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EXPERIENCE

How sensory engagement can produce atmospheric qualities

by

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A 120-point thesis submitted to the
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(Professional)

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The Bach Boys. For helping turn one of the weirdest years of our lives into a mean as one.

My Supervisors. Thankyou for constantly pushing me, providing the much needed support and at times giving me well deserved check ups.

PREFACE

My childhood best friend coined me 'Fish', I spent my entire adolescence in and around the water. My passion for Swimming, blossomed into a love for Water Polo which I played during most of my schooling life. The experience of being in the water was always fascinating to me, the reliance on your other senses become heightened as your vision is diminished. The submergence of the body within the water drastically changes your bodily perception of location, and you suddenly become very aware of the space around you.

Over the course of architecture, my passion for human experience has consistently grown. I believe that the connection between the body and the spaces we design is so important for generating successful architectural design. So, when I was told I needed to choose something to research for an entire year, my mind naturally ran a thousand different directions, resulting in panic and stress. So I grabbed my togs and towel, headed to the pool, knowing a swim would help clear my mind.

My swims often involve an extended period of time spent sitting on the bottom of the pool, time spent clearing my head and solving problems. I vividly recall sitting at the bottom of the pool watching the crepuscular rays of the sun streaming through the water from the surface. The warmth of the pool, transcendence of visually seeing light moving through space and perhaps lack of oxygen gave me my thesis idea. For I wondered, why don't we perceive this spatial quality whilst we are in the built environment? It can't just be because I am underwater? Light travels through air, why can't we experience it then? Is it the warmth of the sun on the skin that makes this so special underwater?

*And so, there it was.. **'Experience' began.***

ABSTRACT

The dominance of vision within the human sensory system, particularly in fields such as Architecture, has created an ocular-centric paradigm prevalent in Western architectural culture. “Experience” is an architectural design thesis that uses Virtual Reality (VR) design techniques to explore how we, as designers, can affect spatial presence by integrating other bodily senses within virtual environments. “Experience” integrates four senses, Vision, Audition, Kinaesthesia and Thermoception, as combined for exploration.

The relationship between the human senses, in particular thermoception, and the spaces we experience is the particular focus of this thesis. Juhani Pallasmaa’s theories of sensory fragmentation have been applied as an important critical theoretical approach. This study aims to determine the extent to which our less commonly simulated sensory functions can be used within VR design to experience virtual spatial qualities. Specifically, it introduces a physical thermal atmosphere around the VR user to alter spatial and sensory perceptions and create virtual atmospheres. The development of a real ‘spatialised’ heating environment allows the thermal qualities of virtual space to be perceived by the user.

In this context, space is defined as the experiential medium that situates itself within the bounds of a room. It is not of a fixed size, nor does it have fixed qualities. Instead, this research applies Henry Lefebvre’s ideas that the body creates space due to the relationship between the body’s deployment in space and its occupation of space.

Through theoretical reviews and James Turrell and Olafur Eliasson’s artwork analysis’, ‘Experience’ generates an understanding of spatial perceptions, human sensory experience and space. These understandings were then applied to the virtual environment through a range of computational design means.

The ideas of sensory fragmentation were then applied to a series of design experiments. Each sense was treated as its own sensory system fragment, which allowed a series of conceptual, and developed spatