CC BY 3.0

Gregory argues that the distortion caused by the Ponzo illusion, as well as in many other illusions of this type, are caused by an inappropriate application of 'Size Constancy.' He explains that 'this is the tendency for the perceptual system to compensate for changes in the retinal image with changes of viewing distance.'[410] As the converging lines produce the illusion of depth, even though they are on a flat surface, this combines with the rule of size constancy to distort our perception of the length of the lines.

For the observer to have a metaperceptual experience while viewing these illusions, their attention needs to be brought to the distortion that their perceptual processes are causing. The distortion in the Ponzo illusion only becomes clear once either the converging lines are removed, or the two lines are measured in some way. Therefore, metaperceptual artworks that use these cognitive artefacts need to afford an interaction between the audience and the stimuli to allow for the distortion effect to become apparent.

Gianni Sarcone creates this interaction by animating the illusory figures in his series of *Dynamic Müller-Lyer Illusions*. The Müller-Lyer's illusion[411] is similar to the Ponzo illusion, in that lines appear longer or shorter depending on contextual factors. The illusion, shown in Fig. 95, consists of lines with arrowheads at each end, with the direction of the arrowheads effecting the perception of the length of the centre line. Those lines that have arrowheads pointing outwards are often perceived as shorter than lines with arrowheads pointing inwards.

---

[410] Richard Langton Gregory.
[411] Franz Carl Müller-Lyer, 'Optische Urteilstäuschungen', *Archiv Für Anatomie Und Physiologie, Physiologische Abteilung*, 2.9 (1889), 263–270.

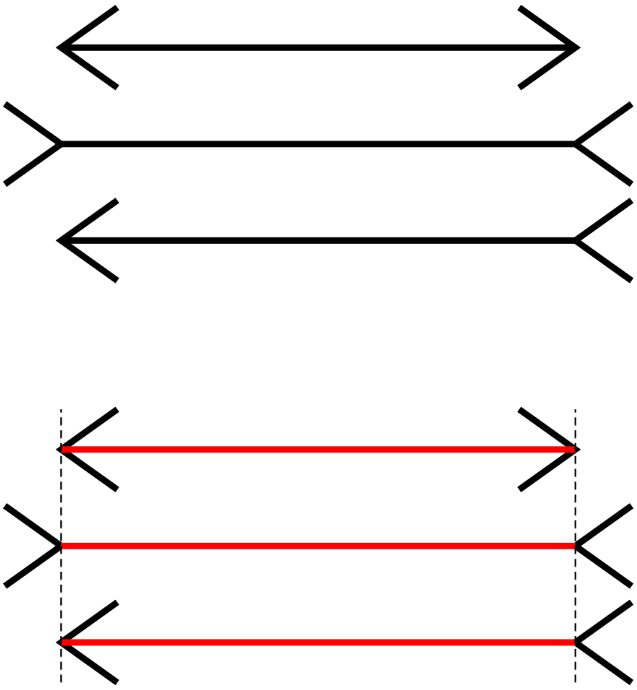


Fig. 95 Müller-Lyer illusion. Top: three different combinations of arrowhead directions. Bottom: annotated version showing that the middle line is the same length in all versions. Image: 'Müller-Lyer illusion' by Fibonacci, licenced under CC BY 2.5

Sarcone animates the arrowheads in a series of works, causing the distortion effects to oscillate and change over time. In *Müller-Lyer Pulsating Star* (2018), shown in Fig. 96, a series of these figures are arranged in a circular form, spanning out from a central point. Each segment includes three sets of arrowheads, that slowly oscillate in direction. This causes the distortion effect to become dynamic, as the viewer's perception warps over time in different sections of the line. The effect is further heightened through colour, as the contrast between black and blue centre lines draws attention to this comparison.

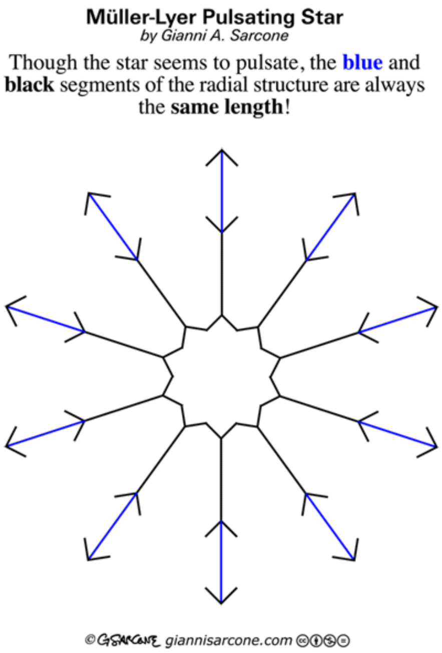


Fig. 96 A still image from Gianni Sarcone's Müller-Lyer Pulsating Star. Image provided courtesy of the artist.

While Sarcone's addition of animation to the illusion is simple, it radically changes the interaction between the viewer and the image. The connection between the arrowhead's direction and the distortion effect that it causes is revealed. This interaction allows for a metaperceptual experience, as the observer becomes aware that their perception is causing the distortion effects, and is actively mediating their experience of the artwork.

Distortion illusions are created when the viewer's perceptual system follows normally correct rules that are not appropriate to the situation. Gregory's third type of cognitive illusions are paradoxes, which seemingly break the rules of normal behaviour. These illusions are discussed in the following section.

11.1.3 Paradoxes

The paradoxes type is the only category in which Gregory includes artworks as examples of illusions, identifying M.C. Escher's paintings as using cognitive paradoxes, as well as the Penrose Triangle. Many of Escher's paintings, as well as the Penrose triangle, use what have been described as impossible objects. These illusions are usually two-dimensional drawings that depict a three-dimensional structure which defies the rules of geometry and physics. Kōkichi Sugihara defines these impossible objects as 'a mental image of a "solid object" which a picture evokes in the viewer's mind but which cannot exist in a real three-dimensional world.'[412]

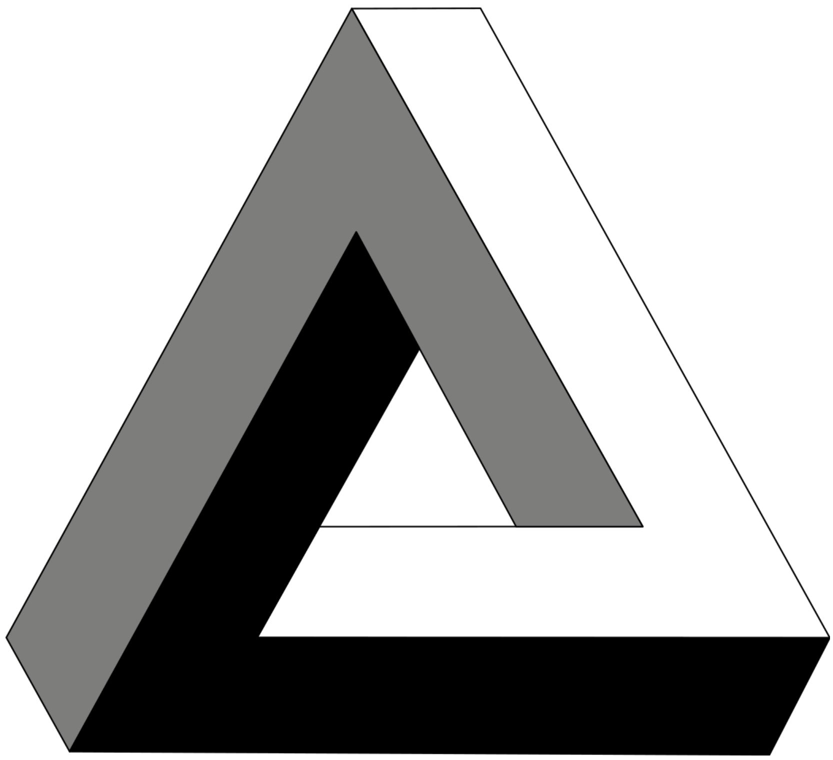


Fig. 97 Penrose Triangle

[412] Kōkichi Sugihara, 'Classification of Impossible Objects', *Perception*, 11.1 (1982), 65–74.

The Penrose Triangle, shown above in Fig. 97, was first popularised in a 1958 paper entitled 'Impossible Objects: A Special Type of Visual Illusion'[413] by Lionel Penrose and his mathematician son Roger Penrose. The triangle appears to be a solid object, made of three straight beams of square cross-section that meet pairwise, at right angles, at the vertices of the triangle they form. While each vertex of the triangle is possible in isolation, the combining of all three makes an impossible object. In describing the experience of looking at the triangle, Penrose and Penrose write that 'each individual part is acceptable as a representation of an object normally situated in three-dimensional space; and yet, owing to false connexions of the parts, acceptance of the whole figure on this basis leads to the illusory effect of an impossible structure.'[414] This interaction with the artwork allows for metaperceptual experiences. The tension between the coherent details and the impossible whole figure are controlled by the viewer, as they shift their attention to different elements of the work. Furthermore, it reveals the rule-following nature of object recognition. As the figure appears similar to many other normal three-dimensional objects, our initial perception may be that there are no extraordinary characteristics of the figure. It is only once we examine the details that the illusion is broken, as the impossibility of the shape becomes apparent.

While the impossible object was popularised by Penrose and Penrose, it was first created by the Swedish artist Oscar Reutersvärd in 1934.[415] Roger Penrose's creation of the Penrose Triangle was heavily influenced by his encounter with M. C. Escher's artwork *Relativity* (1953) in 1954 at the International Congress of Mathematicians.[416] The work features a labyrinth of staircases, with three prominent staircases in a triangular arrangement similar to the Penrose Triangle. Several people are depicted as simultaneously climbing or descending these staircases in an impossible manner, defying the law of gravity.

M. C. Escher's work was heavily influenced by mathematics, and after Roger Penrose's encounter with *Relativity*, the artist and mathematician started a dialogue together with their work influencing each other. Roger's father developed the Penrose Staircase which gives the illusion of an endless staircase: 'Each part of the structure is acceptable as representing a flight of steps but the connexions are such that the picture, as a whole, is inconsistent; the steps continually descend in a clockwise direction.'[417] An aural counterpart to this impossible motion is discussed in Section

---

[413] L. S. Penrose and R. Penrose, 'Impossible Objects: A Special Type of Visual Illusion', *British Journal of Psychology*, 49.1 (1958), 31–33.
[414] Penrose and Penrose.
[415] Al Seckel, *Masters of Deception: Escher, Dalí & the Artists of Optical Illusion* (Sterling Publishing Company, Inc., 2004).
[416] Doris Schattschneider, 'The Mathematical Side of MC Escher', *Notices of the AMS*, 57.6 (2010), 706–718.
[417] Penrose and Penrose.

11.2.2. Penrose shared these sketches with Escher, who in turn used them in creating perpetual motion in his print *Waterfall* (1961), shown in Fig. 98, and the never-ending march of monks in *Ascending and Descending* (1960).

Fig. 98 M. C. Escher, Waterfall

While most impossible objects have been created as two-dimensional drawings, they can also be formed in three-dimensional space. The public artwork, *Impossible Triangle* (2011)*,* in Perth, Australia, by Brian McKay and Ahmad Abas is a three-dimensional Penrose Triangle. When viewed from a certain perspective, the work creates the impossible object through a trick of depth perspective. Although the three bars do not join, from a certain perspective they appear as if they do. Through the creation of a three-dimensional Penrose Triangle, the interaction between observer and artwork is conducive for creating metaperceptual experiences. This parallels the interaction between observer and artwork in many trompe-l'œil works and in sound works such as Carsten

Nicolai's *invertone*, as the observer can move around the structure and investigate how their perception is being deceived by breaking down the illusion.

Fig. 99 Brian McKay and Ahmad Abas, Impossible Triangle. Left: viewed from side showing construction of the illusory figure. Right: viewed from intended perspective, creating the impossible object. Image: 'Impossible Triangle' by Bjørn Christian Tørrissen, licenced under CC BY 3.0

The cognitive paradoxes have aural analogues, such as Shepard tones and Risset rhythms, which appear to have impossible behaviours. These impossible sounds are discussed further in the Aural Cognitive Artefacts section. While paradox illusions create impossible objects, the last type that Gregory identifies, 'fictions', reveals the human perceptual system filling in information that is not present.

11.1.4 Fictions

Gregory identifies Kanizsa's Triangle, shown in Fig. 100, and the filling-in of the blind spot in the eye as fiction illusions. While he does not provide an exhaustive definition of the fiction involved in these illusions, they both involve the perceptual system filling in information that is not present in the stimulus. In the case of the blind spot, this occurs as the visual system compensates for one of its deficiencies. The physiological blind spot, also known as scotoma, is caused by a lack of photoreceptors where the optic nerve and blood vessels leave the eye.[418] Normally, this blind spot does not affect our vision, as 'the same area for one eye's blind spot in space is covered by the normal intact retina in the fellow eye. For this reason, humans have a complete representation of the whole visual field when both eyes are open.'[419] When one eye is blocked, we usually do not notice a blind spot in vision. Rather we perceive the brightness, colour, and texture of the adjacent area as if they were actually there. This filling-in of information appears to be due to cognitive processing of the stimuli, although 'mechanisms underlying this kind of perceptual filling-in remain controversial.'[420]

[418] Richard Gregory and Patrick Cavanagh, 'The Blind Spot', *Scholarpedia*, 6.10 (2011), 9618.
[419] Sheng He and Wendy L. Davis, 'Filling-in at the Natural Blind Spot Contributes to Binocular Rivalry', *Vision Research*, 41.7 (2001), 835–40.
[420] Lothar Spillmann and others, 'Perceptual Filling-in from the Edge of the Blind Spot', *Vision Research*, 46.25 (2006), 4252–57.

To my knowledge, there are no artworks that have explored the perceptual filling-in of the blind spot in a metaperceptual context. As the filling-in mechanism usually goes unnoticed, this could lead to an interesting revelation of an underlying perceptual oddity. However, to explore this cognitive perceptual compensation, the artist would have to devise an interaction between audience and artwork that would direct their attention towards this process. As the conditions for experiencing the blind spot are restricted and specific, this may be difficult to achieve without explicit instruction of the audience in a manner that would be more akin to a psychophysical research trial.

The filling-in of information can also be clearly evidenced in a different manner when looking at Kanizsa's Triangle. The image shows that certain combinations of incomplete figures give rise to clearly visible contours even when the contours do not actually exist. The triangle, shown in Fig. 100, consists of three circles with small triangular areas missing, and three line segments. The negative space between these figures forms a triangle, implying that a solid white triangle sits on top of the drawn figures, obscuring the rest of the shapes. The 'subjective triangle' in the centre of the figure appears to be whiter than the background white when viewing the figure as a whole. This contrast disappears however when the observer fixates on the missing contours. Kanizsa explains that 'if you fix your gaze on one of these contours, it disappears, yet if you direct your gaze to the entire figure, the contours appear to be real.'[421] Accordingly, he concludes that 'it appears that such contours are supplied by the visual system.'[422]

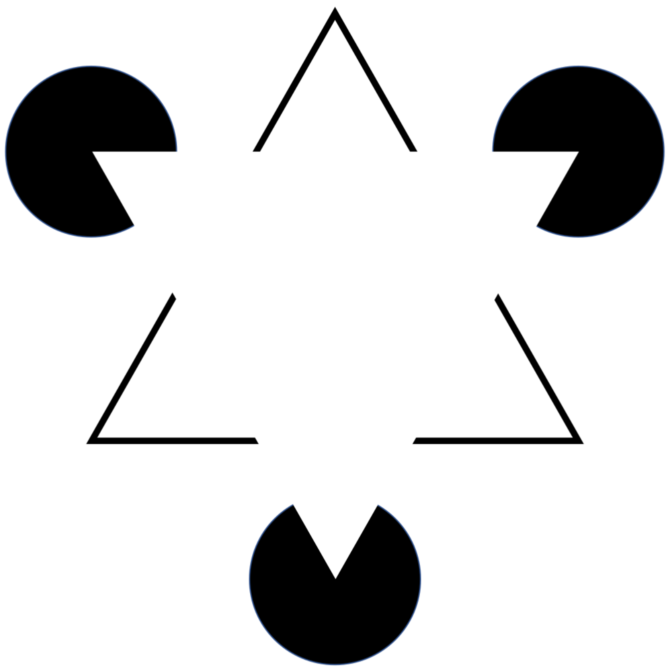


Fig. 100 Kanizsa Triangle. Image: Kanizsa triangle' by Fibonacci, licenced under CC BY-SA 3.0

[421] Gaetano Kanizsa, 'Subjective Contours', *Scientific American*, 234.4 (1976), 48–53.
[422] Kanizsa.

Several decades before Kanizsa developed this clear demonstration of the perceptual system creating subjective contours, Cole Phillips was exploring this perceptual artefact in his graphic design.[423] In a series of covers for *Vogue, Life,* and *Better Housekeeping,* Phillips created so-called ‘fadeaway girls’ in which he coloured the dresses of the models the same as their background. Accordingly, there is no difference in luminance, colour contrast, or texture between the dresses and the background that could give rise to an explicit contour in the image. Regardless, we still perceive the shape of the dress, as our perceptual system fills in the subjective contours.

Fig. 101 Cole Phillip’s cover for a 1908 Life magazine cover

[423] P. U. Tse, ‘Modal and Amodal Completion in the Artwork of Coles Phillips.’, *Perception*, 46.9 (2017), 1011.

Phillips's cover for Life magazine's May of 1908, shown in Fig. 101, manages to produce this illusion through simple patterns and white space. A woman stands in the foreground appearing to wear a white dress with polka dots as she feeds chickens. The white dress and bodies of the chickens offer no distinction from the background, yet despite this, we still perceive the outlines of the dress and chickens. The dress in particular is an elegant example of the illusion, as by only using a series of black dots with slight variations of warping, a vivid outline of the dress is created.

Phillip's 'fadeaway' girls are effective explorations of the filling-in mechanism in the visual system in an artistic context. The work may produce metaperceptual experiences for some, but as it is a subtle effect that often goes unnoticed, many viewers will not experience such effects. Whereas Kanizsa's Triangle is a focused demonstration of the effect, Phillip's 'fadeaway' girls use this illusion as part of the visual language of the works. The framing of the viewer's experience towards this illusory effect is in the minimalist materials, as the white space dominates the composition. A viewer's attention while experiencing the work may be drawn to a range of different elements including its semantic meaning, its composition, or its illusory nature.

Another illusion, face pareidolia, is a common illusory perception caused by the visual system's predisposition to find faces in accidental or vague visual information. Individuals often report seeing a face in the clouds, Jesus in toast, or the Virgin Mary in a tortilla.[424] Face pareidolia suggests that our visual system is highly tuned to perceive faces, likely due to the social importance of faces and our exquisite ability to process them. [425] This tuning of our visual system can be misused by artists to create ambiguous experiences that make the audience question the reality of their perception.

This predisposition can be seen in the previously discussed (Section 11.1.1) multistable image by Salvador Dalí, *Slave Market with the Disappearing Bust of Voltaire*. Dalí also explores face pareidolia in *Paranoiac Visage*, shown in Fig. 102. The work depicts a group of people and a domed stone hut with trees and bush in the background. The organisation of the people, hut and background however, vaguely resemble a face. Dalí's mastery of illusion allows for both interpretations to be stable, as the viewer can oscillate between seeing a landscape or an illusory face.

---

[424] Jiangang Liu and others, 'Seeing Jesus in Toast: Neural and Behavioral Correlates of Face Pareidolia', *Cortex*, 53 (2014), 60–77.
[425] Liu and others.

Fig. 102 Salvador Dalí, Paranoiac Visage

Paranoiac Visage can provoke metaperceptual experiences in a similar way to *Slave Market with the Disappearing Bust of Voltaire*. The ambiguity between the two perspectives draws the viewer's attention to the dynamic mediation that their perception plays in interpreting the work. The convincingness of the illusory face reveals how our perception is fine-tuned to finding faces in accidental or vague visual information.

Richard Gregory's classification of visual illusions is indicative of the biases in the field, in that it is predominantly visual-centric. His work has been highly influential to this research however, as I have used his classification of visual illusions as the basis of my taxonomy of the wider sphere of metaperceptual visual perceptual artefacts. Diana Deutsch's research is a rare example of a thorough investigation into auditory illusions, and has been highly influential in aiding the establishment of the field of cognitive psychology of music. The following Aural Cognitive Artefacts section uses Deutsch's research as a starting point, upon which I expand. Her exploration of cognitive aural illusions is analysed through a metaperceptual lens.

11.2 Aural Cognitive Artefacts

The diversity of visual cognitive artefacts is also found in the aural domain. The auditory system has several mechanisms that process stimuli, allowing us to locate where sounds are coming from, follow streams of musical and vocal sound, and make sense of the sonic barrage that we encounter daily. As with many cognitive processes, under certain conditions unexpected and interesting artefacts are produced, drawing attention to the normally subconscious way they constantly mediate our perception of the world. In order to further clarify these aural cognitive artefacts, I have categorised them into three main groups: Grouping Mechanisms, Paradoxes, and Phantom Sounds. In the following section, I outline these illusions and discuss their metaperceptual implications.

In dozens of articles, her pioneering book *The Psychology of Music*,[426] and two CD releases *Musical Illusions & Paradoxes*[427] and *Phantom Words and Other Curiosities*,[428] Diana Deutsch has researched, presented and explained a range of cognitive auditory illusions. Through the discovery of a series of illusions, Deutsch has provided key insights into cognitive grouping mechanisms, in which the auditory system orders stimuli by certain features in the sound.

11.2.1 Grouping Mechanisms

The Octave Illusion[429] demonstrates one of these grouping mechanisms. The illusion is produced when two tones spaced an octave apart are alternated repeatedly at a moderate rate. The sequence is played over headphones to both ears of the listener, with each ear receiving the inverse pattern from the other. This means that the 'listener is presented with a single, continuous two-tone chord, with the ear of input for each component switching repeatedly.'[430] This pattern is shown below in Fig. 103.

---

[426] Diana Deutsch, 'The Psychology of Music', in *Perceptual Ecology* (Elsevier, 1978), pp. 191–224.
[427] Diana Deutsch, *Musical Illusions & Paradoxes* (Philomel, 1995).
[428] Diana Deutsch, *Phantom Words and Other Curiosities* (Philomel Records, 2003).
[429] Diana Deutsch, 'An Auditory Illusion', *The Journal of the Acoustical Society of America*, 55.S1 (1974), S18–19.
[430] Diana Deutsch, 'Diana Deutsch - Octave Illusion', 2013.

copyrighted material

Fig. 103 Above: the pattern that produces Deutsch's Octave Illusion. Below: the most common perception of the pattern when played through stereo headphones

Deutsch's findings show that 'despite its simplicity, this pattern is almost never heard correctly, and instead produces a number of illusions.'[431] The most common perception is that a single tone switches from ear to ear, while its pitch simultaneously shifts back and forth between high and low. This creates the perception shown in Fig. 103, where one ear receives the pattern of high tone, silence, high tone, silence. At the same time, the other ear hears the pattern of silence, low tone, silence, low tone. Furthermore, what makes this unbalanced perception even more strange is that when the earphone positions are reversed, many people hear no change. Deutsch explains that 'this produces the bizarre impression that reversing headphone positions causes the high tone to migrate from one earphone to the other, and causes the low tone to migrate in the opposite direction!'[432] The orientation of these two tones also have another surprising property, in that dominance of one ear seems to be linked to the handedness of the listener.[433]

Deutsch argues that the cause of this cognitive illusion is due to the interaction of two cognitive processes: 'one determines *what* pitch we hear, and the other determines *where* the tone appears to be coming from.'[434] The *what* process is dependent on the dominant ear, causing listeners to hear an alternating pattern between high and low tones that are presented to the dominant ear. The *where* process is not dependent on a dominant ear but instead which ear is presented with a higher pitch. Deutsch states that the interaction of these two processes 'results in an illusory conjunction

[431] Deutsch, 'Diana Deutsch - Octave Illusion'.
[432] Deutsch, 'Diana Deutsch - Octave Illusion'.
[433] Diana Deutsch, 'The Octave Illusion in Relation to Handedness and Familial Handedness Background', *Neuropsychologia*, 21.3 (1983), 289–293.
[434] Diana Deutsch, 'Musical Illusions', *Scientific American*, 233.4 (1975), 92–105.

of pitch and location, so that the entire sequence is perceived as a high tone to the right, alternating with a low tone to the left.'[435] This also explains why the illusion does not flip when the headphones are inverted, as it is the idiosyncrasies of the cognitive processes, rather than slight differences in the stimulus.

The process of experiencing the 'Octave Illusion' can produce metaperceptual experiences, as when the listener inverts their earphones, the oddity of their perception not changing with the change in stimulus provokes them to question what is causing the illusion. As they have control over the orientation of the headphones, the only plausible answer is themselves, and their own perception. While this may create a metaperceptual experience, the possibilities for presenting this experience in an art context are limited. The effect is a subtle one, and requires the listener to deconstruct the illusion. Exploring the Octave Illusion and other similar cognitive aural artefacts may involve a careful framing of the audience's experience to draw their attention to their own perception. This may include visual and physical elements, which help to indicate the difference between the stimulus and the perception. This framing of experience is a key part of my own work, *Destructive Passages One & Two*, that explores interference patterns and binaural beating. The work presents the simple stimulus of two pure tones by physically actuating tuning forks, making the causation of the tones clearly evident. This austere presentation of the stimulus frames the audience's attention to be drawn back on to themselves, as it reduces the ambiguity in the cause of the artefact. *Destructive Passages One & Two* is further discussed in Part III.

The Octave Illusion is one of a range of stereo pitch illusions that reveal cognitive grouping mechanisms. Related illusions include the Scale Illusion and Chromatic Illusion, which are both produced when a scale is played simultaneously in both ascending and descending forms while alternating between the ears. The Scale Illusion, shown in Fig. 104, uses the major scale, with one pattern starting at middle C and ascending stepwise for an octave while alternating between the ears.[436] Another pattern interlocks with this scale, starting an octave higher than middle C, and descending stepwise while alternating between the ears. The most common perception of the pattern is that the ascending and descending patterns stay in separate ears, forming continuous scales despite the alternating jumps between the ears. The scales also switch in the middle, making two symmetrical contours of half scales, as can be seen in the bottom of Fig. 104. The Chromatic

[435] Deutsch, 'Diana Deutsch - Octave Illusion'.
[436] Diana Deutsch, 'An Illusion with Musical Scales', *The Journal of the Acoustical Society of America*, 56.S1 (1974), S25–S25; Diana Deutsch, 'Two-Channel Listening to Musical Scales', *The Journal of the Acoustical Society of America*, 57.5 (1975), 1156–1160.

Illusion is very similar, with two chromatic scales that span two octaves creating a similar continuous perception.[437]

copyrighted material

Fig. 104 Diana Deutsch's Scale Illusion. Top: the stimulus that is presented to each ear. Middle: another representation of this stimulus that shows the continuous scales. Bottom: the most common perception of the stimulus

The cause of both the Scale Illusion and the Chromatic Illusion have similarities to the Octave Illusion, in that they are also a case of perceptual rule-following leading to false perceptions. Deutsch argues that 'in everyday life, sounds that are similar in pitch are likely to be coming from the same source, and sounds that are different are likely to be coming from different sources. So the most likely interpretation of this sound pattern is that one source is producing the higher tones and another source is producing the lower tones. The brain therefore reorganizes the tones in accordance with the most plausible interpretation, even though it is incorrect.'[438]

Both of these illusions have similar metaperceptual implications to the octave illusion. As they are both subtle and for the listener to become cognisant of the auditory artefact, some experiential framing is needed. Without this experiential framing, the result would be similar to the aforementioned Doppler effect. The listener may believe that there is no discrepancy between stimulus and their perception, causing no redirection of their attention back on to themselves, which is essential for creating metaperceptual experiences.

---

[437] Diana Deutsch, 'Illusions for Stereo Headphones', *Audio Magazine*, 71.3 (1987), 36–48.
[438] Deutsch, 'Musical Illusions'.

11.2.2 Paradoxes

While the grouping mechanisms category of cognitive artefacts need to be framed for the audience to have metaperceptual experiences, the paradoxes category bring attention to themselves due to their seemingly impossible behaviour. Aural paradoxes are similar to visual paradoxes, in that they seem to demonstrate behaviours or properties that break the rules of normality.

11.2.2.1 Shepard Tone

The circularity of the Penrose Staircase, shown in Fig. 105, can be produced in the aural domain by Shepard tones. These tones were first created by Roger Shepard in 1964, and were made possible by a new computer program, MUSIC IV, that Max Mathews developed for synthesising musical sounds.[439] The development of this program allowed Shepard to generate a set of complex tones that created strange aural paradoxes. Shepard repeatedly played a sequence of tones which stepped up one octave in total. Instead of hearing the pattern stop and start again, listeners heard the pattern ascend endlessly in pitch. When Shepard reversed the direction, the subjects heard the pattern descend endlessly.[440]

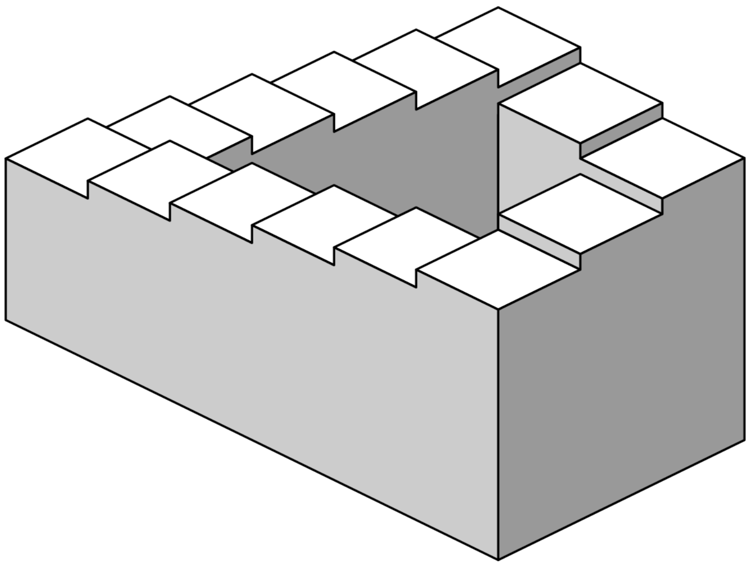


Fig. 105 Penrose Staircase

The strange behaviour of Shepard tones problematises the conception of pitch as a linear scale, and can create metaperceptual experiences by provoking the listener to question their perception. Pitch is generally viewed as extending along a scale from low to high, and while this is usually the case, there is a circular component to our conceptualisation of pitch (in the term ‘pitch class’) that

[439] M. V. Mathews, ‘The Digital Computer as a Musical Instrument’, *Science*, 142.3592 (1963), 553–57.
[440] Diana Deutsch, ‘Paradoxes of Musical Pitch’, *Scientific American*, 267.2 (1992), 88–95.

the Shepard tone exploits. Most musical scales use octave equivalence to determine a set of discrete pitch classes that repeat at the octave. In the perceptual field, the perception of lowness or highness of a sound is referred to as its *pitch height*, while its belonging to a pitch class is referred to as its *pitch chroma*.[441] To accommodate both the linear and circular dimensions, Deutsch has suggested that pitch should be represented as a helix, shown in Fig. 106, having one complete turn per octave as shown below.[442]

Fig. 106 A diagram of the pitch helix

Shepard tones are well-defined in pitch chroma but ambiguous in pitch height. Their ambiguous pitch height effectively collapses the pitch helix into a circle, enabling the creation of scales that ascend or descend endlessly in pitch. The synthesis method is relatively simple: each tone consists of many sinusoidal components locked at successive octaves and sounding simultaneously.[443] The amplitude of these tones is controlled to keep a constant focus on the middle of spectrum by using a stationary Gaussian envelope, shown in Fig. 107. As the Shepard tones sweep up in frequency, the well-defined pitch classes give the perception of upward movement. However, the spectral envelope's shaping means that at the end of a complete octave cycle, the sound is spectrally identical as at the beginning, making the pitch height ambiguous. Expanding upon the discrete Shepard tones, Jean-Claude Risset developed a variant of the illusion for continuous gliding tones.[444] Aptly named the 'Shepard–Risset glissando', this variant allows for an perceptually eternal rising or falling glissando.

---

[441] J. D. Warren and others, 'Separating Pitch Chroma and Pitch Height in the Human Brain', *Proceedings of the National Academy of Sciences of the United States of America*, 100.17 (2003), 10038–42.
[442] Deutsch, 'Paradoxes of Musical Pitch'.
[443] Roger N. Shepard, 'Circularity in Judgments of Relative Pitch', *The Journal of the Acoustical Society of America*, 36.12 (1964), 2346–53.
[444] Jean-Claude Risset, 'Pitch Control and Pitch Paradoxes Demonstrated with Computer-Synthesized Sounds', *The Journal of the Acoustical Society of America*, 46.1A (1969), 88–88.

Fig. 107 Spectral envelope of a Shepard tone with ten simultaneously sounded sinusoidal components spaced an octave apart. The dotted lines show the next tone in an upward rising Shepard scale

These paradoxical sounds have featured in a large range of musical and artistic contexts, and are a rich source for creating metaperceptual experiences. While Roger Shepard's production of the illusory tones was afforded by the newly invented computer synthesis of the 1960s, music historian Ira Braus argues that the similar technique of pitch circularity has been employed by instrumental composers since as early as 1550.[445] He notes circular pitch figures in English keyboard music circa 1550, and analyses a range of instrumental works that explore the idea to different effects, including Johann Sebastian Bach's *Prelude and Fugue in E minor* (1722), Franz Liszt's *Hunnenschlacht* (1857), and Béla Bartók's *String Quartet No. 5* (1934). While these instrumental explorations are similar in intent, their ability to create the paradoxical perceptual effect of endless motion varies, as ambiguity of pitch height depends on precise shaping of the spectrum, which is limited with traditional instruments. The use of synthesis techniques allows for fine-grained control over the spectral characteristics of sound, meaning synthesised Shepard tones and glissandi are generally more convincing auditory illusions.

The Shepard-Risset glissando has been widely used in a range of musical contexts. In popular music, it features in Pink Floyd's "Echoes",[446] Godspeed You! Black Emperor's "Slow Moving Trains",[447] and The Beatles's "A day in the life."[448] The endless upwards movement that the

---

[445] Ira Braus, 'Retracing One's Steps: An Overview of Pitch Circularity and Shepard Tones in European Music, 1550–1990', *Music Perception: An Interdisciplinary Journal*, 12.3 (1995), 323–51.
[446] Pink Floyd, *Meddle* (Los Angeles, USA: Capitol, 1971).
[447] Godspeed You! Black Emperor, *F# A# Infinity* (Montreal, Quebec: Constellation, 1997).
[448] The Beatles, *Sgt Peppers Lonely Hearts Club Band* (UK: Parlophone, 1967).

Shepard-Risset glissando creates makes it well-suited to creating tension especially in film soundtracks. Film composer Hans Zimmer and director Christopher Nolan's usage of the Shepard-Risset glissando garnered mainstream media attention, raising public awareness of the auditory illusion. In *Dunkirk*,[449] the eternal upward motion supports the increasing tension throughout the movie of the three intertwined storylines, with Zimmer basing the entire soundtrack around the illusion.[450] In *Inception*,[451] the illusion supports the themes of surrealism and questioning of reality that lies at the heart of the film. In a more pragmatic usage, The Batpod in *The Dark Knight Rises*,[452] uses a Shepard tone for its engine noise to sound as if it were continuously increasing in speed.[453] In these films, the illusion forms a facet of the audiovisual experience, and their paradoxical behaviour may go unnoticed by the audience. Despite this, the illusions may still have an affective influence on the audience's experience, which I discuss in following sections.

In electroacoustic music, Jean-Claude Risset himself employed the Shepard–Risset glissando in a range of works including *Computer Suite from Little Boy* and *Mutations* (1968). The work is based on Pierre Halet's play that stages the fall of the atomic bomb, codenamed 'Little Boy', on Hiroshima. Risset endeavours to convey the feeling of the pilot who identified himself with 'Little Boy'. Since the fall is in fact only in the mind of the pilot, it never reaches the bottom, creating an endless descent.[454] In another section of the work, Risset 'generated inverted pitch helices—sounds that go up the scale while getting lower.'[455] He likened the effect of these pitch helices to the impossible flow of water in M. C. Escher's *Waterfall*, shown in Fig. 98.

Shepard tones and Shepard–Risset glissandi grab the attention of the listener through their impossible qualities, making them well-suited for creating metaperceptual experiences. Their paradoxical behaviour can elicit a range of responses, which Risset discussed reflecting on his early aesthetic explorations. He writes 'even though the slowing down and the descent are cyclic, their combined effect can be quite depressing for the listeners, to the extent that I renounced using it as the basis of a musical composition inspired by the poem by Henri Michaux, *La ralentie*'[456] Furthermore, he continues, 'a number of them (the listeners) mentioned that pitch glides,

[449] Christopher Nolan, *Dunkirk* (Warner Bros, 2017).
[450] Jason Guerrasio, 'Christopher Nolan Explains the Biggest Challenges in Making His Latest Movie "Dunkirk" into an "Intimate Epic"', *Business Insider Australia*, 2017.
[451] Christopher Nolan, *Inception* (Warner Home Video, 2010).
[452] Christopher Nolan, *The Dark Knight Rises* (Warner Home Video, 2012).
[453] Blair Jackson, 'Batman Rides Again: The Dark Knight | Mixonline', 2008.
[454] Jean-Claude Risset, 'Computer Music Experiments 1964 - ...', *Computer Music Journal*, 9.1 (1985), 11–18.
[455] Jean-Claude Risset, 'Computer Music Experiments 1964 - ...'
[456] Jean-Claude Risset, 'Rhythmic Paradoxes and Illusions: A Musical Illustration.', in *ICMC* (presented at the International Computer Music Conference, Thessaloniki, Greece, 1997).

downward and upward, made them anxious - in several cases, they mentioned the association with sirens which they heard in anxiogenic circumstances (war bombings or ambulances in accident)'[457] Risset's observations are corroborated by recent psychology studies which found that after listening to *Computer Suite for Little Boy,* negative emotions were strongly evoked. The study also found that the 'Shepard-Risset glissando illusion, both within the aesthetic context of a musical composition and on its own, was capable of evoking disruption of equilibrium, frequently leading to the associated feeling of falling.'[458] While this may not be the most pleasant emotional and perceptual response, it shows the power the illusion has for drawing attention. This makes it well-suited for creating metaperceptual experiences, as the listener's attention is drawn to the paradoxical sound, and the way that their perceptual system is seemingly malfunctioning. Shepard-Risset glissandi feature in my own work *rise.risset* which is further discussed in Part III. This work also explores paradoxical rhythmic phenomena known as Risset rhythms, which I discuss in the following section.

11.2.2.2 Risset Rhythms

The paradoxical pitch behaviour of Shepard tones can also be created in the time domain by using Risset rhythms. Instead of endless upwards or downwards movement in pitch, these rhythms are perceived as perpetually accelerating or decelerating. Risset credits Kenneth Knowlton as first generating the effect in 1970,[459] which he then explored extensively in musical works. The method to create the rhythmic illusion is very similar to its pitch counterpart. The superimposed sinusoidal waves are replaced by multiple versions of the same rhythmic figure. Instead of being spaced in octaves, these rhythmic figures are spaced at different tempo divisions and multiples. This creates a stack of rhythmic figures with a centre layer, and outer versions at quarter speed, half speed, double speed, and quadruple speed. The entire phrase increases in tempo, with the amplitude of each tempo layer controlled to keep the centre of the stack loudest. This creates an eternally repeating pattern, as the amplitude of each layer is controlled to make the end of the phrase identical to the beginning (Fig. 108).

---

[457] Jean-Claude Risset, 'Rhythmic Paradoxes and Illusions'.
[458] Eveline Vernooij and others, 'Listening to the Shepard-Risset Glissando: The Relationship between Emotional Response, Disruption of Equilibrium, and Personality', *Frontiers in Psychology*, 7 (2016).
[459] Jean-Claude Risset, 'Pitch and Rhythm Paradoxes: Comments on "'Auditory Paradox Based on Fractal Waveform'" [J. Acoust. Soc. Am. 79, 186–189 (1986)]', *The Journal of the Acoustical Society of America*, 80.3 (1986), 961–62.

copyrighted material

Fig. 108 A diagram of a Risset accelerando. The x-axis shows time, and the y-axis tempo rates. The centre tempo indicated by 0 is kept the loudest, with the outer layers decreasing in amplitude the further they are from the centre

The musical application of Risset rhythms have not been as extensively explored as their pitch counterparts. This may be several reasons for this; Dan Stowell suggests that the ‘complexities of managing accelerating fractal rhythms within compositional and sound-design environments may have held back their usages.’[460] In an attempt to increase their accessibility and help facilitate their use in compositions, Stowell derives mathematical expressions for scheduling accelerating and decelerating Risset rhythms, and provides a discussion of compositional choices available within this framework.

Risset’s work *Contre nature* for solo percussion and tape, is a rare extensive exploration of the different configuration of rhythmic illusions. His paper ‘Rhythmic Paradoxes and Illusions: a Musical Illustration’[461] catalogues the different instantiations used in *Contre nature* (1996). The second movement uses a steady beat that insidiously speeds up through the gradual introduction of the double-speed version. The last minute of the final movement consists of a beat that constantly speeds up, yet ends up much slower than it started. This is achieved by slowly shifting the amplitude of each layer, creating this complex paradoxical behaviour.

Risset rhythms can produce metaperceptual experiences in a similar manner to Shepard tones. Their seemingly impossible behaviour breaks the rules of normal acoustic behaviour, drawing attention to their illusory nature as the audience’s perception is deceived. The realisation of their

[460] Dan Stowell, ‘Scheduling and Composing with Risset Eternal Accelerando Rhythms’, in *ICMC* (presented at the International Computer Music Conference, Huddersfield, UK, 2011).
[461] Jean-Claude Risset, ‘Rhythmic Paradoxes and Illusions’.

illusory nature occurs over time, as the constant perception of acceleration on the micro-level begins to conflict with the overall perception of tempo. Their lack of exploration in musical and artistic contexts makes them well-suited for creating new metaperceptual works. My own metaperceptual work, *rise.risset* (discussed further in Part III), combines Risset rhythms with Shepard-Risset glissandi to create a range of paradoxical sounds.

11.2.3 Phantom Sounds

The final category of aural cognitive artefacts parallels Richard Gregory's 'Fictions' type. These artefacts are caused by the perceptual system filling in information that is not present in the stimuli. This category contains two artefacts: binaural beating and the missing fundamental.

11.2.3.1 Binaural Beating

Binaural beating has similarities in both stimulus and perception to distortion products and interference patterns, previously discussed in the physiological and physical artefacts chapters respectively. As with distortion products, binaural beating is caused by the relationship between two pure tones creating a third, illusory tone. These real tones must be below 1500 Hz and have less than 40 Hz difference.[462] When these tones are presented dichotically—one tone in each ear—a third tone is perceived. This third tone is not perceived like a normal pitch, but instead is heard as a beating effect, amplitude modulating the other two tones and creating an illusion of motion in the sound. This has an extraordinary effect on the listener's perception, as biophysicist Gerald Oster describes it as 'the illusion that the sounds are located somewhere within the head.'[463]

Whereas combination tones and otoacoustic emissions are caused by the non-linear distortion of the cochlear amplifier, binaural beating occurs as a by-product of cognitive processes for pitch perception, which causes confusion in localisation.[464] The most widely accepted physiological explanation for binaural beats is that they are caused by neuron discharge patterns that preserve phase information from each ear converging on binaurally-activated neurons in the ascending auditory pathway.[465] Much like interference patterns in acoustic sound, slight differences in these two separate streams causes a beating interaction. In this case, the interaction is between neurons

---

[462] J. C. R. Licklider, J. C. Webster, and J. M. Hedlun, 'On the Frequency Limits of Binaural Beats', *The Journal of the Acoustical Society of America*, 22.4 (1950), 468–73.
[463] Gerald Oster, 'Auditory Beats in the Brain', *Scientific American*, 229.4 (1973), 94–102.
[464] Oster, 'Auditory Beats in the Brain'.
[465] Hillel Pratt and others, 'Cortical Evoked Potentials to an Auditory Illusion: Binaural Beats', *Clinical Neurophysiology*, 120.8 (2009), 1514–24.

rather than mechanical sound waves. The neuron interaction generates the neurophysiological correlate of binaural beats in the brainstem and the perception of a beating effect.[466]

The reason that binaural beating artefacts only occur with tones below 1500 Hz is due to the method of pitch perception in this frequency range. As discussed in Section 2.2, there are two main cues that the perceptual system uses to encode frequency. Higher frequencies use *frequency-to-place* cues, with the place most strongly resonated along the basilar membrane informing pitch perception.[467] At lower frequencies, the auditory system uses phase information, which is produced by the neurons 'phase locking' to the stimulus. This occurs as the basilar membrane vibrates in synchrony with an input wave, causing auditory nerve fibres to fire during each positive phase of the wave.[468] When a listener is presented with a stimulus that creates binaural beating, it causes neural activity with slightly different volley frequencies in the left and right ears. This activity converges and interacts in the central auditory brainstem pathways to generate beats of neural activity that modulate activities in the higher auditory pathway, giving rise to the illusion of binaural beats.[469]

As with distortion products and many of the physical artefacts discussed in this chapter, binaural beats can create metaperceptual experiences through their extraordinariness. Similar to distortion products, binaural beats can appear to be emanating from within the head, and even moving around the head in a controlled way. Oster writes of his experience that 'that when the beats are very infrequent, fewer than about three per second, they seem to move back and forth in the head. If the intensities of the two tones are different, the motion takes an elliptical path.'[470] Their radical departure from normal experiences of sounds that are perceived as external draws attention to the body and its perceptual system. These perceptual qualities make them well-suited to exploring through the metaperceptual framework.

Many of the existing musical explorations of binaural beats have resulted from their supposed potential for brain entrainment, the idea that the listener can synchronize the electrical activity in ensembles of cortical neurons in their brain to an external stimulus.[471] The scientific testing of this

[466] Joel S. Wernick and Arnold Starr, 'Binaural Interaction in the Superior Olivary Complex of the Cat: An Analysis of Field Potentials Evoked by Binaural-Beat Stimuli.', *Journal of Neurophysiology*, 31.3 (1968), 428–441.
[467] Mather.
[468] Mather.
[469] Pratt and others.
[470] Oster, 'Auditory Beats in the Brain'.
[471] Udo Will and Eric Berg, 'Brain Wave Synchronization and Entrainment to Periodic Acoustic Stimuli', *Neuroscience Letters*, 424.1 (2007), 55–60.

has been problematic, with some researchers finding 'no effect of binaural beat frequency eliciting a frequency following effect in the EEG.'[472] Regardless, many websites and services have been created that devote themselves to binaural beats, with long pieces claiming to awaken intuition, universal healing, and to open the third eye. Jonathan Brent's article 'Music: On binaural beats, self-medication and snake oil' details his own experience with 'Consumer binaural beats which gamely promise to deliver the experience of prescription drugs, recreational drugs, cognitive enhancement, or sexual encounters through "brainwave entrainment", describing them as 'little more than Spotify detritus.'[473]

While it is dubious that binaural beats can cause such radical effects for the listener, they do have great potential for creating metaperceptual experiences and are currently underexplored. My own metaperceptual work *Destructive Passages One & Two* is an exploration of both beat interference and binaural beating, and is further discussed in Part III.

11.2.3.2 Missing Fundamental

As in binaural beating, the addition of information by a cognitive process of sound can be evidenced in the missing fundamental illusion. Similar to binaural beats, the artefact is created through the cognitive mechanism for determining pitch. The missing fundamental illusion arises when a set of harmonics are presented that lack the fundamental frequency. The listener will still perceive the lower fundamental, even though it is not present in the stimulus, as the brain tries to infer the fundamental pitch from the relationship between the harmonics.[474]

This phenomenon was once thought to be due to the same distortions of the cochlea that cause combination tones and otoacoustic emissions,[475] but this theory has since been disproved.[476] It is now widely accepted that the brain processes the information present in the overtones to calculate the fundamental frequency through some form of higher auditory pattern recognition

[472] David Vernon and others, 'Tracking EEG Changes in Response to Alpha and Beta Binaural Beats', *International Journal of Psychophysiology*, 93.1 (2014), 134–139.
[473] Jonathan David Brent, 'Music: On Binaural Beats, Self-Medication and Snake Oil', *Lifted Brow, The*, 2014, 38.
[474] P. A. Cariani and B. Delgutte, 'Neural Correlates of the Pitch of Complex Tones. I. Pitch and Pitch Salience', *Journal of Neurophysiology*, 76.3 (1996), 1698–1716; David A Schwartz and Dale Purves, 'Pitch Is Determined by Naturally Occurring Periodic Sounds', *Hearing Research*, 194.1 (2004), 31–46.
[475] von Helmholtz.
[476] J. C. R. Licklider, '"Periodicity" Pitch and "Place" Pitch', *The Journal of the Acoustical Society of America*, 26.5 (1954), 945–945.

mechanism.[477] The exact nature of this mechanism is still the subject of active research, with leading theories positing that the processing is based on pattern recognition of the timing of neural impulses in the auditory nerve,[478] making this artefact strongly related to the cause of binaural beats.

Guitars, violins, and timpani all produce the illusion which helps us to perceive the fundamental as lower than their physical resonant bodies can in fact support.[479] The missing fundamental illusion is also present in the technological reproduction of sound. Telephone conversations create the illusion, as the small speakers in telephone headsets can only generate frequencies in the range of 300 Hz to 3 kHz. Male voices, which can have fundamental frequencies of 150 Hz, lie outside this range yet the fundamentals are still perceived because of the illusion. The effect has been utilized in a range of commercial DSP plugins that seek to allow speakers to seemingly produce loud bass frequencies lower than their physical limits.[480]

The missing fundamental illusion has the potential for metaperceptual works, but the artist needs to afford an interaction between the audience and the stimuli that allows for the illusion to become apparent. While the experience of the illusion is surprisingly common, it is often experienced without the listener noticing its illusory nature. This may be due to the brain filling in the missing information, but which still fits the expectation for what would normally be present. A metaperceptual artwork would have to devise a method for making the illusory nature of the phenomenon to become apparent.

One possible approach is to create experiences in which the missing fundamental does not fit the expectation of the listener. In La Monte Young's highly influential work *The Well-Tuned Piano* (1964)*,* missing fundamentals are caused by retuning the strings to a seven-limit just intonation scheme. This tuning allows for certain combinations of notes to act as partials of a lower illusory fundamental that are too low to possibly be created by the piano.[481] John Schaefer describes experiencing this passage as 'keyboard filigrees and shimmering harmonics …a strongly implied

---

[477] Julius L. Goldstein, 'An Optimum Processor Theory for the Central Formation of the Pitch of Complex Tones', *The Journal of the Acoustical Society of America*, 54.6 (1973), 1496–1516; Ernst Terhardt, 'Calculating Virtual Pitch', *Hearing Research*, 1.2 (1979), 155–182.
[478] Cariani and Delgutte.
[479] David Martin Howard and Jamie Angus, *Acoustics and Psychoacoustics* (Taylor & Francis, 2006).
[480] Juniana Grimm, Lon Schnittgrund, and James Harley, 'Waves Gold Native Bundle Version 3.0', *Computer Music Journal*, 25.4 (2001), 102–106.
[481] Kyle Gann, 'La Monte Young's The Well-Tuned Piano', *Perspectives of New Music*, 31.1 (1993), 134–62.

drone, although since it's several octaves below the range of the piano, it's never actually heard'[482] Although this quote seems to indicate that Schaefer was referring to experiencing an extremely low missing fundamental, Jeremy Grimshaw has determined that 'all the pitches in the scale (used in *The Well-Tuned Piano)* derive from the overtone series of a theoretical subsonic E flat that falls eleven octaves below the lowest E flat on a standard piano.'[483] While the work may not elicit a perceivable missing fundamental that transgress the audience's expectations, it offers a template for future works to explore.

11.3 Perceptual Hacking as a Metaperceptual Approach

The Perceptual Hacking approach explores a diverse range of illusions, artefacts, and oddities that can be used to make powerful metaperceptual experiences. The classes of artefacts—Physical, Physiological, and Cognitive—each have their qualities and potentials for creating metaperceptual experiences.

The physical category of artefacts confront our expectations, as they break the normal modes in which stimuli usually behave. This confrontation is subject to an understanding of the normal modes in which light, sound and other stimuli usually behave. Accordingly, this class of artefacts may be the most subjective in their ability to elicit metaperceptual responses. Despite this, there are strong precedents in metaperceptual visual and sound art. Olafur Eliasson's work *Beauty* offers an elegant example of creating extraordinary stimuli, which draws the attention of the audience back onto themselves by giving them the autonomy to interact with the visual phenomenon of a rainbow in a new context. The existence of the phenomenon is dependent on their position in the work, revealing their role as an active enactor of the work. Alvin Lucier's *Crossing* creates extraordinary phenomena in the aural domain, with an austere exploration of interference patterns. The work caused music reviewer Tim Perkis to declare that 'the effect is unlike anything one is likely to have heard in normal life or in normal music.'[484]

The physiological class of artefacts are able to excite metaperceptual experiences by exploring the underlying perceptual processes that constantly mediate our perception. These metaperceptual experiences reveal that the perceptual apparatus is not a neutral interface providing us an objective perception of the world. Each sense organ has its own characteristics and processes that cause perceptual by-products that are non-existent in the outside world. As these physiological artefacts

---

[482] John Schaefer, *New Sounds: A Listener's Guide to New Music* (Harpercollins, 1987).
[483] Jeremy Grimshaw, *Draw a Straight Line and Follow It: The Music and Mysticism of La Monte Young* (Oxford University Press, 2011).
[484] Perkis.

occur in the perceptual apparatus itself, they often draw the attention of the observer back onto themselves. The works of Bridget Riley exhibit this effectively, as the extraordinary movement they create in the perception of the viewer is in conflict with the concept of a painting as a static object. This leaves the audience contemplating how this movement is caused, as their eyes dart around the painting, with the only plausible answer is that it is their perception warping the image. In the aural domain, otoacoustic emissions are emblematic of the perceptual system as active mediator of experience. They problematise the common conception of the aural sense as a passive receiver, as the strength of the distortion products in the basilar membrane reverse the flow of vibration and resonate the bones in the middle ear. Their perceptual qualities are unique in their localisation, as they lack spatial context due to their creation inside the ear. This makes them well-suited to metaperceptual explorations as the uniqueness of experiencing the distortion products immediately grabs the listener's attention, directing their attention towards their perceptual apparatus.

The cognitive class of artefacts are often the most subtle, as they frequently mediate perception without the observer being aware of them. Their exploration in art has a long history through the technique of trompe-l'œil, which serves as a related paradigm to the Perceptual Hacking approach. The artworks deceive the audience through a thorough understanding of perceptual processes, exploiting the information that the audience's visual system uses to perceive depth. The ability for the audience to investigate the veracity of their perception is vital to creating metaperceptual experiences, as this allows the audience to become cognisant of the illusory nature of the artworks. The cognitive class of perceptual artefact may be the most diverse of the three, as there are many underlying cognitive processes that mediate our perception. While some of these processes can be exposed in pronounced ways (such as paradoxical behaviour of Shepard tones and Risset rhythms), others are more subtle and necessitate the artist creating an interaction between audience and artwork to reveal the artefact's nature.

The Perceptual Hacking category of works creatively misuse facets of the perceptual apparatus and perceptual processes of their audiences to create metaperceptual experiences. This is facilitated by a thorough understanding of the inner workings of the perceptual system, and identifying the extraordinary possibilities that they allow. The creation of this framework has informed two new metaperceptual sound artworks, *rise.risset* and *Destructive Passages One & Two* which are discussed in Part III.

In Part II, I mapped out the terrain of approaches for creating metaperceptual artworks. In Part III of this document, I present a portfolio of new metaperceptual works that have been informed by the creation of the metaperceptual framework. The portfolio evidences the application of the metaperceptual framework as a creative tool for provoking new works. While these works span a range of the categories and approaches discussed in the Part II, they do not exhaust the potential and possibilities for new metaperceptual sound artworks. Part III will conclude with a discussion of the potential for future research in this field, and a summation of the research project.

Part III:

New Metaperceptual Works

Chapter Twelve

Portfolio

The metaperceptual framework explicated in Part II informs the portfolio of new works which I present in Part III. In this chapter, I present a portfolio of new sound artworks, which are informed by the development of the metaperceptual framework. These works span a range of the approaches identified in the metaperceptual framework, and are manifestations of the framework as a creative tool. This chapter's structure is based on the categories identified in Part II, presented in Fig. 109. In presenting this portfolio, I discuss the ways in which these works explore metaperceptual themes, and situate them within the larger context of the metaperceptual framework developed in Part II.

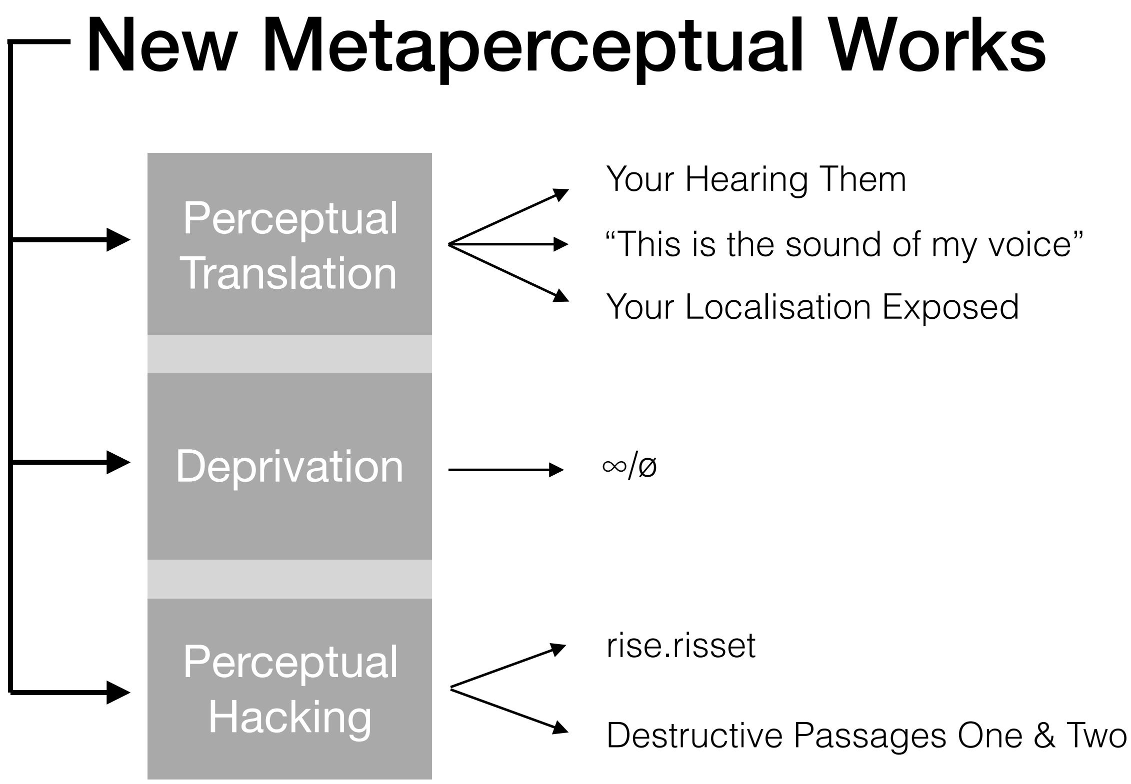


Fig. 109 Overview of the portfolio of works and their respective metaperceptual categories

12.1 Your Hearing Them

A New Metaperceptual Perspective Shifter

Your Hearing Them is the largest project undertaken during this research. The work included the design and construction of a new headset and a software application for filtering live audio. The project was further refined through a user study, which incorporated feedback from a range of users. The work was exhibited at the International Symposium on Electronic Art in Manizales, Colombia, in 2017. As the work involved an extensive design and refinement period, and its themes typify the metaperceptual approach, I dedicate a large portion of this chapter to examining its design, conceptual, and exhibition details.

The title of this work, *Your Hearing Them*, is a homage to Olafur Eliasson and his metaperceptual explorations. Many of his works include 'your' in the title: *Your Blue Afterimage Exposed* (discussed in Section 10.1.1), *Your Making Things Explicit* (discussed in Section 9.3)*,* and *Your Atmospheric Colour Atlas,* to name a few. My intent is the same as Eliasson, as the title clearly represents what the subject of the artwork is: you. *Your Hearing Them* includes a play on words between your or you're, which represents a duality that lies at the core of its materials. This duality is explicated in the next paragraphs.

Your Hearing Them explores the Perceptual Translation approach by allowing an audience member to experience someone else's voice in the way that they do. It fits into the perspective shifters category, as it seeks to give the wearer the experience of someone else. At the core of this artwork is the question: What does your voice sound like? While this question may appear seem simple, its answer is problematic and depends on who is being asked. One's perception of one's voice is different to everyone else's perception of it. This difference can be evidenced in a common reaction to hearing one's voice played back through a recording of disgust or disownership. While this caricature of our voice may seem strange and alien, this version is much closer to the way others hear it. This reveals a duality of the voice—there is a conflict between your own perception of it and what others hear. *Your Hearing Them* creates metaperceptual experiences by revealing this duality which is often overlooked and, for some, unknown. The work shifts the perceptive of the wearer, allowing them to experience the sound of someone else's voice as they do, and in doing so, draws their attention to their own subjective perception.

The cause of this duplicity is the physiology of our perceptual system mediating our experience. When we speak, the sound of our voice propagates through space, reflecting off surfaces in our environment and entering the ears of proximate observers. We hear these sound waves as well, as they reflect of surfaces in the room and return to our ears. The difference is caused by an additional layer of experience, as our skull is resonated by the vibration of our vocal folds. The conduction of sound through the bones of the skull strongly reinforces the lower frequency content of the voice, making our perception of our own voice rich and deep. It is the lack of bass and richness in our voice when heard back in recordings that provoke the reaction of "is that really what I sound like?"

A duplicate pair of wearable technology headsets were created, which enable two people to have an augmented conversation. By appending the perceptual apparatus with the wearable technology, a set of bone transducers are able to reintroduce the speaker's extra layer of experience. This allows for a conversation to be had where two participants experience each other's voice the way the speaker hears themself - creating a metaperceptual experience by shifting the perspective of the wearer. This augmented conversation reveals the duplicity of our voice, and the title. You are hearing them as they speak, but *you're* hearing them as they do, revealing how this differs from *your* normal hearing of them.

The following sections present the design and development of the work, including its construction, electronics, filtration, and installation. Following this, I contextualise the work within the metaperceptual framework, and discuss how it creates metaperceptual experiences. *Your Hearing Them* is constructed with bamboo and 3D-printed parts, as are the majority of the works in this portfolio. While these works are considered as primarily *experience shapers*, the aesthetic qualities of the objects are also considered, as these inform the ways in which they act as experience shapers. As a prelude to the design of *Your Hearing Them*, I discuss the use of materials in this portfolio and the way they inform the experience of the work.

12.1.1 Materiality of the Metaperceptual Portfolio

Your Hearing Them demonstrates an important relationship between artwork as object and artwork as experience shaper which features throughout the works in this portfolio. One of the design considerations in creating this work's headsets was that they needed to instil trust in the wearer, as they would be putting this object on to their head. While the headset looks similar to headphones, for most users, the surface transducers will be unfamiliar, and may cause a degree of trepidation. As the surface transducers also create the extraordinary experience of the skull bones being vibrated, this can be met by some users with apprehension, as they may be concerned about potential health risks, for example. The full design considerations, which are discussed in the following section, could have been met via a range of other fabrication methods. One approach was to use existing technological solutions, and make alterations to fit the design brief. While I use this approach in another wearable technology work, *Your Localisation Exposed* (discussed in Section 12.3), I was concerned that in this work that involves bone transduction, the headset may appear to be unstable, unprofessional, and most saliently, untrustworthy.

While the works in this portfolio are primarily considered as experience shapers, the artwork's visual, physical, tactile, and aesthetic qualities are strongly considered as they inform the way in which the works act as experience shapers. In the case of *Your Hearing Them*, these qualities inform the wearers interaction with the object, and their willingness to trust the safety and construction of the headset. In other works in this portfolio, these elements may tie into the conceptual themes of the work, and are used to guide the audience's attention. As the audience experience these works through their multi-modal perceptual apparatus, considering every factor strengthens the works ability to facilitate metaperceptual experiences.

12.1.2 Design

Your Hearing Them is comprised of two main components: the physical bespoke headsets and audio electronics, and the software DSP system.

12.1.2.1 Headsets

The headsets, shown in Fig. 110, created for *Your Hearing Them* contain three types of electronic components: a microphone, which captures the voice of the wearer in order to send their voice to the reciprocal headset, a pair of speakers, which sit on the ears like headphones, and lastly, a pair of surface transducers which sit on the cheekbones of the wearer. Surface transducers work in a similar manner to a loudspeaker. Instead of a speaker cone which creates sound by displacing air though, the coil is attached to a pad that conducts the vibration into whatever is pressed against it. The headset locates the surface transducer onto the cheekbone of the wearer, coupling the pad and the bone to vibrate their skull. This skull vibration reintroduces the embodied quality of hearing one's own voice, and helps recreate the experience of hearing someone else's voice as they do.

Fig. 110 Side view of one of the headsets for Your Hearing Them. From left to right: microphone, surface transducer, and speaker

The headsets of *Your Hearing Them* went through a series of iterations, as I refined their design and construction. I determined a set of design considerations that would allow for the headset to realistically translate the experience of the speaker's voice. These included the inclusion of both speakers and surface transducers to produce sound. The speakers needed to be placed on the ears, while the transducers need to be positioned flat against the cheekbones. To ensure a strong coupling between transducers and the wearer's cheekbones, the headband needs to provide sufficient inwards pressure. This is essential for the transducers to transmit vibrations effectively. A microphone was needed to capture the wearer's speech, and send this audio to the other headset. To reduce unwanted environmental sounds, the microphone needed to be located close to the wearers mouth. Lastly, the headsets needed to accommodate a range of users, with various head shapes and sizes. They should be adjustable by the wearer, so as to best fit them.

The design choice of including both speaker and surface transducers is informed by a series of tests that I conducted early in the development of the work. Original designs, including the design presented in Fig. 111, only implemented surface transducers. The components were found to be most effective at low to low-mid frequencies. Above this, the fidelity and clarity of the sonic information was limited. While this element was able to recreate the embodied and rich bass elements of the sound, the overall fidelity of the sound suffered, and the exteriority of the speaker's voice was missing. The experience that this design created is similar to hearing while fingers are blocking your ears. The design choice was made to include both speakers and transducers, which was corroborated by the responses received in the user study, discussed in Section 12.1.3.

Fig. 111 Early design of headset with only transducer

The headset's headband is made from bamboo, which was dry bended, laminated, and clamped onto a mould to form its shape, shown in Fig. 112. While the headband needed to a have a degree of flexibility to allow for a range of wearers with differently shaped and sized heads, this could not be at the expense of maintaining inwards pressure. This force is essential to allow for the surface transducers to vibrate the cheekbones of the user, and to ensure the headset does not easily fall off. Through an iterative design process, the shape and rigidity of the headband were fine-tuned, with the final design using three 1.8mm thick strips of bamboo that were laminated and shaped onto the mould shown in Fig. 112.

Fig. 112 Left: Three strips of bamboo. Right: Headband being dry bended, glued, and then clamped to form the shape

Connecting to the headband, a perpendicular wooden part holds the speaker, surface transducer, and (on one side) a microphone. These two wooden pieces are connected by a dowel hinge, which can be seen in Fig. 110, that allows for the perpendicular part to rotate through a limited range on one axis, and to be adjusted by moving up and down. These two features help to accommodate the diversity of head sizes and shapes, and allows for the surface transducers to be gently pushed onto the cheekbones of the wearer if the coupling is inadequate. The electronic components are held in place by elastic ties, which allows for them to be shifted along the length of the wooden piece. The microphone is inserted at the end of one of the wooden parts, allowing for it to be close to the wearer's mouth. The full system being worn is presented in Fig. 113.

Fig. 113 Wearing the headset. The microphone can be seen embedded in the wooden perpendicular part on the left.

12.1.2.2 Electronics and Software

The electronics used and built for this work consist of a signal combiner, an amplifier, and a software application. The full signal flow overview is presented in Fig. 114.

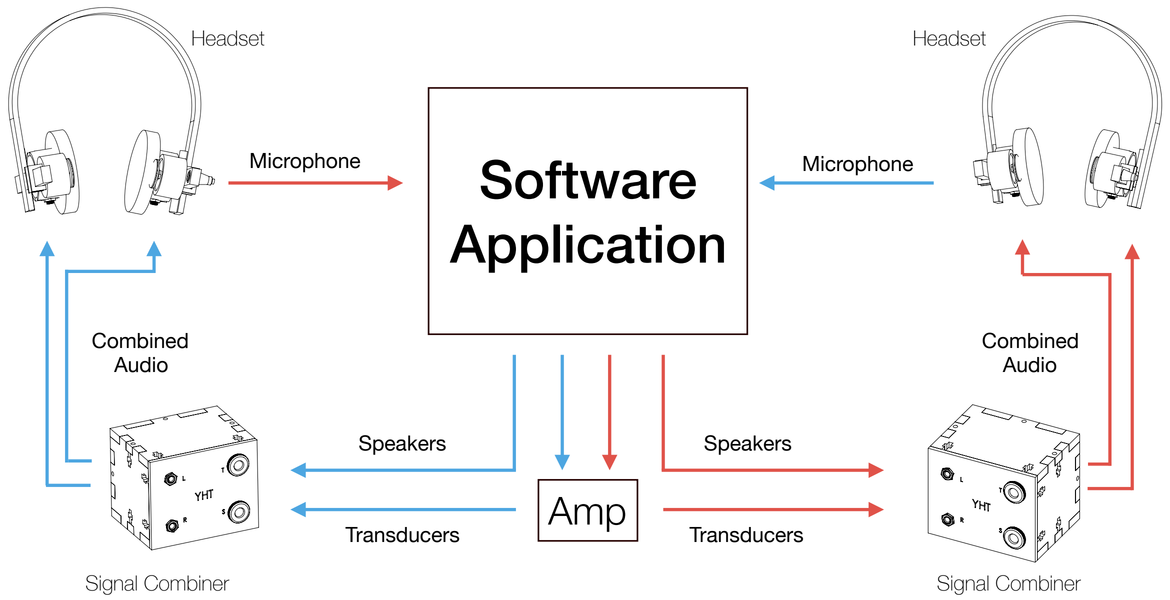


Fig. 114 Signal Path of Your Hearing Them

The signal flow for *Your Hearing* Them starts at the microphone. This audio is sent to the software application through an audio interface. In this application, the audio signal is duplicated, with one version being sent to the speakers and the other to the transducers. Each signal is filtered independently, a process further discussed in Section 12.1.3. As the surface transducer has a higher impendence than the speakers, its signal is amplified, whereas the speaker is driven directly from the audio interface. In order to reduce the amount of cables connecting to the headset, which may distract from the wearer's experience, both signals are sent in a single 4-core cable. These two signals are joined in the signal combiner, illustrated in Fig. 115, and are sent to each side of the headset.

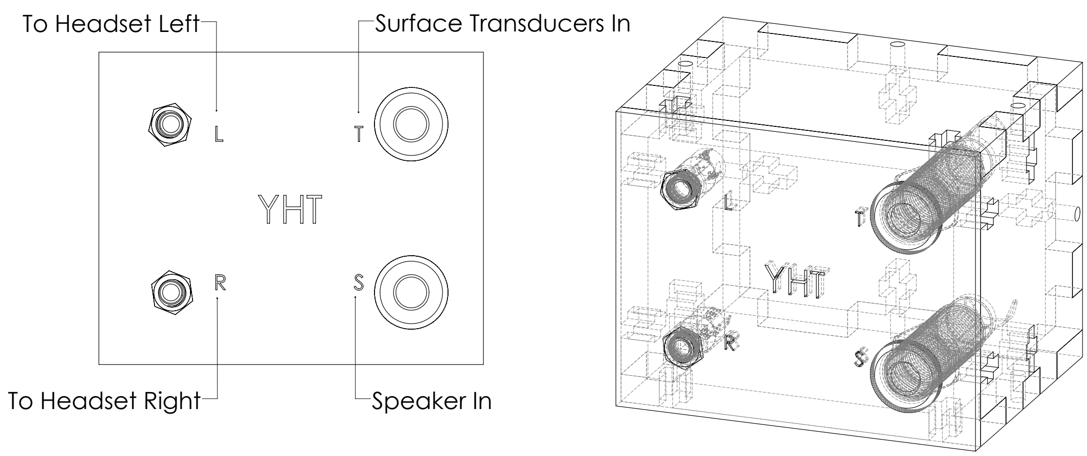


Fig. 115 Design of Signal Combiner, with labelled inputs and outputs

12.1.2.3 Software Application

The software application developed for *Your Hearing Them,* shown in Fig. 116, was produced in Max/MSP.[485] The application controls the audio processing of the artwork, and is not directly interacted with by the audience. It duplicates the audio received from the microphone and controls a filter and the gain of each stream.

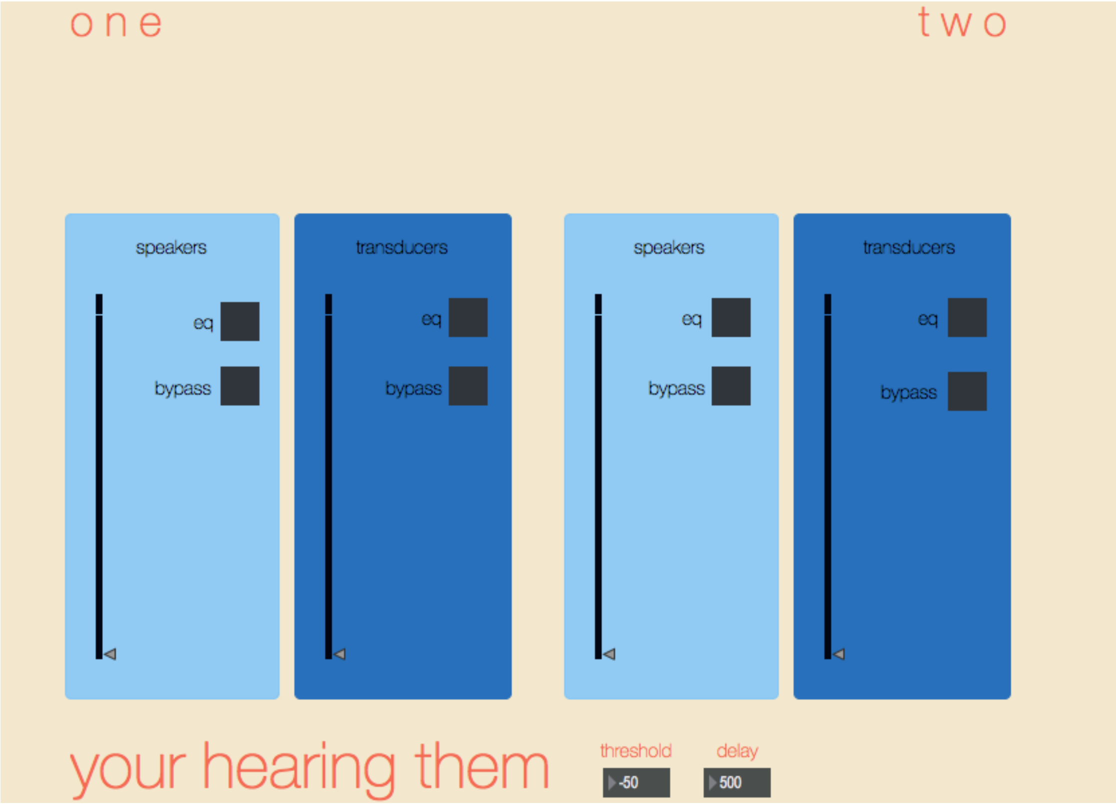


Fig. 116 The software interface developed for exhibiting Your Hearing Them

Without software intervention, the system is prone to feedback, that can be caused when the noise levels of the environment are too high or when the two wearers are very close to each other. In order to combat this, a responsive system was developed in the software which only allows for one direction of the signal chain to be enabled. This is triggered and controlled by the microphone input levels. When a wearer starts to speak, the system detects whether the microphone level is above a threshold value, set according to the environment in the interface shown in Fig. 116, and mutes the reciprocal microphone. This forces one of the users to be the speaker, and the other to be the listener. Once the person has stopped speaking, the system returns to its initial state of detecting sounds after a prespecified delay period, also set in the interface. This feedback cancelling feature can be turned on and off, and the decision to use this contingency is based on the details of the exhibition. While this feature was developed as a contingency, the interaction that it forces upon the two wearers is conducive to focusing the attention of the audience towards

[485] https://cycling74.com/products/max/

the qualities of their perception. The interaction removes the tendency to speak over one another, and designates clear roles for the participants to enact.

As the surface transducer and speaker have contrasting frequency spectrum responses, a filter on each audio stream allows for the relationship between the two to be carefully altered. The variability between each wearer's voice, head, hearing, and subjective experience means that it is impossible to have one setting that perfectly fits users. To best approximate a filter setting that accommodates the variability of the work's audience, the settings of each graphical equaliser (EQ) are informed by a user study. This survey, discussed in 12.1.3 involved a range of users manipulating the system's parameters to best suit their own voice. The resulting average filter was taken from this range of participants in order to create a generalisation. While this means that each wearer's experience may not be optimally tuned to recreating their conversation partner's voice, this generalisation allows for a large range of users to experience a generalised model of their partner's voice. This is a compromise that allows for many users to easily engage with the installation in a gallery context. In addition to the average filter parameters, the feedback gathered from the user study provides phenomenological accounts of the work's recreation of the wearer's voice and evaluates aspects of the headset's design. This feedback informed another work utilising the wearable headset, *"This is the sound of my voice"*, further discussed in Section 12.2.

12.1.3 User Study

As outlined above, a user study was conducted to further refine *Your Hearing Them* by incorporating a range of perspectives. The intent of the study was two-fold. Firstly, to collect qualitative data of the users experience through a questionnaire, which informed any revisions needed, evaluated the design choices made, and gave phenomenological evaluations of the experience of using the headset. Secondly, to collect quantitative data of the users *tuning* the system to best recreate the sound of their voice. This tuning involved manipulating audio DSP parameters which shape the volume and frequency spectrum of the sounds created by the headset. These two factors allowed for the work to be further refined. The methodology and results of the user study are discussed in the following sections, followed by details about the practical applications of the study's findings.

12.1.3.1 Methodology

The study involved two sections: the task of tuning the system, and then the answering of a questionnaire. For the task of tuning the system, each participant was asked to alter a set of DSP parameters, through the provided interface shown in Fig. 117, in order for the headset to best recreate the sound of their voice. These DSP parameters were volume and EQ for the speakers and transducers individually. The process for tuning the system was began with the participant recording a spoken phrase through the headset's microphone, which was then played back to them. The suggested phrase was "This is the sound of my voice", that influenced the creation of subsequent work, discussed in Section 12.2, using the headsets designed for *Your Hearing Them*. While listening to this phrase being played back, the participant altered the DSP parameters to best match their experience of their voice. This process was repeated three times, each time using a different approach with a different set of DSP parameters to control. The three approaches were using only the speakers (Only Speakers), using only the transducers (Only Transducers), and using both speakers and transducers (Combined). The order of these approaches was randomised to minimise their influence on each other. This repetition offers two main analytical insights. Firstly, it allows for evaluation of my design choice to include both speakers and surface transducers. Secondly, it allows the participant to experience each element in isolation, allowing for a more focused and detailed phenomenological account of their experience.

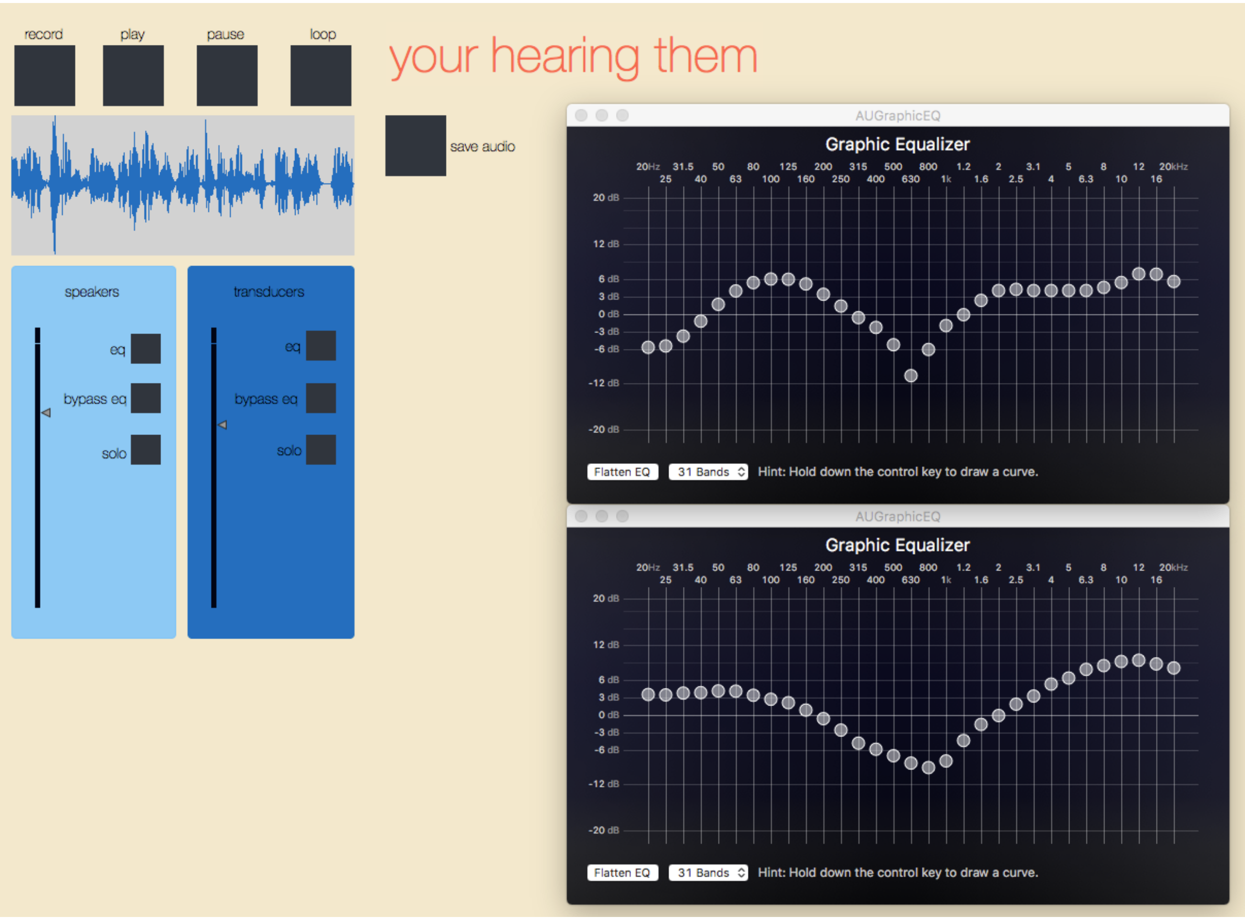


Fig. 117 User interface presented to the participants of the user study, with both EQ's control interfaces open

Following these tasks, the participant completed a questionnaire which detailed their experience and asked them to evaluate the system. The questionnaire contained three sections: User Experience, Individual Approaches, and Comparing Approaches. The findings of this questionnaire are presented in the next section.

Eleven participants partook in the study. This restricted sample size may mean that their collective tuning of the system does not fully represent the wider public, but the intent of undertaking this study is to further refine the work. The median of the participants' tuning of the system was used when exhibiting the artwork, allowing for a more diverse set of subjectivities to inform the work than just my own. The participants' discussion of their experience using the headset helps to inform a discussion of the experiential elements of the work in Section 12.1.4.

12.1.3.2 Selected Findings from Tuning Task

In the questionnaire, the participants were asked to rank the approaches from most effective to least effective. All eleven participants ranked the Combined approach as the most effective. This ranking justifies the inclusion of the more complicated transducer and speaker configuration. The overwhelming preference was for the Combined approach, and accordingly, I only discuss tuning data from this approach here.

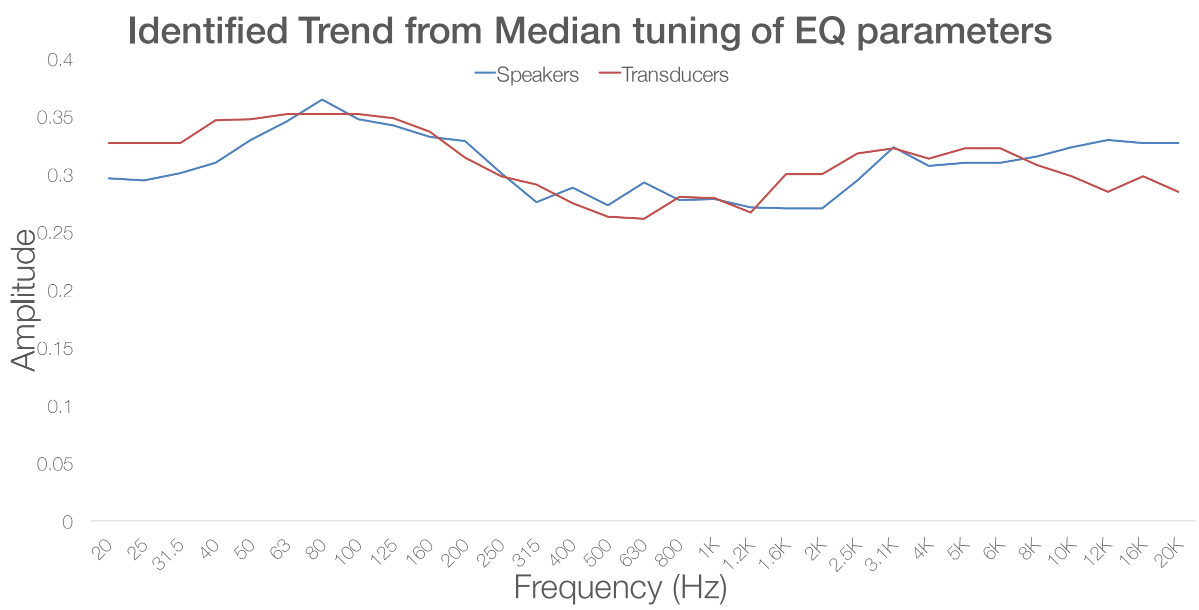


Fig. 118 The trend identified from taking the median of all participant's tuning data for combined approach

A trend was identified in the tuning of both the transducers and speakers. The median of both tunings, shown in Fig. 118, show a similar overall shape. Participants chose to manipulate both filters to increase bass frequencies, with the transducers most strongly amplifying them. The fundamental frequencies of most people's voices lie in this range, and the median tuning indicates that these frequencies are more prominent in their experience of their voice.[486] Both filters were shaped to reduce mid-range frequencies, between 200 Hz and 2000 Hz relative to rest of the frequency spectrum. The strongest attenuation occurs around the 600 Hz band. The lower

[486] Ingo R. Titze, *Principles of Voice Production*, 1 edition (Englewood Cliffs, N.J: Prentice Hall, 1994).

harmonics of the speaker's voice lie in this range, and the tunings indicate that these do not need to be amplified as much as the fundamental frequencies and higher frequencies. Both filters also amplify the high frequencies. Above 6 kHz, the transducers are attenuated more while the speakers continue to be strengthened. While the tuning of both transducers and speakers have a similar shape, the phenomenological accounts of the participants given in the questionnaire suggest they fulfil different roles in recreating the experience of hearing one's own voice. These are discussed in the following section. This median tuning was used when exhibiting *Your Hearing Them*, which is further discussed in 12.1.3.

12.1.3.3 Selected Findings from Questionnaire

The phenomenological accounts given in the questionnaire suggests that the two components complement each other in recreating the experience of hearing one's own voice. For each approach, the participant was asked to rate how close they were able to manipulate the system to recreate the experience of their own voice (1 being not close at all, 10 being very close). A comparison between the Only Speakers and Only Transducers approach reveals salient phenomenological differences. This comparison also evaluates the design choice made to include both elements.

While both approaches received a similar average rating (Only Speakers approach 6.86 out of 10, and Only Transducers approach 6.65 out of 10), the reason for this appears to be due to different factors. For each approach, participants were asked: If the recreation does differ from the experience of hearing your own voice, please describe how it does? For the Only Speakers approach, the common themes include: a lack of depth and richness, a disembodiment, and the recreation being less immersive than their experience of their voice. For the Only Transducers approach, the themes included a lack of accuracy of the mid and higher frequencies, an incompleteness and foreignness, and lack of exteriority. One user described this element as it felt like their voice *"was inside a box, not like the ambience and size of the room where it was recorded."*

The Combined approach of using both elements received a high average rating of 8.75 out of 10, and in ranking the approaches from most successful to least successful, all participants ranked the combined approach as the most successful. Comparing this approach to the other two approaches, participants described how the combining of the elements allowed for a more 'three-dimensional' sound with a more full and resonant quality. Multiple users described the elements as working in a complementary manner, with each component fulfilling different roles of the experience. The transducers support lower frequencies and provide an embodied quality to the experience, while the speakers provide clarity in the mid and higher frequencies that the transducers struggle to produce.

While many of the users felt that the headset was able to recreate the experience of their own voice, some differences were identified. Multiple users commented on the spatial element of hearing their own voice, and describing the recreation as being isolated from a wider spatial environment. The focused nature of the experience does not recreate the room response and the contextual elements of hearing one's voice in a specific space. This is due to the placement of the microphone, as its proximity to the speaker's mouth means that it does not capture the wider reflections of the speaker's voice in the room. This difference may be lessened in the exhibition context, as the listener will hear their partner's voice through the headset as well as directly as they normally do.

Additionally, the questionnaire included a user experience section, which investigated whether unintended factors were negatively impacting the wearer's ability to experience the work. The results found that there were no major issues that caused a negative impact on the experience. Most participants found that the headset was reasonably comfortable, with only a few finding it becoming uncomfortable after an extended period (average rating was 6.3 out of 10). Most participants found it easy to adjust (average rating 7.1 out of 10) and not invasive (average rating 2.9 out of 10). These three results suggest that these factors did not negatively impact their experience.

Given the participatory nature of the artwork, this user study provided valuable qualitative and quantitative data for the refinement of the work. While using one tuning of the DSP parameters for a range of users is a compromise, it allows a range of users to have a close approximation of the intended translation of experience in a gallery context without the need for time-consuming calibration procedures. The metaperceptual themes and exhibition of *Your Hearing Them* is discussed in the next section.

12.1.4 Exhibiting Your Hearing Them

Your Hearing Them was exhibited at the Teatro los Fundadores gallery in Manizales, Colombia, as a part of the International Symposium on Electronic Art in 2017.[487] The symposium had 1250 attendees, and the work was experienced by a large number of people over five days. From this exhibition, I identified design considerations for future versions of this work, and observed a range of interactions with the work.

487 More documentation available at https://www.blakejohnston.net/your-hearing-them

Fig. 119 Installation view of Your Hearing Them at Teatro los Fundadores gallery in Manizales, Colombia, as a part of the International Symposium on Electronic Art in 2017

During the exhibition, one of the headsets was accidentally damaged by an audience member. This accident caused me to present a restricted version of the work. One headset was permanently the speaker, and the other was the receiver. While this meant that a dynamic transportation of perspective between the two users was not possible, it created a clear demarcation of roles within the conversation. The audience members became creators and receivers of the specific experience through the artwork, one sharing the sound of their voice, and one experiencing the other's subjectivity. As with the contingency feature implemented in the software to combat feedback, this adaptation does not necessarily negate the experiential transportation that is the core of the work, but instead frames the audience's attention on different elements of the duplicitous nature of the voice.

Your Hearing Them creates metaperceptual experiences by allowing the wearer to transport their subjectivity to the perspective of another person. This allows them to experience someone else's voice the way they do, and draws attention to their subjective experience of their own voice and how it is unique and different to how others hear it. The experiential elements of the work are reinforced by its semantic content. The title implies the subjectivity of experience which is being explored. While it is impossible to verify if you are hearing someone else's voice exactly as they do, the reciprocal nature of the work means that each wearer can share their experiences with the partner. As they realise that they are hearing an augmented version of their partner's voice, the differences between this version and their normal perception of their partner's voice can be focused upon. In installing the work, once this realisation occurred, the two participants entered into a dialogue where often the listener would ask the speaker to say certain things and make different sounds. This type of dialogue can lead to a shared metaperceptual experience in which both audience members have their attention drawn onto their own subjective perception. By revealing the duplicitous nature of the voice, the work can question the wearer's constructed identity of what they sound like and how this differs between their own perception and those of others.

Fig. 120 The final design of the Your Hearing Them headset

The headset created in the development of *Your Hearing Them* does not only allow for this specific translation of experience, but also as an experiential tool for creating metaperceptual works. In the next section, I present the work *"This is the sound of my voice"* which is closely related to *Your Hearing Them*.

12.2 "This is the sound of my voice"

A New Metaperceptual Perspective Shifter

"This is the sound of my voice" was conceptualised in response to the diversity of the participants' experience while undertaking the previously discussed user study for *Your Hearing Them.* The purpose of conducting the user study was to refine the tuning of the DSP parameters in order to best approximate the wide range of audience members whose voices the work recreates. While this created a helpful generalisation of people's experience, the choice of using a static filter

compromises a degree of quality for the sake of allowing the artwork to be applicable to a wide range of people. The only way to ensure that the work's recreation of one's voice is as convincing as possible is to undertake the process of manually tuning the system's response as detailed in the user study.

"This is the sound of my voice" favours the accuracy of the work's recreation of the voice over interactivity and dialogue. The work involves wearing the same headset as in *Your Hearing Them*, and experiencing a series of recordings in which different people speak the phrase *"This is the sound of my voice"*. This was the phrase that participants of user study were suggested to record for playing back through the headset. The DSP applied to each phrase has been tuned by the speaker, in the same procedure detailed in the user study. This process allows them to present the closest recreation of their voice allowed for by the system. The work endlessly cycles through the phrases, allowing the wearer to experience a range of people's voices as they do.

"This is the sound of my voice" creates metaperceptual experiences, in a similar way to *Your Hearing Them*, by shifting the perspective of the audience. While *Your Hearing Them* allows two audience members to interact with the work and each other by discussing their experience, *"This is the sound of my voice"* positions the wearer solely as the listener. While they may not know who the speaker is, and therefore not a have a reference for how that person's voice normally sounds, the extraordinariness of the work's perceptual qualities reinforces the translation of experience. Most people have not experienced bone transduction through technology, and the responses from the user study discussed in Section 12.1.3, indicate the uniqueness of its phenomenology. Multiple participants commented on the embodiment of sounds seemingly coming from inside of them, and the richness of the experience that the bone transduction produced. Furthermore, the phrase itself reinforces this translation of experience, as the work endlessly asserts that "this is the sound of *my* voice".

"*This is the sound of my voice*" was exhibited in the Listening to Yourself Listening exhibition at Toi Pōneke in July 2018.

12.3 Your Localisation Exposed

A New Metaperceptual Perceptual Rearranger

Your Localisation Exposed is the last work in this portfolio that explores the Perceptual Translation category. It explores the Perceptual Rearrangers subcategory in a manner similar to Carsten

Höller's *Upside-Down Goggles*. Whereas the *Upside-Down Glasses* invert the wearer's visual sense, *Your Localisation Exposed* inverts the wearer's aural field along the horizontal plane. This makes their left their right, and their right their left. By rearranging the wearer's perceptual apparatus, the perceptual processes which often go unnoticed are disrupted, revealing themselves as the wearer is forced to renegotiate their perceptual system. *Your Localisation Exposed* has been exhibited in various events and spaces including TEDxVUW (2017) shown in Fig. 121, New Zealand School of Music (2017), and was installed in the Listening to Yourself Listening exhibition at Toi Pōneke in July 2018. [488] In the following sections, I outline the design of the wearable technology and discuss the ways in which it provokes metaperceptual experiences.

Fig. 121 Your Localisation Exposed at Listening to Yourself Listening exhibition, Toi Pōneke gallery, Wellington, New Zealand

12.3.1 Design

The design of *Your Localisation Exposed* consists of the two parts, the headset and audio electronics.

12.3.1.1 Headsets

The design of the wearable headset went through a series of iterations to refine its qualities. The design considerations for this work are simpler than *Your Hearing Them*. The headset contains a

[488] More documentation available at https://www.blakejohnston.net/your-localisation-exposed

pair of speakers and a pair of microphones. These microphones needed to be positioned approximately in the same space and orientation as the ears. The initial design, shown in Fig. 122, was based on the construction methods used for *Your Hearing Them.* In testing this design, the need for isolating the wearer from their aural environment became apparent. Without this feature, the spill from the outside world obscures the gestalt experience of the work.

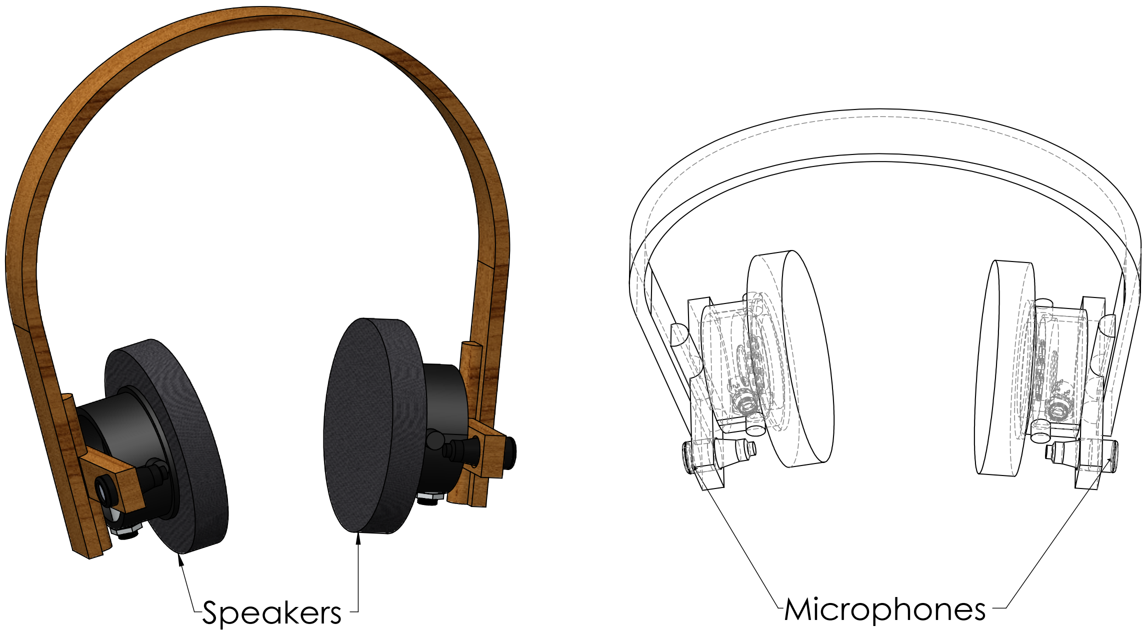


Fig. 122 Early design of headset for Your Localisation Exposed, which did not sufficiently isolate the wearer

In order to achieve this isolation, a new approach of augmenting an existing headset was adopted. As discussed in Section 12.1.2, one of the design considerations for *Your Hearing Them* was that it needed to instil trust in the wearer, as the unfamiliarity of the headset and the experience of the surface transducers may be met with apprehension. While *Your Localisation Exposed* also involves wearing a headset, the user interaction is more familiar, as the headset resembles a common set of headphones, rather than one augmented with added transducers. The augmentations made to the headset were made from 3D printed ABS plastic and bent bamboo, retaining the visual aesthetic of the previously discussed works. A pair of industrial hearing protection earmuffs/headphones were chosen for their high reduction rating of 31 dB and for their embedded speakers.[489] A coupling part, shown in Fig. 123, was designed to attach to the earmuffs and hold a single channel's microphone in place. The microphones and the electronics for the work are described in the following section.

[489] http://www.howardleight.com/ear-muffs/sync

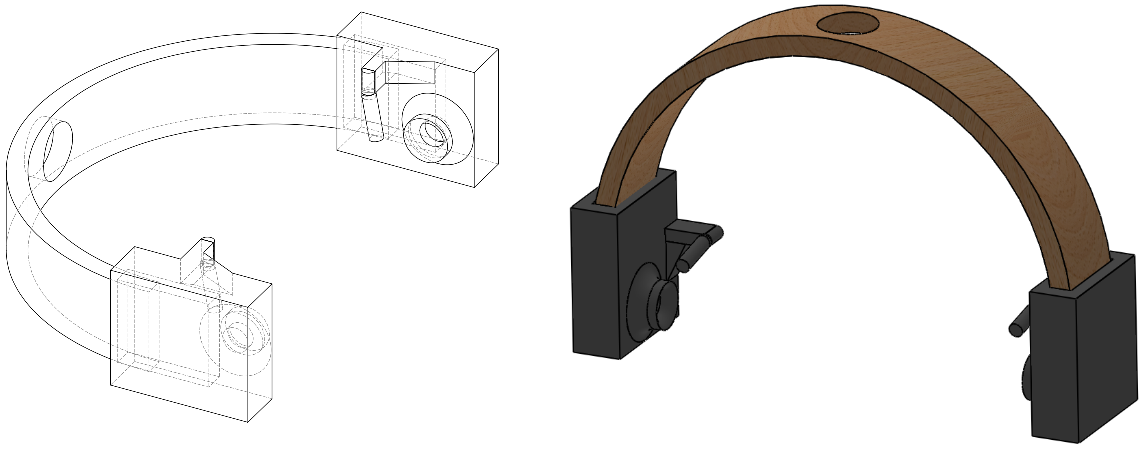


Fig. 123 Design of coupling part which attaches to the earmuffs and holds the microphone

12.3.1.2 Electronics

The electronics for *Your Localisation Exposed* include the microphones, speakers, amplifier and enclosure. The audio from each microphone is sent to an amplifier, which increases the signal and sends the audio to the speaker on the opposite side of the head. The signal flow is illustrated in Fig. 124.

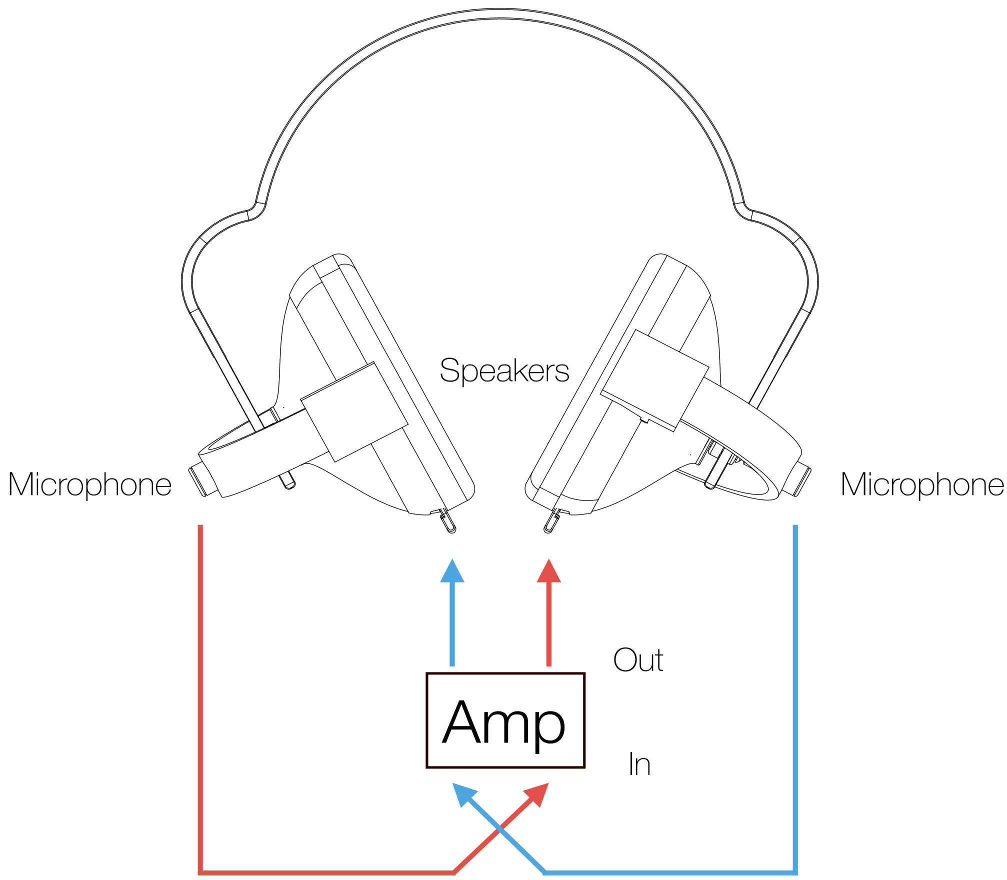


Fig. 124 Signal Diagram for Your Localisation Exposed

As the headset is intended to be worn, and the wearer encouraged to walk through their environment, the amplifier needs to be battery powered to allow this mobility. A commercial mobile recording unit was chosen which satisfied these requirements. The in-built microphones were detached from the unit, and altered to allow them to be embedded in the headset design. An enclosure was built to house the electronics and allow for the individual parts to be plugged and unplugged when needed. The final headset and electronics system is presented in Fig. 125.

Fig. 125 Your Localisation Exposed headset and electronics

12.3.2 Phenomenology of Your Localisation Exposed

Your Localisation Exposed's rearrangement of the wearer's perceptual apparatus creates an immediate response. By inverting the aural field, the wearer's perceptual system is forced into a state of conflict, as the information from their visual and aural sense becomes incongruent. For some users, they immediately understand this conflict, provoking a metaperceptual experience as their attention is drawn to their perception. For other users, the peculiarity of their experience may be immediate, but the cause of it may stay a mystery. This in itself can create a metaperceptual experience, as they examine the extraordinariness of their perception and question how the headset has altered their experience. Most users eventually comprehend the inversion when a clear example of their visual sense and aural sense comes into conflict.

The contradiction between the senses breaks down the integrative synthesis of the wearer's sensorium, and creates a metaperceptual experience by bringing attention to underlying processes that often go unnoticed. Our constant mapping of objects and people in our environment is informed by our aural sense, and walking through a busy environment while wearing the inverting headset can reveal how much we normally rely on this information. For some wearers, this can be a somewhat uncomfortable or uneasy experience, as the malfunctioning of the senses can lead to other co-ordination problems. For others, this becomes a fascinating lens through which to experience the world. Based upon installation experience, the Gestalt effect is most acute in active environments that are not overly busy. Extremely quiet environments do not present enough aural stimuli for the wearer to experience the conflict of senses, and overly busy environments can present difficulties in separating discrete sound objects in space.

As with Carsten Höller's *Upside-Down Goggles*, the experience of the work is on a much smaller timespan than George Malcolm Stratton's pioneering perceptual experiments. Accordingly, the experience is more focused on the disruption of the sensory system rather than our ability to adapt to the reorganisation. To my knowledge, our ability to adapt to this reorganisation in the aural domain is not an active subject of research, and could warrant further study. The close thematic links to *Upside-Down Goggles* makes *Your Localisation Exposed* an exemplar of using metaperceptual approaches to visual works to inform a new sound work.

There are limitations to the headset's inversion of the wearer's aural perception. The aural localisation processes (discussed in Section 2.2) rely on the slight differences between the stimuli of each ear, and the outer ear's acoustic filtration of higher frequencies. The inversion that *Your Localisation Exposed* creates is produced through the location of the two microphones. As the microphones are slightly wider apart than the wearer's ears, the interaural time difference and phase differences between each ear will be affected. Furthermore, the design of the coupling part which holds the microphone is not based on the outer ear, and will not have the filtration effects that provide localisation cues in the vertical plane. The microphone also has its own characteristics which differ from the ear and are imparted on to the sound. While these factors are not recreated in the experience, I have observed that the Gestalt impact of the rearrangement of the perceptual apparatus is the main focus for the audience. I believe these slight differences are overshadowed by the conflict of the perceptual system, and the provocation of having to renegotiate your normal experience of your environment.

12.4 ∞/ø

A New Metaperceptual Deprivation Work

The title of this work, ∞/ø, suggests the extremes of contrast which form its artistic materials. ∞/ø is a collaborative work between sound artist Mo H. Zareei and I, which explores provision and deprivation through multiple opposing forces: light and darkness, noise and silence, and absorption and reflection. The work creates metaperceptual experiences through the dramatic perceptual contrast of deprivation and provision. Provision is created by a speaker and light unit, emitting white noise and white light into the space. The stimuli are directed towards a large panel suspended on the wall, which is divided in to two. One half of the panel reinforces the stimuli, with a mirror's surface reflecting light and soundwaves. The other half creates deprivation though a lack of stimuli, with acoustic foam covered in black cloth absorbing sound and light. I detail its design and construction in the following Section 12.4.1, and the experiential elements of the work in Section 12.4.2.

12.4.1 Design

∞/ø consists of two parts which are separated in space: a panel, and a speaker and light unit. The panel, illustrated in Fig. 126, includes a frame constructed from bamboo that is 1750mm wide, 1200mm long, and 70mm deep. The frame contains a sheet of QuietFibre[490], a foam engineered specifically for maximum noise absorption. While no material can completely absorb all sounds, QuietFibre has a high noise reduction level (NRC 1.00)[491] and is effective at drastically dampening sounds. This material is exposed on one half of the frame, with the other half covered in 3mm acrylic mirror. This creates a hard reflective surface of off which sound and light to reflect.

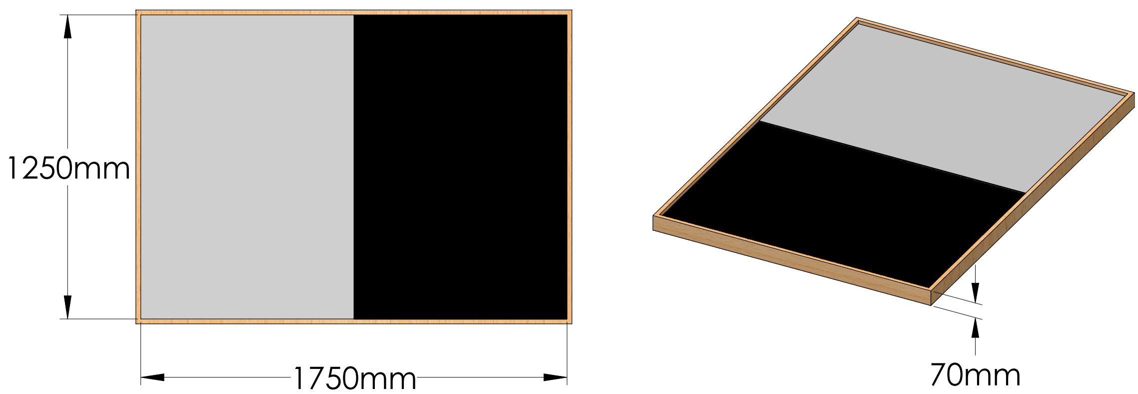


Fig. 126 Diagram of the panel in ∞/ø

---

[490] Acoustiblok, Inc., 'QuietFiber® - Products', *Acoustiblok New Zealand*, 2018.
[491] Acoustiblok, Inc., 'QuietFibre Hydrophobic Noise Absorption Material Product Data Sheet' (Acoustiblok, Inc.).

The sound and light unit consists of a speaker and a strip of white LEDs. The speaker emits noise, which has been filtered to best be absorbed by the QuietFibre material. The QuietFibre datasheet provides the frequency attenuation of the material, and this is mapped to the noise spectrum to maximise the dampening effect.[492] The LED strip is housed in a custom-made laser-cut acrylic enclosure, that has a diffuse front panel. This creates a uniform field of light, illuminating the spectator in the mirror of the panel and offering a stark contrasting to the black of the acoustic foam panel. The design of the sound and light unit is presented in Fig. 127.

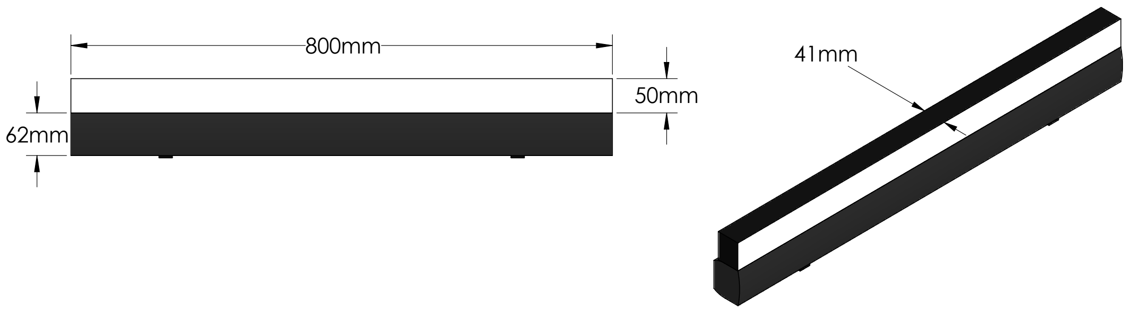


Fig. 127 Diagram of the light and sound emitter in ∞/ø

12.4.2 Phenomenology of ∞/ø

The spatial position of the work, illustrated in Fig. 128, creates an environment in which both provision and deprivation are active experiential elements. Audience member's move between the two elements, with the call of the sound and light emitter on one side, and the response of reflection and absorption on the other. While the sound and light elements of the work remain static, providing the totality of their respective spectrums at once, the dynamic element of the experience is created by the audience's movement in the environment. They are free to engage with the work on their own terms, investigating the environment and the ways in which it interacts with their perception.

[492] Acoustiblok, Inc., 'QuietFibre Hydrophobic Noise Absorption Material Product Data Sheet'.

Fig. 128 ∞/ø installed at the Listening to Yourself Listening exhibition, Toi Pōneke Gallery, Wellington, New Zealand, 2018 [493]

Standing in front of the mirror, they are bombarded by noise and light from both sides, with their visual attention directed back at themselves by the mirror's reflection. While this may draw the attention of the audience back on to themselves, as discussed in Section 9.3, the ubiquity of seeing one's reflection in a mirror means that this experience does not often create metaperceptual experiences. This side of the panel conceptually reinforces the metaperceptual themes of the works, as well as primes the audience's perception as they move towards the other half.

The other half of the panel creates an isolated space of deprivation. The dampening effects of the sound absorption material are quite profound, as it can feel like sounds are being sucked out of your ears. As in many deprivation works, the experience is similar to the malfunctioning of a sense, as it can feel like your ears have been blocked or you have been temporarily deafened. This deprivation creates a metaperceptual experience, as you attend to your sensory sense system and question what is happening to it. This can cause a physiological reaction, as you may strain your ears to hear better and attempt to fix the seemingly malfunctioning sense organ. To cite Robert Welch again, 'Like a perfectly running automobile, human perception is both taken for granted and poorly understood; it has often required a severe malfunction or obstruction of its performance to reveal its workings'[494]

[493] More documentation available at https://www.blakejohnston.net/infinity-over-zero
[494] Welch.

As the deprivation of stimuli draws attention to your perception through making it appear to malfunction, the mirror provides a “palate cleanser” and reference for the deprivation as a counterpart. Moving back and forth over the precipice between provision and deprivation enhances the effect, and makes the cause of the perceptual oddity apparent. As an audience member is free to move throughout the space, they can rotate their head and experience both deprivation and provision simultaneously. One ear can be directed towards the light and sound emitting unit, while the other is directed at the absorption panel. This draws attention to the binaural nature of our auditory system, as the stark contrast between the two ears creates an extraordinary juxtaposition of the two extremes. By rotating their heads, the audience have control over the magnitude of the work’s perceptual effects.

∞/ø is informed by Jacqueline Kiyomi Gordon’s work *I Want You To Want Me To Want You To Want Me*, discussed in Chapter Four. Gordon’s work also creates an isolated space of aural deprivation through sound absorption foam which is presented on the wall of the gallery space. Whereas Gordon’s work contrasts this deprivation with the ambient din in the gallery, ∞/ø seeks to carefully frame the audience’s experience to maximise this contrast and the work’s metaperceptual themes. The wash of noise emitted from the sound and light unit creates a more focused contrast between the two extremes than the ambient noise in a gallery. The work presents these two elements as direct opposites, rather than Gordon’s contrast of her work and the encompassing space. By filtering the noise emitted by the sound and light unit, the absorption effects of the panel’s materials are maximised. The contrast between provision and deprivation is furthered by the reflective half of the panel, which allows the audience to negotiate the juxtaposition, moving their head through the space and experiencing the opposing forces.

This spatial organisation of the juxtaposition allows for the audience to control their interaction with the work, allowing them to investigate the veracity of their experience and their perceptual effects that the panel crates. The positioning of the two elements also creates a demarcation in space in which the audience are guided to inhabit. The only way to investigate both elements is to get between them. The static nature of the light and sound unit means that it does not draw the audience’s attention for an extended period. Contrastingly, as the audience move through the demarcated space, the panel’s effects on their perception draws their attention, and in turn, directs their attention back on to themselves and their seemingly malfunctioning aural sense.

Fig. 129 ∞/ø installed at the Listening to Yourself Listening exhibition, Toi Pōneke Gallery, Wellington, New Zealand, 2018.

∞/ø is the only work in this portfolio which explores the metaperceptual category of deprivation. While there are many avenues for creating new metaperceptual sound works exploring deprivation, many of the ideas in which I was interested in fell outside the scope of this research due to cost, materials, and access required to create deprivation environments. Works such as Doug Wheeler's *PSAD Synthetic Desert III*, discussed in Section 4.1, create powerful deprivation environments that typify the metaperceptual approach, but involve a large amount of resources. I believe that deprivation is an exciting avenue for future artistic explorations, which I further discuss in Chapter Thirteen. Despite ∞/ø small scale, the juxtaposition of provision and deprivation allow it to create a powerful metaperceptual experiences.

12.5 rise.risset

A New Metaperceptual Perceptual Hacking Composition

rise.risset explores the metaperceptual framework in a music performance context. The work is an eight-minute electroacoustic composition written for sonic artist Bridget Johnson's mechatronic speaker array, *speaker.motion*.[495] The work has been performed at The National Library of New Zealand (2016), The Adam Art Gallery (2016), Te Kōkī, New Zealand School of Music Composer's Competition (2016), and Lower Hutt's Dowse Art Museum (2016) shown in Fig. 130.[496] *rise.risset* explores the Perceptual Hacking approach discussed in Part II, by employing a range of aural paradoxes and ambiguities. The mechatronic speaker array affords a high degree of control over the spatial elements of sound, which I use to construct and deconstruct auditory illusions. I outline the technological forces of the work in the next section, and then discuss its metaperceptual themes.

Bridget Johnson's *speaker.motion* is a quartet of mechatronic speakers that can be automated in real-time to rotate and tilt. Through MIDI messages, the composer can send control data to the system to precisely orchestrate their behaviour and position. This allows for the user to control the directionality of the speaker, and in doing so, manipulate the spatial behaviour of sounds. As the speakers move, the strain of the motors can be heard, with jolts of rotation creating bursts of noise, and uniform rotation producing stable pure tones. For most compositions using this system, this is not a major factor as the sound emitted by the speakers masks the noise of the mechatronics. However, instead of treating these sounds as unwanted noise, they form the sonic palette from

---

[495] Bridget Johnson, Michael Norris, and Ajay Kapur, 'Speaker.Motion: A Mechatronic Loudspeaker System for Live Spatialisation', in *NIME'16* (presented at the New Interfaces for Musical Expression, Brisbane, Australia, 2016).

[496] More documentation available at https://www.blakejohnston.net/rise-risset

which the composition is built upon in *rise.risset.* The four *speaker.motion* units are positioned in a square, surrounding and within the audience space.

Fig. 130 Performance of rise.risset at the Dowse Art Museum, Lower Hutt, New Zealand (2016).

rise.risset explores the ambiguous perceptions of causation, localisation, and paradoxical trajectories in pitch and rhythm. The work is structured in three sections, with each section focussing on a different ambiguity or paradox with the intention of creating a compositional exploration of the metaperceptual artefacts discussed in Section 11.2. This structure is illustrated in Fig. 131.

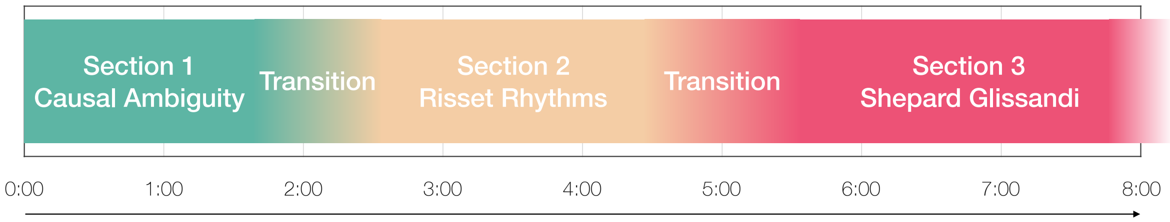


Fig. 131 Illustration of rise.risset's structure

12.5.1 Causal Ambiguity

The opening section explores the ambiguity of the causation of sound. The ensemble is directed to sharply twitch and jolt, creating bursts of mechanical noises which are organised into a rhythmic pattern. The cause of the sounds is evident, as the movement of the speakers directly matches the sonic result. The reasonably quiet noises of the system were recorded during the composition of the work, and as this opening section develops, the cause of the sounds becomes ambiguous. The pre-recorded sounds of the mechanical noises are slowly faded-in, the speakers reinforcing the rhythmic patterns of the ensemble and creating an ambiguous amalgam. As the speaker's reproduction start to rise in volume, the once evident cause of the noises becomes vague. This gradual shift from certainty to ambiguity is a reoccurring theme in the work, provoking the audience to question the veracity of their experience, and in doing so, promoting their attention to be drawn to the fallibility of their perception in a manner akin to many of the metaperceptual works explored in prior chapters.

12.5.2 Risset Rhythm

The first section of the work transitions into the next through focusing on a rhythmic cell. The motif is first articulated by the mechanical sounds, and is then superseded by white noise bursts produced by the speakers, which become the focus of the audience's attention. The rhythmic pattern forms the basis of a Risset rhythm, an auditory illusion discussed in Section 11.2. This paradoxical illusion creates the perception of a rhythm eternally accelerating. As the section progresses, the illusory nature of the acceleration becomes evident, as the listener realises that the overall figure has not truly sped up. As in the first section, the gradual shift from certainty to ambiguity provokes the audience to question the veracity of their experience. This shift is thematic of metaperceptual works that seek to reveal facets our perception that often go unnoticed and overlooked. The impossibility of the rhythmic figure creates metaperceptual experiences by drawing the audience's attention to its deceptive nature and the fallibility of our sensory apparatus.

The Risset rhythm is constructed from four tempo layers, which are distributed across the speakers, one layer in each. As the illusion of the Risset rhythm is constructed through the shifting of attention between the multiple layers that constitute the sound, the spatial distribution of the Risset rhythm adds another facet to the experience. As each layer speeds up and shifts from being the perceptual focus of the audience, this creates a shift in spatial focus. The loudest layer slowly rotates around the audience, adding to the cyclical nature of the illusion. As this section comes to a close, the speakers start to slowly rotate, creating moments where the Risset rhythm disintegrates into its multiple streams as the amplitudes of the noise bursts are filtered by the space.

The disintegration leads into the transition between the second and last section. The Risset rhythm unravels, and each speaker starts to repeat the original rhythmic cell in unison. To further the ambiguity of this section, the evolution of the rhythmic cell mirrors the section's trajectory, but this time the acceleration is not an illusion. The ensemble accelerates together while each unit starts to continuously spin at different rates. The noise bursts swell and reach a crescendo and as the speakers rotate. These discharges reflect off the walls of the space creating a complex dialogue between space and noise. This acceleration of the figure eventually exhausts itself, and fades out while a new element fades in.

As in the beginning of the work, the mechanical noise of the ensemble becomes the sonic palette. The whine of the motors create pure tones, with the four speakers combining to make a tetrachord. The changes in rotation and direction of the speakers indicate the causation of the sounds, and a similar shift from certainty to ambiguity occurs as these pitches swell in volume. The tones created by the mechanical noise of the rotating speakers were recorded, and now are reproduced by the speakers themselves, as they crescendo to an impossibly loud volume for the small mechanical systems to be emitting. This chord forms the basis for the final section.

12.5.3 Shepard Glissandi

The final section of the piece balances the energetic accelerating Risset rhythms with perpetual downwards pitch trajectories. The chord, created by magnifying the mechanical noise of the ensemble, starts to descend in pitch. This downward glissando is created by using Oli Larkin's *Endless Series* Shepard Tone filter effect,[497] which applies a resonant filter bank to create the illusion. This method creates the illusion while retaining timbral elements of the input sound, allowing for a perceptually seamless transition from chord to descending glissandi. Each speaker descends at a different rate, and as the speakers rotate, the audience is bathed in multiple layers of descending trajectories that swirl around the performance space.

As in the second section, the last section creates metaperceptual experiences as the audience realise the movement of pitch is impossible. The complexity of the four streams of descending pitch may prolong this realisation, but as these streams are segregated in the attention of the audience, this paradoxical behaviour becomes apparent. This downwards descent eventually exhausts itself, slowly fading out, with the speakers stopping one by one.

rise.risset is the only work in this portfolio that explores the metaperceptual approach in a compositional and musical performance context. This context allows for the artist to shape the experience of the audience in different ways than in the gallery context. Many of the works in this portfolio create environments in which the audience has a degree of autonomy over their experience. While the performance context restricts this autonomy, it allows for the spatiotemporal experience of the audience to be carefully curated. In *rise.risset*, this temporal organisation allows for careful shifts between unambiguous and ambiguous perceptual phenomena including the

[497] http://www.olilarkin.co.uk/eseries

causality of sound, the tempo of rhythmic figures, and the trajectory of pitch. By exploring the themes of ambiguity and deceptive phenomena, the work creates metaperceptual experiences by drawing the audience's attention to the fallibility of their senses. The potential for new metaperceptual works in this context are further discussed in Chapter Thirteen.

12.6 Destructive Passages One & Two

A New Metaperceptual Perceptual Hacking Installation

The final work in this portfolio of artworks which explore the applications of the metaperceptual framework employ two related aural artefacts: binaural beating and interference patterns. Both artefacts are produced by the interaction of two pure tones that are slightly detuned from one another. The way in which these two tones are presented to the audience determines the artefact that they cause. *Destructive Passages One & Two* is an austere production of these two artefacts, which allows for the audience to investigate the oddities that are being created in their perception. *Destructive Passages One & Two* has been installed at the Adam Art Gallery (2016), Wellington's Alpha Gallery (2017), and as part of the Victoria University Creativity Week in Wellington, New Zealand (2016). The work also featured in the Listening to Yourself Listening exhibition at Toi Pōneke in July 2018.[498] In the following sections, I outline the design of the artwork, and discuss its metaperceptual themes.

12.6.1 Design

The work consists of four sound sculptures positioned in two pairs. Each sound sculpture has a tuning fork which is connected to a bamboo resonating cavity. The fork is actuated by a solenoid, with its sound amplified and channelled into a small area of space by the wooden resonator. The design of the sound sculpture is illustrated in Fig. 132.

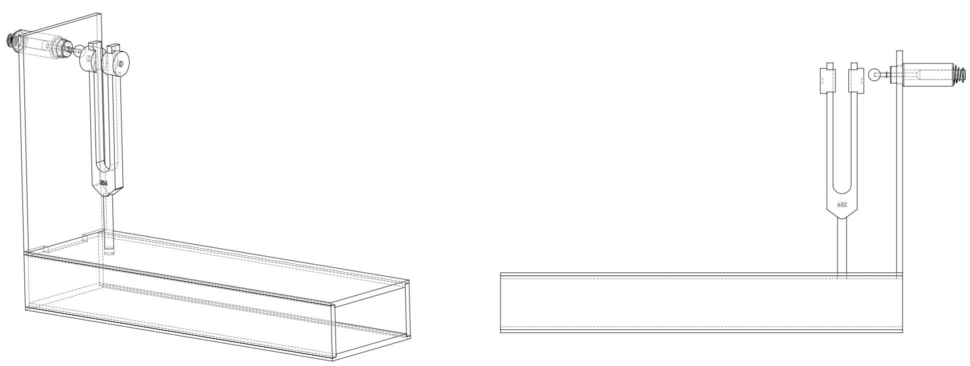


Fig. 132 Design of individual sound sculptures for Destructive Passages One & Two

[498] More documentation available at https://www.blakejohnston.net/destructivepassages

The sculptures are positioned into two pairs, with the orientation of the sculptures playing a key role in the audience's experience of the tones. The first arrangement creates the aural physical artefact of interference patterns, whereas the second arrangement creates the aural cognitive artefact of binaural beating. The first arrangement, shown in Fig. 133, creates nodes of destructive and constructive interference patterns by channelling the detuned tones together. As previously discussed in Section 9.4, the slight difference in frequencies causes a beating effect, with the amplitude fluctuating at the rate of the difference between the two frequencies. The tuning forks were set to 256 Hz and 259 Hz, with this 3 Hz difference strongly producing the beating effect. Due to the small space at which the two sounds are channelled into each other, this arrangement invites the audience to listen in with one ear. As they move their head through the space, the blend between the two tones changes, controlling the intensity of the illusion effect.

Fig. 133 First arrangement of Destructive Passages One & Two which creates interference patterns

The second arrangement, shown in Fig. 134, separates these two tones in space and invites the audience to listen to the two tones dichotically. The two resonating cavities are positioned to address each ear when the audience is facing forward, as can be seen in Fig. 134. As in the first arrangement, the two tuning forks are slightly detuned, this time with a smaller difference of 1.5 Hz to best promote the production of the artefact. As discussed in Section 11.2.3, binaural beating occurs as a by-product of cognitive processes for pitch perception, causing the perception of a third illusory tone which has a confusing pattern of localisation. By presenting the slightly detuned pure tones independently to each ear, the timing of nerve fibres that encode pitch information create the binaural beating artefact. As binaural beats only occur for tones below 1500 Hz, the relatively low frequencies of the tuning forks work well in producing the effect. The audience can move their head through the space around the resonators, blending the two tones together, creating the illusory localisation of the tones moving around the head.

Fig. 134 Second arrangement of Destructive Passages One & Two that creates binaural beating

12.6.2 Electronics

The electronics for *Destructive Passages One & Two* control and actuate the solenoid to strike each arrangement's tuning forks in unison. Each arrangement has a button, which the audience presses to activate the solenoids. The button is connected to an Arduino, which sends control logic to a power MOSFET circuit. This circuit, when activated by the control logic, supplies the solenoid with 24V DC, magnetising its coil which forces the plunger forwards into the tuning fork. The full circuit diagram is presented in Fig. 135.

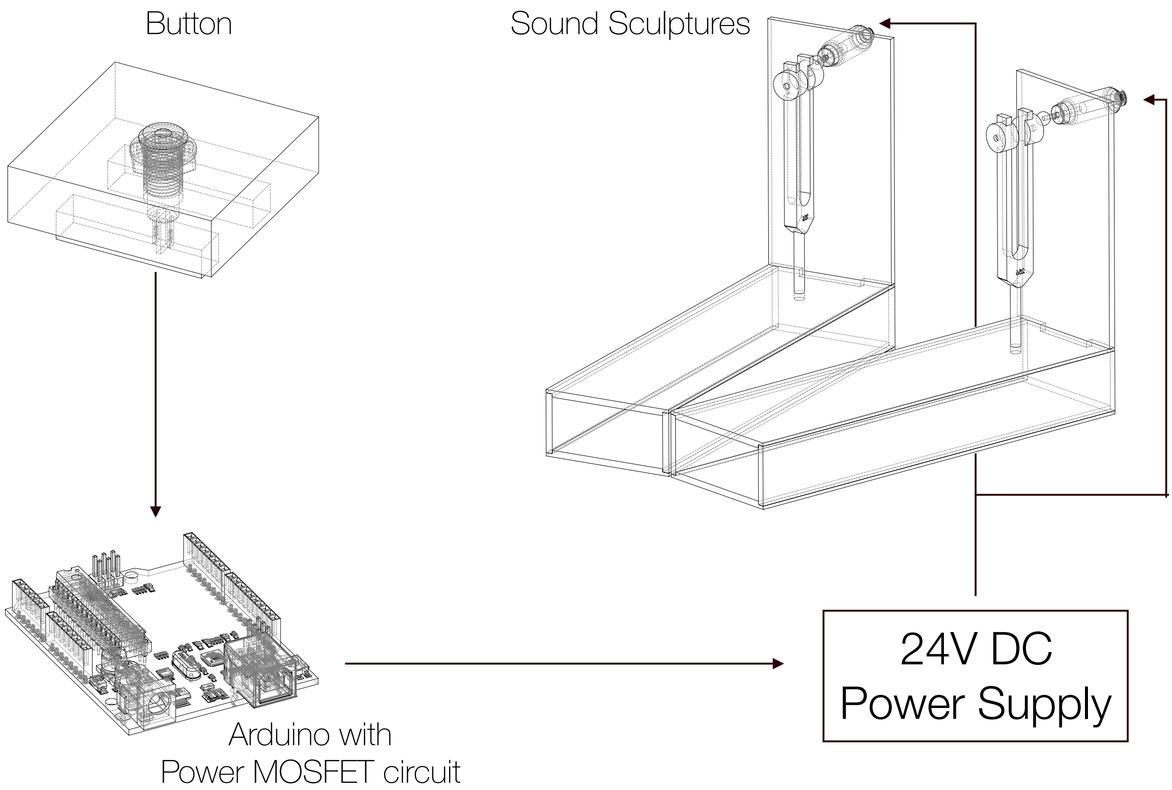


Fig. 135 Circuit diagram for the electronics in Destructive Passages One & Two

12.6.3 Phenomenology of Destructive Passages One & Two

Destructive Passages One & Two creates metaperceptual experiences through the Perceptual Hacking approach, producing perceptual artefacts through two different presentations of pure tones. The austere presentations of the tones by actuating tuning forks is important in framing the audience's experience. The causality of the stimuli is evident, as the audience have control over the triggering of the solenoids firing, and can see the physical actuation of the tuning forks being struck. This means that there is little ambiguity in the source of the artefact, drawing the audience's attention to their own perception. As the tones are channelled by the wooden resonators into a small space, this affords the audience a degree of autonomy over their interaction with the work. The audience can move their head through the small space, controlling the construction and deconstruction of the artefacts in their perception. In this way, they can investigate the veracity of their experience, and in doing so, their attention is drawn back onto their own perception of the sound, creating a metaperceptual experience.

The degree and ways in which each arrangement creates metaperceptual experiences differs. The first arrangement is similar to two previously discussed works in Section 9.4: Carsten Nicolai's *invertone*, and Nicolas Bernier's *Frequencies* series, and in particular, *Frequencies (a/ friction).* Bernier's work was a source of inspiration for *Destructive Passages One & Two,* as his minimalist aesthetic and use of tuning forks presented an elegant way of exploring the physical, visual, and sonic elements of interference patterns. As interference patterns are extraordinary physical stimuli, the directness of the audience's intentionality will often be lead to outside their bodies and to the physical world. The spatial element of these works is what allows them to create metaperceptual experiences. The audience have the ability to move through the space and experience the construction and deconstruction of the extraordinary artefact, which allows for the audience's attention to be drawn back onto their own positionality and subjectivity. In *Destructive Passages One & Two*, this space is the small area at the end of the two wooden resonators. As the audience move their head through the space, they can investigate how the blending of the two tones effects the construction and deconstruction of the artefact.

The way in which the second arrangement creates metaperceptual experiences differs from the first arrangement, as the aural cognitive artefact it produces is experienced internally, and happening inside the body of the audience. As Oster described, 'listening to binaural beats produces the illusion that the sounds are located somewhere within the head.'[499] The extraordinariness of this experience draws the audience's intentionality back onto themselves and the odd phenomena that is occurring inside their heads. As in the first arrangement, the spatial organisation of the production of the artefact is essential in allowing for metaperceptual experiences, as it allows for the audience to have a degree of autonomy over the creation and deconstruction of the artefact in their perception.

The differences between each arrangement work together to heighten the perceptual differences between the two. Both arrangements are very similar in materials, with the actuation of two pure tones evidently caused by the tuning forks. The contrast in experiencing each arrangement reinforces the perceptual system's constant mediation of experience. By revealing the artefacts caused by our perceptual processes, the work seeks to reveal the audience's perception as a subjective vessel through which to experience the world.

[499] Oster, 'Auditory Beats in the Brain'.

Fig. 136 Destructive Passages One & Two Right – Arrangement One. Left – Arrangement Two. Photo Credit: Jim Murphy

As discussed at the beginning of this document, the metaperceptual framework was developed in order to be used as an analysis and a creative tool. The portfolio of new metaperceptual sound artworks presented in this chapter are exemplars of using the metaperceptual framework as a creative tool. They have been informed by the explication of the metaperceptual framework in Part II, where I identified a range of rich artistic avenues to explore. While the works span a range of the approaches identified in the metaperceptual framework, they do not exhaust the possible new avenues for creative exploration. Chapter Thirteen offers a summary of this research project and discusses the potential for future work.

Chapter Thirteen

Conclusions

The research presented in this thesis develops a new creative and analytical framework for sound art. It has identified a thematic trend in the nascent field of sound art, and has sought to provide a coherent framework that contextualises these themes in the wider contemporary art sphere. Furthermore, by mapping the terrain of metaperceptual themes, it has identified new avenues for creative exploration. This chapter provides a summary of the scope of this thesis, presents the key contributions that have arisen from this research, and discusses avenues for future work.

13.1 Summary

As discussed in Chapter One, the overarching goal of this thesis is to explicate the metaperceptual framework. The term metaperceptual is developed in this document to identify a range of artworks that use the perception of the audience as their core artistic material. These works draw the audience's attention back onto themselves, and, in doing so, reveal the idiosyncrasies and nuances of their own subjective experience. Metaperceptual works elevate the audience's perception from a vehicle through which to experience the work to the site of creative exploration. They embrace the subjective nature of experience, and offer the audience an environment in which to investigate their own subjectivities.

The motivations for this research are informed by the nebulous state of the sound art field. In comparison to the visual arts, it is only recently that sound has entered into the gallery space as a core artistic material. As sound art as a field matures, the need for coherent frameworks to explore the creative affordances of the relatively new practice becomes evident. This research connects implicit perceptual themes that exist in a range of works, and by making these implicit themes explicit, seeks to organise a section of the field into a more coherent whole. In Chapter Two, I identify three key movements which are precedents for the exploration of these metaperceptual themes. The evolution of these themes is traced throughout art history, providing a set of artistic paradigms for creating experience-based works. This includes trompe-l'œil and its recently identified sonic counterpart trompe-l'oreille*,* Op Art, and Installation art.

In discussing metaperceptual approaches and works, the need for linguistic and conceptual tools for analysing the audience's experience is evident. Chapter Two discusses related philosophical and artistic precedents that have informed the development of the metaperceptual framework. The philosophical field of Phenomenology offers linguistic tools for discussing our subjective experience, and for articulating the differences between our visual and aural perception. While this allows for nuanced descriptions of experience, phenomenology does not seek to explain perceptual phenomena. For the metaperceptual framework to be a creative tool, an understanding of core perceptual processes is instrumental for exploring perception as an artistic material. Chapter Two's overview of perceptual science allows for complimentary approach to analysing and creating metaperceptual experiences.

The metaperceptual framework is developed in Part II by surveying a range of existing works and producing a taxonomy of the approaches they employ. Three main categories are identified: 'Deprivation', 'Perceptual Translation', and 'Perceptual Hacking'. These three categories provide different perspectives on creating metaperceptual experiences, that together allow us to better understand the possibilities that this framework affords. Chapters Three and Four examine deprivation works that involve the removal, reduction, or denial of the audience's perceptual field. These works often intervene in the audience's everyday modes of interaction by silencing the din of the world around them. This distillation can be a powerful experience, as it offers a brief moment of respite from the barrage of our everyday stimuli environments. Deprivation works create metaperceptual experiences by revealing the facets of experience that often go overlooked, unnoticed, and masked from our awareness.

'Perceptual Translation' is the second metaperceptual category, examined in Chapter Five, Six, Seven, and Eight. These works directly interface with the audience's perceptual apparatus by shifting, extending, and rearranging its orientation and organisation. Many of the Perceptual Translators explore the allure of experiencing what it is like to be someone or something else. By allowing us to experience the world through an altered lens, these works give us a new perspective on the ways in which our perceptual apparatus mediates our experience.

The last category identified is 'Perceptual Hacking', detailed in Chapter Nine, Ten, and Eleven, which involves a rich diversity of perceptual oddities and artefacts. The term 'Perceptual Hacking' has been coined in this thesis to describe an approach to creating artworks that creatively misuse facets of the perceptual apparatus and perceptual processes. Our perception is not a neutral objective lens through which to perceive the world, and these works reveal its constant mediation. The diversity of perceptual oddities is organised into three large sub-categories of artefacts:

Physical, Physiological, and Cognitive. Each category has its own potential for creating metaperceptual experiences, and offers to reveal different facets of our subjective experience.

As well as being an analytical framework to understand the perceptual elements of artworks and the experience of their audiences, the metaperceptual approach is identified as being a rich and underexplored creative framework for the development of new sound art works. To this end, I present a portfolio of new metaperceptual works in Chapter Eleven that were informed by the development of the metaperceptual framework. These works test the artistic avenues identified in the metaperceptual framework, exploring the use of the framework as an artistic tool. They explore a range of approaches discussed in Part II, and are exemplars and manifestations of the creative potential of the metaperceptual framework. By discussing their design and development, the salient artistic considerations for creating metaperceptual works are explored.

13.2 Key Contributions

The key contributions that have arisen from this research are summarised in this section.

The development of the metaperceptual framework for the analysis of existing works and the creation of new works.
Part II is dedicated to explicating the metaperceptual framework through cataloguing the rich diversity of approaches to creating metaperceptual experiences. Within the framework, the three categories of Deprivation, Perceptual Translation, and Perceptual Hacking are identified. Each category features a range of different approaches that have unique metaperceptual potential. Together, this framework offers a powerful tool for analysing a broad range of related works and creating new metaperceptual works.

Using the framework to identify implicit metaperceptual themes in a range of existing artworks.
The method for creating the metaperceptual framework was surveying the approaches explored in artworks which create metaperceptual experiences. These works span a range of styles, media, and forms, creating a broad collection of different metaperceptual approaches. By analysing these works through a metaperceptual lens, new insights into the phenomenology of the audience's experience can be amassed.

The identification of potential avenues for creating new metaperceptual sound artworks.

Through mapping the terrain of metaperceptual approaches, the avenues that are underexplored are identified. The portfolio presented in Chapter Eleven is informed through the identification of these avenues, and are exemplars of using the metaperceptual framework as a creative tool. These works do not exhaust the potential identified in the framework, which is further discussed in the next section.

The contextualisation of the metaperceptual framework in contemporary art and philosophical fields.

Chapter Two focuses on the development of metaperceptual themes throughout art history and identifies three artistic paradigms to creating experience-based works. These are trompe-l'œil and its recently identified sonic counterpart trompe-l'oreille, Op Art, and Installation art. In doing so, the metaperceptual approach is contextualised within the contemporary art sphere.

A portfolio of new metaperceptual sound artworks

This portfolio is informed by the metaperceptual framework, and covers a range of the approaches identified in this document. These publicly exhibited works are exemplars of using the metaperceptual framework as a creative tool. This portfolio includes:

- *Your Hearing Them*, a wearable technology art installation which allows for two audience members to have an augmented conversation in which they experience their partners voice as they do. This work reveals the duplicitous nature of experiencing one voice, and exposes the subjectivity of our constructed identity.
- "*This is the sound of my voice",* a revisitation of *Your Hearing Them*, which allows for the listener to experience the voice of others as they do. Where *Your Hearing Them* compromises a degree of fidelity in recreating a speaker's voice for interactivity and a wide range of users, *"This is the sound my voice"* presents a person's voice in a form that matches the original as closely as possible.
- *Your Localisation Exposed*, a wearable headset which rearranges the user's perceptual apparatus by inverting their perceptual field. This intervention reveals perceptual processes which often go unnoticed are disrupted, revealing themselves as the wearer is forced to renegotiate their perceptual system.
- *∞/ø*, a sound installation that creates an isolated space of deprivation. To further the work's metaperceptual themes, the audience's experience is heightened through a juxtaposition between provision and deprivation, with half of the work creating a barrage of light and noise, and the other half absorbing it.

- *rise.risset*, an electroacoustic composition written for Bridget Johnson's mechatronic speaker array, *speaker.motion*. The work explores the Perceptual Hacking approach by employing a range of aural paradoxes and ambiguities. The work creates a dialogue between deception and revelation, inviting the listener to investigate the veracity of their experience and the fallibility of their perception.
- *Destructive Passages One & Two*, a series of sound sculptures which austerely present the aural artefacts of binaural beating and interference patterns. Through producing the artefact creating stimuli in delimited spaces, the audience can interact with the construction and deconstruction of the phenomena, allowing them to investigate the oddities in their perception.

13.3 Publications, Performances, and Exhibitions

Exhibitions and Performances

Your Hearing Them

- International Symposium on Electronic Art, Manizales, Colombia, 2017.

Your Localisation Exposed

- VUW, Victoria University, Wellington, New Zealand, 2017
- Dawn Chorus Concert, ACR, Te Kōkī, Wellington, New Zealand 2017
- *Listening to Yourself Listen Exhibition,* Toi Pōneke, Wellington, New Zealand 2018.

Destructive Passages One & Two

- Alpha Gallery, Wellington, New Zealand, 2017.
- Victoria University Creativity Week, The Hub, 2016.
- Adam Art Gallery, Wellington, New Zealand, 2016.
- *Listening to Yourself Listen Exhibition*, Toi Pōneke, Wellington, New Zealand 2018.

rise.risset

- The Dowse Art Museum, Lower Hutt, New Zealand, 2016.
- National Library of New Zealand, Wellington, New Zealand, 2016.
- Adam Art Gallery, Wellington, New Zealand, 2016.
- Te Kōkī, New Zealand School of Music Composers Competition, ACR, 2016.

"This is the sound of my voice"

- *Listening to Yourself Listen Exhibition*, Toi Pōneke, Wellington, New Zealand 2018.

∞/ø

- *Listening to Yourself Listen Exhibition*, Toi Pōneke, Wellington, New Zealand 2018.

Publications

- B. Johnston, M. Norris, A. Kapur, J. Murphy 'Extending/Appending The Perceptual Apparatus: A History of Wearable Technology in Art. *Proceedings for the International Symposium on Electronic Art*, *Manizales, Colombia, 2017.*

- B. Johnston, M. Norris, A. Kapur, J. Murphy 'Deceptive Sounds: Auditory Illusions & Artefacts in Sound Art.' *Proceedings for the Australasian Computer Music Conference, Adelaide, Australia, 2017.*

Fig. 137 Original metaperceptual works exhibited and performed as a part of this research

13.4 Future Work

The metaperceptual framework was developed to serve two main functions. As an analytical framework, it can be applied to a large range of artworks to draw out their implicit experiential themes. There are multiple ways in which the metaperceptual framework can develop further as an analysis tool. The framework presented in Part II aims to catalogue the diversity of approaches to creating metaperceptual experiences, but does not claim to be a comprehensive survey of existing metaperceptual works, nor metaperceptual approaches. The works included offer examples of metaperceptual approaches and allow for a detailed discussion of the metaperceptual repercussions of each approach. As the metaperceptual framework is applicable to a larger range of works than discussed in this thesis, future work may include applying the framework to other works not discussed herein. There may be existing artworks that employ approaches not covered in this document, or new works which devise new methods. I see both of these exciting future avenues for research, as both would add to the richness and robustness of the metaperceptual framework.

The second main function of developing the framework is as a creative tool. While this function is evidenced in the portfolio of new metaperceptual works presented in Chapter Twelve, I believe that this avenue has the most potential for further exploration. I believe that the portfolio merely scratches at the surface of the potential creative explorations of the metaperceptual framework, and it is my intention to further pursue this in the future. Furthermore, it is intended that this framework can be a creative tool for other artists, who will bring their own creative practices and perspectives to the metaperceptual framework. It is hoped that this research will disseminate throughout the field and be a provocation of new artworks for other practitioners. The portfolio of new metaperceptual artworks presented in Part III also provides tools for new artistic explorations. The approaches and techniques employed in the portfolio can form the basis for new artistic exploration.

This thesis has provided significant steps towards the explication of a creative and analytical framework in sound art. It has identified implicit themes explored in a range of artworks, and has made them explicit by ordering them in to a coherent taxonomy. The framework has then been used as a creative tool, informing a portfolio of new sound artworks. It is hoped that this is the beginning of fruitful field that can be furthered by a range of practitioners.

Bibliography

Acoustiblok, Inc., 'QuietFiber® - Products', *Acoustiblok New Zealand*, 2018

———, 'QuietFibre Hydrophobic Noise Absorption Material Product Data Sheet' (Acoustiblok, Inc.)

Akers, Larry, 'Mixed Media Moire Animations', *Eye Play Studio -- Artwork by Larry Akers*

'Anagram | Door Into The Dark'

Anderson, Joseph, and Barbara Anderson, 'The Myth of Persistence of Vision Revisted', *Journal of Film and Video*, 45 (1993), 3–12

Anstis, Stuart, Frans A. J Verstraten, and George Mather, 'The Motion Aftereffect', *Trends in Cognitive Sciences*, 2 (1998), 111–17

Azzarello, Nina, 'Thomas Leveritt Highlights Sunscreen's Protective Power with UV Footage', *Designboom*, 15 August 2014

Baker, Kenneth, 'Meg Webster and James Turrell at the Mattress Factory', *Art in America*, May 1985, p. 19

Banks, Robin, and Daniel Cappon, 'Effect of Reduced Sensory Input on Time Perception.', *Perceptual and Motor Skills*, 1962

Barlow, H. B., and J. M. B. Sparrock, 'The Role of Afterimages in Dark Adaptation', *Science*, 144 (1964), 1309–14

Batchelor, Peter, 'Really Hearing the Thing: An Investigation of the Creative Possibilities of Trompe l'Oreille and the Fabrication of Aural Landscapes', in *Proceedings of the 2007 Electroacoustic Music Studies Conference*, 2007

Bätschmann, Oskar, *Ausstellungskünstler: Kult Und Karriere Im Modernen Kunstsystem* (DuMont Köln, 1997)

Bauer, Carol A., Thomas J. Brozoski, and Kristin Myers, 'Primary Afferent Dendrite Degeneration as a Cause of Tinnitus', *Journal of Neuroscience Research*, 85 (2007), 1489–98

Baumgartner, G., 'Indirekte Grössenbestimmung Der Rezeptiven Felder Der Retina Beim Menschen Mittels Der Hermannschen Gittertäuschung', *Pflügers Archiv European Journal of Physiology*, 272 (1960), 21–22

Beccaria, Marcella, *Tate Modern Artists: Olafur Eliasson* (London : New York: Tate, 2013)

Berger, Harris M., and Giovanna P. Del Negro, *Identity and Everyday Life: Essays in the Study of Folklore, Music and Popular Culture* (Wesleyan University Press, 2004)

Bergsland, Andreas, and Trond Engum, 'Unheard Sounds: The Aesthetics of Inaudible Sounds Made Audible', *Journal on The Art of Record Production*, 2015

Bernstein, Paula, '"Door Into the Dark" Immerses You in Darkness and Lets You Find Your Way Out', *IndieWire*, 2015

Bhushan, Bharat, *Biomimetics: Bioinspired Hierarchical-Structured Surfaces for Green Science and Technology* (Springer, 2016)

Bohme, Gernot, Julian Heynen, Agostino de Rosa, and James Turrell, *James Turrell: Geometry of Light*, ed. by Ursula Sinnreich, 1 edition (Ostfildern: Hatje Cantz, 2009)

Bonabeau, Eric, Marco Dorigo, and Guy Theraulaz, *Swarm Intelligence: From Natural to Artificial Systems* (OUP USA, 1999)

Bonnar, Lizann, Frédéric Gosselin, and Philippe G. Schyns, 'Understanding Dali's Slave Market with the Disappearing Bust of Voltaire: A Case Study in the Scale Information Driving Perception', *Perception*, 31 (2002), 683–91

Brandt, Thomas, and Robert B. Daroff, 'The Multisensory Physiological and Pathological Vertigo Syndromes', *Annals of Neurology*, 7 (1980), 195–203

Braus, Ira, 'Retracing One's Steps: An Overview of Pitch Circularity and Shepard Tones in European Music, 1550–1990', *Music Perception: An Interdisciplinary Journal*, 12 (1995), 323–51

Bregman, Albert S., *Auditory Scene Analysis: The Perceptual Organization of Sound* (MIT Press, 1994)

Brent, Jonathan David, 'Music: On Binaural Beats, Self-Medication and Snake Oil', *Lifted Brow, The*, 2014, 38

Brigid Delaney, '"You Could Disappear into It": Anish Kapoor on His Exclusive Rights to the "Blackest Black"; Architect and Artist Defends Controversial Deal with Developers of Vantablack, the Blackest Material "after a Black Hole"', *The Guardian (London, England)*, 2016

Brown, W. C., 'The History of Power Transmission by Radio Waves', *IEEE Transactions on Microwave Theory and Techniques*, 32 (1984), 1230–42

Brughera, Andrew, Larisa Dunai, and William M. Hartmann, 'Human Interaural Time Difference Thresholds for Sine Tones: The High-Frequency Limit', *The Journal of the Acoustical Society of America*, 133 (2013), 2839–2855

Buchan, Kit, 'Decelerator Helmet: Viewing the World in Slow Motion', *The Guardian*, 10 June 2014

Bullock, Theodore Holmes, Carl D. Hopkins, and Richard R. Fay, *Electroreception* (Springer Science & Business Media, 2006)

Cage, John, *Silence: Lectures and Writings* (Wesleyan University Press, 2011)

Cai, Zhi, D. G. Richards, M. L. Lenhardt, and A. G. Madsen, 'Response of Human Skull to Bone-Conducted Sound in the Audiometric-Ultrasonic Range.', *The International Tinnitus Journal*, 8 (2002), 3–8

Campbell, Murray, *The Musician's Guide to Acoustics / Murray Campbell and Clive Greated.* (London: Dent, 1987)

Canévet, Georges, Bertram Scharf, and Marie-Claire Botte, 'Simple and Induced Loudness Adaptation', *Audiology*, 24 (1985), 430–36

Cariani, P. A., and B. Delgutte, 'Neural Correlates of the Pitch of Complex Tones. I. Pitch and Pitch Salience', *Journal of Neurophysiology*, 76 (1996), 1698–1716

Carterette, Edward C., and Roger A. Kendall, 'On the Tuning and Stretched Octave of Javanese Gamelans', *Leonardo Music Journal*, 4 (1994), 59–68

Chechile, Alex, 'Creating Spatial Depth Using Distortion Product Optoacoustic Emissions in Music Composition' (Georgia Institute of Technology, 2015)

———, 'On The Sensations of Tone VIII', *Projects*, 2010

———, 'The Ear Tone Toolbox for Auditory Distortion Product Synthesis', 2016

Cherry, E. Colin, 'Some Experiments on the Recognition of Speech, with One and with Two Ears', *The Journal of the Acoustical Society of America*, 25 (1953), 975–79

Chilvers, Ian, Harold Osborne, and Dennis Farr, *The Oxford Dictionary of Art* (Oxford University Press, 1988)

Chittka, Lars, and Axel Brockmann, 'Perception Space—The Final Frontier', *PLOS Biology*, 3 (2005), e137

Chung, Becky, 'I Looked Into The Void And Saw Marina Abramovic', *Creators*, 2014

Cohen, Walter, 'Form Recognition, Spatial Orientation, Perception of Movement in the Uniform Visual Field', *Visual Search Techniques*, 1960, 119–123

Connolly, Cleary, 'Future Helmets'

Connolly, Denis, Anne Cleary, and Neil McKenzie, 'Meta-Perceptual Helmets for the Dead Zoo' (unpublished Talk, National Museum of Ireland - Natural History, 2015)

Crary, Jonathan, and Olafur Eliasson, *Olafur Eliasson: The Curious Garden: Kunsthalle Basel: 8/1997* (Schwabe & Co. AG Verlag , Basel, 1997)

Crawford, David, 'The Sound of One Ant Walking – inside the World of a Wildlife Audio Expert', *Radio Times*, 19 February 2013

Daly, Scott, 'The Ganzfeld as a Canvas for Neurophysiologically Based Artworks', *Leonardo*, 17 (1984), 172–175

Dars, Célestine, *Images of Deception. The Art of Trompe-L'oeil*, 1st Ed. edition (Oxford: Phaidon Press Ltd, 1979)

Deutsch, Diana, 'An Auditory Illusion', *The Journal of the Acoustical Society of America*, 55 (1974), S18–19

———, 'An Illusion with Musical Scales', *The Journal of the Acoustical Society of America*, 56 (1974), S25–S25

———, 'Diana Deutsch - Octave Illusion', 2013

———, 'Illusions for Stereo Headphones', *Audio Magazine*, 71 (1987), 36–48

———, 'Musical Illusions', *Scientific American*, 233 (1975), 92–105

———, *Musical Illusions & Paradoxes* (Philomel, 1995)

———, 'Paradoxes of Musical Pitch', *Scientific American*, 267 (1992), 88–95

———, *Phantom Words and Other Curiosities* (Philomel Records, 2003)

———, 'The Octave Illusion in Relation to Handedness and Familial Handedness Background', *Neuropsychologia*, 21 (1983), 289–293

———, 'The Psychology of Music', in *Perceptual Ecology* (Elsevier, 1978), pp. 191–224

———, 'Two-Channel Listening to Musical Scales', *The Journal of the Acoustical Society of America*, 57 (1975), 1156–1160

Dictionaries, Oxford, *Oxford English Dictionary*, 7 edition (Oxford: Oxford University Press, 2013)

Doane, B. K., Winston Mahatoo, W. Heron, and T. H. Scott, 'Changes in Perceptual Function after Isolation.', *Canadian Journal of Psychology/Revue Canadienne de Psychologie*, 13 (1959), 210

Doppler, Christian, *Über Das Farbige Licht Der Doppelsterne Und Einiger Anderer Gestirne Des Himmels* (Calve, 1842)

'Doug Wheeler: PSAD Synthetic Desert III', *Guggenheim*, 2016

Dougan, Alice Maria, and Margaret Furlong, *Art Index* (H.W. Wilson., 1978)

Drake, Carolyn, 'Review: Hear|say: Round and Round', *The Listener*, 2015

Duensing, Sally, and Bob Miller, 'The Cheshire Cat Effect', *Perception*, 8 (1979), 269–73

Dwyer, Jim, 'Moved to Tears at the Cloisters by a Ghostly Tapestry of Music', *The New York Times* (New York, 19 September 2013), section N.Y. / Region

E, Willoughby Colin, Ponzin Diego, Ferrari Stefano, Lobo Aires, Landau Klara, and Omidi Yadollah, 'Anatomy and Physiology of the Human Eye: Effects of Mucopolysaccharidoses Disease on Structure and Function – a Review', *Clinical & Experimental Ophthalmology*, 38 (2010), 2–11

Ebert-Schifferer, S., and National Collection of Fine Arts (U.S.), *Deceptions and Illusions: Five Centuries of Trompe l'oeil Painting* (National Gallery of Art, 2002)

Etani, Takehito, 'The Third Eye Project', *Takehito Etani*, 2016

Etherington, Rose, 'Eidos by Tim Bouckley, Millie Clive-Smith, Mi Eun Kim and Yuta Sugawara', *Dezeen*, 1 May 2013

Eugene Jones, C., and Stephen L. Buchmann, 'Ultraviolet Floral Patterns as Functional Orientation Cues in Hymenopterous Pollination Systems', *Animal Behaviour*, 22 (1974), 481–85

Evening Standard, 'Lost in the Fog', *Evening Standard*, 2007

Fleischer, Gerald, *Evolutionary Principles of the Mammalian Middle Ear* (Springer Science & Business Media, 2013)

Fletcher, Neville H., and Thomas D. Rossing, *The Physics of Musical Instruments* (Springer Science & Business Media, 2012)

Fossati, Giovanna, *From Grain to Pixel: The Archival Life of Film in Transition* (Amsterdam University Press, 2009)

Franosch, Jan-Moritz P., Richard Kempter, Hugo Fastl, and J. Leo van Hemmen, 'Zwicker Tone Illusion and Noise Reduction in the Auditory System', *Physical Review Letters*, 90 (2003), 178103

Frearson, Amy, 'Dalston House by Leandro Erlich', *Dezeen*, 2013

Fung, Kai-hung, 'The Rainbow Technique: An Innovative Approach to the Artistic Presentation of 3D Computed Tomography', *Leonardo*, 39 (2006), 101–101

Gann, Kyle, 'La Monte Young's The Well-Tuned Piano', *Perspectives of New Music*, 31 (1993), 134–62

———, *No Such Thing as Silence: John Cage's 4'33"* (Yale University Press, 2010)

Gelfand, Stanley A., and Stanley Gelfand, *Hearing: An Introduction to Psychological and Physiological Acoustics, Fourth Edition* (Taylor & Francis, 2004)

Gibson, James J., *The Ecological Approach to Visual Perception: Classic Edition* (Psychology Press, 2014)

Godspeed You! Black Emperor, *F# A# Infinity* (Montreal, Quebec: Constellation, 1997)

Goldberger, Leo, and Robert R. Holt, 'Experimental Interference with Reality Contact (Perceptual Isolation): Method and Group Results.', *Journal of Nervous and Mental Disease*, 1958

Goldstein, Bruce E., *Sensation and Perception*, 8th Edition (Cengage Learning, 1994)

Goldstein, Julius L., 'An Optimum Processor Theory for the Central Formation of the Pitch of Complex Tones', *The Journal of the Acoustical Society of America*, 54 (1973), 1496–1516

Gombrich, Ernst Hans, Ernst Hans Gombrich, Ernst Hans Gombrich, and Ernst Hans Gombrich, *Art and Illusion: A Study in the Psychology of Pictorial Representation* (Phaidon London, 1977), V

González, Jennifer A., *Subject to Display: Reframing Race in Contemporary Installation Art* (MIT Press, 2008)

Gordon, Jacqueline Kiyomi, Artist Profile: Jacqueline Kiyomi Gordon, 2012

Govan, Michael, Christine Y. Kim, Florian Holzherr, Alison de Lima Greene, and E. C. Krupp, *James Turrell: A Retrospective*, 1st edition (Los Angeles : Munich ; New York: Prestel USA, 2013)

Gregory, Richard, and Patrick Cavanagh, 'The Blind Spot', *Scholarpedia*, 6 (2011), 9618

Gregory, Richard L., 'Knowledge in Perception and Illusion', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 352 (1997), 1121–1127

Gregory, Richard L, 'Putting Illusions in Their Place', *Perception*, 20 (1991), 1–4

Gregory, Richard Langton, *Eye and Brain: The Psychology of Seeing* (McGraw-Hill, 1978)

Grimm, Juniana, Lon Schnittgrund, and James Harley, 'Waves Gold Native Bundle Version 3.0', *Computer Music Journal*, 25 (2001), 102–106

Grimshaw, Jeremy, *Draw a Straight Line and Follow It: The Music and Mysticism of La Monte Young* (Oxford University Press, 2011)

Grunebaum, Henry U., Sandford J. Freeman, and Milton Greenblatt, 'Sensory Deprivation and Personality', *American Journal of Psychiatry*, 116 (1960), 878–882

Gryczkowska, Agnieszka, '"Changing Light Corridor with Rooms", Bruce Nauman, 1971', *Tate*, 2011

Grynsztejn, Madeleine, Daniel Birnbaum, Michael Speaks, and Olafur Eliasson, *Olafur Eliasson*, Revised & Expanded ed. edition (London ; New York, NY: Phaidon Press, 2002)

Guerrasio, Jason, 'Christopher Nolan Explains the Biggest Challenges in Making His Latest Movie "Dunkirk" into an "Intimate Epic"', *Business Insider Australia*, 2017

Hampton, Chris, 'I Stared Into the Void at a Secret Light Show in Las Vegas', *Motherboard*, 2015

Han, Byung In, Ho Won Lee, Tae You Kim, Jun Seong Lim, and Kyoung Sik Shin, 'Tinnitus: Characteristics, Causes, Mechanisms, and Treatments', *Journal of Clinical Neurology (Seoul, Korea)*, 5 (2009), 11–19

von Hantelmann, D., 'The Experiential Turn', *Living Collections Catalogue*, 1 (2014)

He, Sheng, and Wendy L. Davis, 'Filling-in at the Natural Blind Spot Contributes to Binocular Rivalry', *Vision Research*, 41 (2001), 835–40

Heidegger, Martin, *Being and Time*, Reprint edition (New York: Harper Perennial Modern Classics, 2008)

von Helmholtz, Hermann, 'On the Sensations of Tone as a Physiological Basis for the Theory of Music, Trans', *London*, 168 (1885)

Helmholtz, Hermann von, and James Powell Cocke Southall, *Treatise on Physiological Optics* (Courier Corporation, 2005)

Herman, Gabor T., *Fundamentals of Computerized Tomography: Image Reconstruction from Projections* (Springer Science & Business Media, 2009)

Higgins, Charlotte, 'A Life in Art: Anish Kapoor', *The Guardian*, 8 November 2008, section Art and design

Hjertmann, Ben, 'Combination Tones as Harmonic Material' (unpublished Doctor of Music, Northwestern University, 2013)

Hochberg, Julian E., William Triebel, and Gideon Seaman, 'Color Adaptation under Conditions of Homogeneous Visual Stimulation (Ganzfeld).', *Journal of Experimental Psychology*, 41 (1951), 153

Holcombe, Alex O., Donald I. A. MacLeod, and Scott T. Mitten, 'Positive Afterimages Caused by a Filled-in Representation', *Journal of Vision*, 4 (2004), 485–485

Höller, Carsten, *Experience / Carsten Höller ; [Director's Foreword by Lisa Phillips ; Introduction by Massimiliano Gioni ; Curated by Massimiliano Gioni, with Gary Carrion-Murayari and Jenny Moore.]* (New York, N.Y: Skira Rizzoli in association with New Museum, 2011)

Hollerweger, Florian, 'The Revolution Is Hear! Sound Art, the Everyday and Aural Awareness'

Holmberg, Jan, 'Ideals of Immersion in Early Cinema', *Cinémas : Revue d'études Cinématographiques / Cinémas : Journal of Film Studies*, 14 (2003), 129–47

Holtham, Susan, and Fiontan Moran, 'Five Ways to Look at Malevich's Black Square', 2014

Howard, David Martin, and Jamie Angus, *Acoustics and Psychoacoustics* (Taylor & Francis, 2006)

Howells, Thomas, 'Inside a Room Built for Total Silence', *Motherboard*, 2015

Hudspeth, A. J., 'How the Ear's Works Work', *Nature*, 341 (1989), 397–404

Husserl, Edmund, 'Ideas, Trans. WR Boyce Gibson', *London: George Allen & Unwin LTD*, 19 (1931), 69

———, *Logical Investigations. Translated by JN Findlay* (Humanities Press, 1970)

Hwang, Jangsun, Yoon Jeong, Jeong Min Park, Kwan Hong Lee, Jong Wook Hong, and Jonghoon Choi, 'Biomimetics: Forecasting the Future of Science, Engineering, and Medicine', *International Journal of Nanomedicine*, 10 (2015), 5701–13

Hylton, Wil S., 'How James Turrell Knocked the Art World Off Its Feet', *The New York Times*, 13 June 2013, section Magazine

Ihde, Don, *Listening and Voice: Phenomenologies of Sound*, 2 edition (Albany: State University of New York Press, 2007)

Jackson, Blair, 'Batman Rides Again: The Dark Knight | Mixonline', 2008

Jacob, Pierre, 'Intentionality', in *The Stanford Encyclopedia of Philosophy*, ed. by Edward N. Zalta, Winter 2014 (Metaphysics Research Lab, Stanford University, 2014)

Janiuk, Jessica, 'Gaming Is My Safe Space: Gender Options Are Important for the Transgender Community', *Polygon*, 2014

Jastrow, Joseph, 'The Mind's Eye.', *Popular Science Monthly*, 1899

Johnson, Bridget, Michael Norris, and Ajay Kapur, 'Speaker.Motion: A Mechatronic Loudspeaker System for Live Spatialisation', in *NIME'16* (presented at the New Interfaces for Musical Expression, Brisbane, Australia, 2016)

Johnson, Ken, 'At Marina Abramovic's "Generator," Blindfolds Are Required', *The New York Times*, 6 November 2014

Jones, Arthur Taber, 'The Discovery of Difference Tones', *American Journal of Physics*, 3 (1935), 49–51

Kahn, Douglas, 'Active Hearing: Jacob Kirkegaard Labyrinthitis', *Labyrinthitis*, 2008

———, *Noise, Water, Meat: A History of Sound in the Arts*, Reprint edition (Cambridge, Mass.: The MIT Press, 2001)

Kane, Brian, ‘Musicophobia, or Sound Art and the Demands of Art Theory’, *EDITORIAL BOARD*, 2013, 76

———, *Sound Unseen: Acousmatic Sound in Theory and Practice* (Oxford University Press, USA, 2014)

Kanizsa, Gaetano, ‘Subjective Contours’, *Scientific American*, 234 (1976), 48–53

Kapoor, Anish, *Descent into Limbo*, 1992

Kapoor, Anish, and Andrew Marr, Anish Kapoor on Light and Dark, Start the Week - BBC Radio 4, 2016

Keele, Kenneth D., *Leonardo Da Vinci's Elements of the Science of Man* (Academic Press, 2014)

Kemp, David T., ‘Otoacoustic Emissions, Their Origin in Cochlear Function, and Use’, *British Medical Bulletin*, 63 (2002), 223–41

Kendall, Gary S., Christopher Haworth, and Rodrigo F. Cádiz, ‘Sound Synthesis with Auditory Distortion Products’, *Computer Music Journal*, 38 (2014), 5–23

Kim-Cohen, Seth, *In the Blink of an Ear: Toward a Non-Cochlear Sonic Art*, 1 edition (New York: Bloomsbury Academic, 2009)

King, Anthony, ‘Interview: Olafur Eliasson’, *ECSJ2017*, 2017

Kirkegaard, Jacob, ‘Labyrinthitis’, 2008

Kleinberger, Rebecca, Gershon Dublon, Joseph Paradiso, and Tod Machover, ‘PHOX Ears: Parabolic, Head-Mounted, Orientable, EXtrasensory Listening Device’

Krauss, Rosalind, ‘Sculpture in the Expanded Field’, *October*, 8 (1979), 31–44

Krochmal, Aaron R., George S. Bakken, and Travis J. LaDuc, ‘Heat in Evolution's Kitchen: Evolutionary Perspectives on the Functions and Origin of the Facial Pit of Pitvipers (Viperidae: Crotalinae)’, *Journal of Experimental Biology*, 207 (2004), 4231–38

Kubisch, Christina, ‘Electrical Walks’, *Electromagnetic Investigations in the City*

Land, Michael F., and Dan-Eric Nilsson, *Animal Eyes* (Oxford University Press, 2002)

Landy, Leigh, *Understanding the Art of Sound Organization* (Cambridge, Mass: The MIT Press, 2007)

Lansky, Paul, ‘Stepping Outside for a Moment: Narrative Space in Two Works for Sound Alone’, *Music, Electronic Media and Culture*, 2000, 217

Leeder, Murray, ‘Collective Screams: William Castle and the Gimmick Film’, *The Journal of Popular Culture*, 44 (2011), 773–95

Leopold, David A., and Nikos K. Logothetis, ‘Multistable Phenomena: Changing Views in Perception’, *Trends in Cognitive Sciences*, 3 (1999), 254–64

Levitt, Harry, ‘A Historical Perspective on Digital Hearing AIDS: How Digital Technology Has Changed Modern Hearing AIDS’, *Trends in Amplification*, 11 (2007), 7–24

Licklider, J. C. R., '"Periodicity" Pitch and "Place" Pitch', *The Journal of the Acoustical Society of America*, 26 (1954), 945–945

Licklider, J. C. R., J. C. Webster, and J. M. Hedlun, 'On the Frequency Limits of Binaural Beats', *The Journal of the Acoustical Society of America*, 22 (1950), 468–73

Life in the Undergrowth (BBC Home Entertainment, 2006)

Lilly, John C., 'Mental Effects of Reduction of Ordinary Levels of Physical Stimuli on Intact, Healthy Persons.', *Psychiatric Research Reports*, 1956

Lilly, John Cunningham, *The Deep Self: Profound Relaxation and the Tank Isolation Technique* (Simon & Schuster, 1977)

Liu, Jiangang, Jun Li, Lu Feng, Ling Li, Jie Tian, and Kang Lee, 'Seeing Jesus in Toast: Neural and Behavioral Correlates of Face Pareidolia', *Cortex*, 53 (2014), 60–77

Lo, Teddy, 'Positive Void', *Teddy Lo Studio - A LEDARTIST SUBSIDIARY*, 2014

Loizeau, Jimmy, and James Auger, *Social Tele-Presence*, 2001

London, Andrew, '2017 Is the Year VR Went from Gimmick to Game-Changer', *TechRadar*, 2017

Long, Gerald M., 'Duration and Resolution Effects on Visual Persistence (Positive Afterimages)', *Bulletin of the Psychonomic Society*, 23 (1985), 409–12

López, Francisco, 'Environmental Sound Matter', April 1998

———, Interview for DB magazine, 2004

———, *La Selva* (V2_Archief, 1998)

Lundell, Niklas, and Louise Höjer, 'Lundahl & Seitl: Symphony of a Missing Room', *Thisistomorrow*

Maître, Ikse, 'Primary Intimacy of Being', *Le Pixel Blanc*, 2013

Mallock, A., 'I. Insect Sight and the Defining Power of Composite Eyes', *Proceedings of the Royal Society of London*, 55 (1894), 85–90

Manaugh, Geoff, 'Make It A Cross-Species Halloween', *Gizmodo Australia*, 2013

Marshmallow Laser Feast, 'In the Eyes of the Animal', *Experiences | Oculus*

Martinez-Conde, Susana, Dave Conley, Hank Hine, Joan Kropf, Peter Tush, Andrea Ayala, and others, 'Marvels of Illusion: Illusion and Perception in the Art of Salvador Dali', *Frontiers in Human Neuroscience*, 9 (2015)

Maryanne Amacher, *Sound Characters*, Composer Series – TZ 7043 (US: Tzadik, 1999), TZ 7043

Mather, George, *Foundations of Sensation and Perception: Second Edition*, 2 edition (Hove, East Sussex England ; New York: Psychology Press, 2009)

Mathews, M. V., 'The Digital Computer as a Musical Instrument', *Science*, 142 (1963), 553–57

McCollough, Celeste, ‘Color Adaptation of Edge-Detectors in the Human Visual System’, *Science*, 149 (1965), 1115–1116

McCoy, Alfred, *A Question of Torture: CIA Interrogation, from the Cold War to the War on Terror*, Reprint edition (New York: Holt Paperbacks, 2006)

McDermon, Daniel, ‘How Much Silence Is Too Much? I Found Out’, *The New York Times*, 7 April 2017, section Art & Design

McIntyre, Ronald, and David Woodruff Smith, ‘Theory of Intentionality’, in *Husserl's Phenomenology: A Textbook*, ed. by William R. McKenna and J. N. Mohanty (University Press of America, 1989)

McKinnon, Dugal, ‘Dead Silence: Ecological Silencing and Environmentally Engaged Sound Art’, *Leonardo Music Journal*, 23 (2013), 71–74

Mckinnon, Dugal, ‘Janet Cardiff, The Forty-Part Motet’, *Dugal McKinnon — Composer, Sound Artist, Researcher*, 2011

Merleau-Ponty, Maurice, *Phenomenology of Perception* (Psychology Press, 2002)

———, *The World of Perception*, trans. by Oliver Davis (Abingdon, United Kingdom: Routledge, 2004)

Miller, James W., and Robert J. Hall, ‘The Problem of Motion Perception and Orientation in the Ganzfeld’, *Visual Problems of the Armed Forces. Washington: National Academy of Science-National Research Council*, 1962, 14–20

Mills, M., ‘Hearing Aids and the History of Electronics Miniaturization’, *IEEE Annals of the History of Computing*, 33 (2011), 24–45

Minsky, Marvin, ‘Telepresence’, 1980

Misa, Thomas J., and Robert W. Seidel, *College of Science and Engineering: The Institute of Technology Years (1935-2010)* (Lulu Press, Inc., 2011)

Moncrieff, R. W., ‘Olfactory Adaptation and Odour Likeness’, *The Journal of Physiology*, 133 (1956), 301–16

Moorhouse, Paul, *Bridget Riley*, 1st edition (London : New York: Tate, 2003)

Mosse, Richard, ‘Heat Maps’, *Heat Maps*

Müller-Lyer, Franz Carl, ‘Optische Urteilstäuschungen’, *Archiv Für Anatomie Und Physiologie, Physiologische Abteilung*, 2 (1889), 263–270

Nagel, Thomas, ‘What Is It Like to Be a Bat?’, *The Philosophical Review*, 83 (1974), 435–50

Necker, L. A., ‘Observations on Some Remarkable Phenomenon Which Occurs in Viewing a Figure of a Crystal or Geometrical Solid’, *London and Edinburgh Philosophical Magazine and Journal of Science*, 3 (1832), 329–337

Neuhaus, Max, ‘Elusive Sources and" Like" Spaces’, *Turin, Galleria Giorgio Persano*, 1990

Nolan, Christopher, *Dunkirk* (Warner Bros, 2017)

———, *Inception* (Warner Home Video, 2010)

———, *The Dark Knight Rises* (Warner Home Video, 2012)

Oliveira, Nicolas De, Nicola Oxley, and Michael Petry, *Installation Art in the New Millennium: The Empire of the Senses* (Thames & Hudson, 2003)

'Op Art: Pictures That Attack The Eye', *Time Magazine*, 23 October 1964, 78–85

Oram, Daphne, *An Individual Note: Of Music, Sound and Electronics* (Galliard Ltd, 1972)

Ortner, Ingrid, 'Architekturbüro O&O Baukunst', *BAUKUNST*

Oster, Gerald, 'Auditory Beats in the Brain', *Scientific American*, 229 (1973), 94–102

———, 'Phosphenes', *Scientific American*, 222 (1970), 82–87

Packer, Lelia, and Jennifer Sliwka, *Monochrome: Painting in Black and White* (New Haven, CT: National Gallery London, 2017)

Paris Photo, Richard Mosse, 2017

Pasek, Anne, 'Seeing Yourself Strangely: Media Mirroring in Takehito Etani's The Third Eye Project', *Metaverse Creativity*, 4 (2014), 121–38

Penrose, L. S., and R. Penrose, 'Impossible Objects: A Special Type of Visual Illusion', *British Journal of Psychology*, 49 (1958), 31–33

Perkis, Tim, review of *Review of Crossings*, by Alvin Lucier and Emanuel Dimas de Melo Pimenta, *Leonardo Music Journal*, 1 (1991), 112–112

Pierre, Schaeffer, 'Traité Des Objets Musicaux', *Editions Du Seuil. Paris. France*, 1966

Pink Floyd, *Meddle* (Los Angeles, USA: Capitol, 1971)

Pittock, M., *Material Culture and Sedition, 1688-1760: Treacherous Objects, Secret Places* (Springer, 2013)

Ponzo, Mario, *Intorno Ad Alcune Illusioni Nel Campo Delle Sensazioni Tattili, Sull'illusione Di Aristotele e Fenomeni Analoghi* (Wilhelm Engelmann, 1910)

Potthast, Lorenz, 'The Decelerator Helmet', 2018

Pratt, Hillel, Arnold Starr, Henry J. Michalewski, Andrew Dimitrijevic, Naomi Bleich, and Nomi Mittelman, 'Cortical Evoked Potentials to an Auditory Illusion: Binaural Beats', *Clinical Neurophysiology*, 120 (2009), 1514–24

Previc, Fred H., and William R. Ercoline, *Spatial Disorientation in Aviation* (Reston, United States: American Institute of Aeronautics and Astronautics, 2000)

Pugliese, Marina, *Ephemeral Monuments: History and Conservation of Installation Art*, ed. by Barbara Ferriani (Los Angeles, USA: Getty Publications, 2013)

Rackham, Harris, William Henry Samuel Jones, and D. E. Eichholz, *Pliny: Natural History* (Harvard University Press, 1947), VII

Railing, Patricia, *Malevich Paints: The Seeing Eye* (London: Artists Bookworks, 2018)

Raspet, August, ‘Biophysics of Bird Flight’, *Science*, 132 (1960), 191–200

Raz, Mical, ‘Alone Again: John Zubek and the Troubled History of Sensory Deprivation Research’, *Journal of the History of the Behavioral Sciences*, 49 (2013), 379–95

Ready at Dawn, *Lone Echo*, 2017

Regine, ‘Animal Superpowers’, *We Make Money Not Art*, 2008

———, ‘Inner World / Innen Welt: The Projects of Haus-Rucker-Co., 1967-1992’, *We Make Money Not Art*, 2012

Reiss, Julie H., *From Margin to Center: The Spaces of Installation Art*, Reprint edition (Cambridge, Mass.: The MIT Press, 2001)

‘Research Concept’, *The Machine to Be Another*

Rich, Sarah K., ‘Allegories of Op’, *Artforum*, May 2007, 312–27

Richards, Austin, and Rachel Leintz, ‘Forensic Reflected Ultraviolet Imaging’, *Journal of Forensic Identification; Alameda*, 63 (2013), 46–69

Richardson, Mark, ‘Maryanne Amacher and Stepping Into It’, *Pitchfork*, 2009

Ridenour, Thomas, *Alvin Lucier: Crossings* (Lovely Music, Ltd., 1990)

Risset, Jean-Claude, ‘Computer Music Experiments 1964 - ...’, *Computer Music Journal*, 9 (1985), 11–18

Risset, Jean-Claude, ‘Pitch and Rhythm Paradoxes: Comments on “‘Auditory Paradox Based on Fractal Waveform’” [J. Acoust. Soc. Am. 79, 186–189 (1986)]’, *The Journal of the Acoustical Society of America*, 80 (1986), 961–62

Risset, Jean-Claude, ‘Pitch Control and Pitch Paradoxes Demonstrated with Computer-Synthesized Sounds’, *The Journal of the Acoustical Society of America*, 46 (1969), 88–88

———, ‘Rhythmic Paradoxes and Illusions: A Musical Illustration.’, in *ICMC* (presented at the International Computer Music Conference, Thessaloniki, Greece, 1997)

Rogers, Brian, and Kenneth Brecher, ‘Straight Lines,“Uncurved Lines”, and Helmholtz’s “Great Circles on the Celestial Sphere”’, *Perception*, 36 (2007), 1275–1289

Roginska, Agnieszka, and Paul Geluso, *Immersive Sound: The Art and Science of Binaural and Multi-Channel Audio* (Milton, United Kingdom: Taylor & Francis Group, 2017)

Rokos, Jim, ‘Jim Rokos Design - Leaping Rabbit’, *Leaping Rabbit*

Rosen, Edward, ‘The Invention of Eyeglasses: Part II’, *Journal of the History of Medicine and Allied Sciences*, 11 (1956), 183–218

Russolo, Luigi, *The Art of Noises*, 6 (Pendragon Press, 1986)

Rutkin, Aviva, ‘Digital Mirror Reveals What Lies under Your Skin’, *New Scientist*, 15 April 2014

Sacks, Oliver, *The Mind's Eye*, 1 edition (New York: Alfred A. Knopf, 2010)

Sakitt, Barbara, 'Iconic Memory.', *Psychological Review*, 83 (1976), 257

Sakitt, Barbara, and Gerald M. Long, 'Cones Determine Subjective Offset of a Stimulus but Rods Determine Total Persistence', *Vision Research*, 19 (1979), 1439–1441

———, 'Relative Rod and Cone Contributions in Iconic Storage', *Perception & Psychophysics*, 23 (1978), 527–536

Sanzaru, and Oculus Studios, *Marvel Powers United VR*, 2018

Schaefer, John, *New Sounds: A Listener's Guide to New Music* (Harpercollins, 1987)

Schaeffer, Pierre, 'Acousmatics', *Audio Culture: Readings in Modern Music*, 2004, 76–81

———, *In Search of a Concrete Music* (Univ of California Press, 2012), XV

Schafer, R., *Murray: The Soundscape. Our Sonic Environment and the Tuning of the World* (Destiny Books, Rochester, Vermont, USA, 1994)

Schattschneider, Doris, 'The Mathematical Side of MC Escher', *Notices of the AMS*, 57 (2010), 706–718

Schaub, Mirjam, *Janet Cardiff: The Walk Book* (Köln: Walther König, Köln, 2005)

Schiller, Peter H., and Christina E. Carvey, 'The Hermann Grid Illusion Revisited', *Perception*, 34 (2005), 1375–97

Schiller, Peter H., and Edward J. Tehovnik, *Vision and the Visual System* (Oxford University Press, 2015)

Schwartz, David A, and Dale Purves, 'Pitch Is Determined by Naturally Occurring Periodic Sounds', *Hearing Research*, 194 (2004), 31–46

Searle, Adrian, 'Monochrome Review – White Stripes, Shocking Yellow and 500 Shades of Grey', *The Guardian*, 2017

Seckel, Al, *Masters of Deception: Escher, Dalí & the Artists of Optical Illusion* (Sterling Publishing Company, Inc., 2004)

Seitz, William, 'The Responsive Eye' (The Museum of Modern Art, 1965)

Shepard, Roger N., 'Circularity in Judgments of Relative Pitch', *The Journal of the Acoustical Society of America*, 36 (1964), 2346–53

Shurley, Jay T., 'Profound Experimental Sensory Isolation', *American Journal of Psychiatry*, 117 (1960), 539–545

Simmel, Georg, *The Metropolis and Mental Life* (Routledge, 1997)

Sims, Elizabeth, 'Take Your Time: Olafur Eliasson', *X-TRA*, 11 (2008)

Sines, George, and Yannis A. Sakellarakis, 'Lenses in Antiquity', *American Journal of Archaeology*, 91 (1987), 191–96

Smalley, Denis, ‘Spectromorphology: Explaining Sound-Shapes’, *Organised Sound*, 2 (1997), 107–126

Smith, David Woodruff, ‘Phenomenology’, in *The Stanford Encyclopedia of Philosophy*, ed. by Edward N. Zalta, Summer 2018 (Metaphysics Research Lab, Stanford University, 2018)

Smith, S., and W. Lewty, ‘Perceptual Isolation Using a Silent Room’, *Lancet (London, England)*, 2 (1959), 342–45

Soby, James Thrall, *Rene Magritte* (Museum of modern Art, 1965)

Souppouris, Aaron, ‘Virtual Reality Made Me Believe I Was Someone Else’, *The Verge*, 2014

Spillmann, Lothar, ‘The Perception of Movement and Depth in Moiré Patterns’, *Perception*, 22 (2016), 287–308

Spillmann, Lothar, Tobias Otte, Kai Hamburger, and Svein Magnussen, ‘Perceptual Filling-in from the Edge of the Blind Spot’, *Vision Research*, 46 (2006), 4252–57

Stanley, Gordon, and William C. Hoffman, ‘Orientation-Specific Color Effects without Adaptation’, *Bulletin of the Psychonomic Society*, 7 (1976), 513–14

Stearns, Jason, ‘Shocking Pink’, *The Guardian*, 2011

Sterne, Jonathan, *The Audible Past: Cultural Origins of Sound Reproduction* (Durham: Duke University Press Books, 2003)

Storr, Robert, ‘No Stage, No Actors, But It’s Theater (and Art)’, *The New York Times* (New York, 28 November 1999), section Arts

Stowell, Dan, ‘Scheduling and Composing with Risset Eternal Accelerando Rhythms’, in *ICMC* (presented at the International Computer Music Conference, Huddersfield, UK, 2011)

Stratton, George M., ‘Some Preliminary Experiments on Vision without Inversion of the Retinal Image.’, *Psychological Review*, 3 (1896), 611

Sugihara, Kōkichi, ‘Classification of Impossible Objects’, *Perception*, 11 (1982), 65–74

Takeda, Shintaro, Ikuharu Morioka, Kazuhisa Miyashita, Akeharu Okumura, Yoshiaki Yoshida, and Kenji Matsumoto, ‘Age Variation in the Upper Limit of Hearing’, *European Journal of Applied Physiology and Occupational Physiology*, 65 (1992), 403–8

Telekom, ‘“In Terms of Freedom, More Was Possible”: Hans Ulrich Obrist Talks to Carsten Nicolai’, *Telekom Electronic Beats*, 2012

Terhardt, Ernst, ‘Calculating Virtual Pitch’, *Hearing Research*, 1 (1979), 155–182

The Beatles, *Sgt Peppers Lonely Hearts Club Band* (UK: Parlophone, 1967)

‘The Talking Phonograph’, *Scientific American*, 37 (1877), 384–85

Theocharous, S. P., E. Theocharous, and J. H. Lehman, ‘The Evaluation of the Performance of Two Pyroelectric Detectors with Vertically Aligned Multi-Walled Carbon Nanotube Coatings’, *Infrared Physics & Technology*, 55 (2012), 299–305

Thomson, G., and Fiona Macpherson, ‘Negative Afterimages’, *The Illusions Index*, 2017

Tilley, R. J. D., *Colour and the Optical Properties of Materials: An Exploration of the Relationship between Light, the Optical Properties of Materials and Colour / Richard J.D.Tilley.*, 2nd ed.. (Hoboken, N.J.: Wiley, 2011)

Titze, Ingo R., *Principles of Voice Production*, 1 edition (Englewood Cliffs, N.J: Prentice Hall, 1994)

Trueman, Matt, 'Symphony of a Missing Room, Royal Academy of Arts, Review: "Ticklish Trickery"', 22 May 2014, section Culture

Trumpler, Robert J., 'Observational Evidence of a Relativity Red Shift in Class O Stars', *Publications of the Astronomical Society of the Pacific*, 47 (1935), 249–56

Tse, P. U., 'Modal and Amodal Completion in the Artwork of Coles Phillips.', *Perception*, 46 (2017), 1011

Turrell, James, Richard Andrews, and Peter Weber, *James Turrell: The Wolfsburg Project* (Hatje Cantz, 2009)

Tyson, Philip John, Dai Jones, and Jonathan Elcock, *Psychology in Social Context: Issues and Debates* (John Wiley & Sons, 2011)

Vernon, David, Guy Peryer, Joseph Louch, and M. Shaw, 'Tracking EEG Changes in Response to Alpha and Beta Binaural Beats', *International Journal of Psychophysiology*, 93 (2014), 134–139

Vernooij, Eveline, Angelo Orcalli, Franco Fabbro, and Cristiano Crescentini, 'Listening to the Shepard-Risset Glissando: The Relationship between Emotional Response, Disruption of Equilibrium, and Personality', *Frontiers in Psychology*, 7 (2016)

'Vi. Conception and Perception of Ambiguous Figures', *Monographs of the Society for Research in Child Development*, 76 (2011), 87–104

Vincent, Julian F. V., Olga A. Bogatyreva, Nikolaj R. Bogatyrev, Adrian Bowyer, and Anja-Karina Pahl, 'Biomimetics: Its Practice and Theory', *Journal of The Royal Society Interface*, 3 (2006), 471–82

Voegelin, Salomé, *Listening to Noise and Silence: Towards a Philosophy of Sound Art*, 1 edition (New York: Bloomsbury Academic, 2010)

Von Békésy, Georg, and Ernest Glen Wever, *Experiments in Hearing* (McGraw-Hill New York, 1960), VIII

Von Helmholtz, Hermann, *Handbuch Der Physiologischen Optik* (Voss, 1867), IX

Voyce, Thomas, 'Do I Get a Say in This? Environmental Sound Composition, the Phonograph and Intentionality', 2016

Wackermann, Jiří, Peter Pütz, and Carsten Allefeld, 'Ganzfeld-Induced Hallucinatory Experience, Its Phenomenology and Cerebral Electrophysiology', *Cortex*, Special Issue on 'Neuropsychology of Paranormal Experiences and Beliefs', 44 (2008), 1364–78

Wade, Nicholas, 'Moiré and Motion', in *Art and Illusionists*, Vision, Illusion and Perception (Springer, Cham, 2016), pp. 311–34

Wade, Nicholas J., 'Op Art and Visual Perception', *Perception*, 7 (1978), 21–46

Wargo, Eric, 'Infinite Recess: Perspective and Play in Magritte's La Condition Humaine', *Art History*, 25 (2002), 47–67

Warner, Richard, *The Mind-Body Problem: A Guide to the Current Debate* (Wiley, 1994)

Warren, J. D., S. Uppenkamp, R. D. Patterson, and T. D. Griffiths, 'Separating Pitch Chroma and Pitch Height in the Human Brain', *Proceedings of the National Academy of Sciences of the United States of America*, 100 (2003), 10038–42

Watson, Chris, *Outside The Circle Of Fire* (Touch, 2012)

Weibel, Peter, *Beyond Art: A Third Culture: A Comparative Study in Cultures, Art and Science in 20th Century Austria and Hungary* (Springer Science & Business Media, 2005)

Weiss, Paul, 'Autonomous versus Reflexogenous Activity of the Central Nervous System', *Proceedings of the American Philosophical Society*, 84 (1941), 53–64

Welch, Robert B., *Perceptual Modification: Adapting to Altered Sensory Environments* (Elsevier, 2013)

Wernick, Joel S., and Arnold Starr, 'Binaural Interaction in the Superior Olivary Complex of the Cat: An Analysis of Field Potentials Evoked by Binaural-Beat Stimuli.', *Journal of Neurophysiology*, 31 (1968), 428–441

Wever, Ernest Glen, 'Theory of Hearing.', 1949

Wilk, Deborah, 'Antony Gormley, "Blind Light"', *Time Out New York*, 2007

Wilkinson, Judith, '"Supernovae", Victor Vasarely, 1959-61', *Tate*, 2016

Will, Udo, and Eric Berg, 'Brain Wave Synchronization and Entrainment to Periodic Acoustic Stimuli', *Neuroscience Letters*, 424 (2007), 55–60

Wilson, Catherine, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton University Press, 1997)

Woebken, Chris, 'Animal Superpowers — Chris Woebken'

Yoshizawa, Tôru, and George Wald, 'Pre-Lumirhodopsin and the Bleaching of Visual Pigments', *Nature*, 197 (1963), 1279–86

Yost, William, *Fundamentals of Hearing: An Introduction: Fifth Edition*, 5 edition (Lieden ; Boston: Brill, 2013)

Zahm, John Augustine, *Sound and Music* (University of Michigan Library, 1892)

Zareei, Mo H., Dale A. Carnegie, and Ajay Kapur, 'Physical Glitch Music: A Brutalist Noise Ensemble', *Leonardo Music Journal*, 2015, 63–67

Zareei, Mo H., Dale A. Carnegie, Ajay Kapur, and Dugal McKinnon, 'Mutor: Drone Chorus of Metrically Muted Motors', in *ICMC*, 2014

Zareei, Mo H., Dale A. Carnegie, Dugal McKinnon, and Ajay Kapur, 'Rippler: A Mechatronic Sound-Sculpture', *Journal of Comparative Media Arts*, 1 (2015)

Zareei, Mo, Ajay Kapur, and Dale A. Carnegie, ‘Rasper: A Mechatronic Noise-Intoner.’, in *NIME*, 2014, pp. 473–478

Zwicker, Eberhard, ‘“Negative Afterimage” in Hearing’, *The Journal of the Acoustical Society of America*, 36 (1964), 2413–2415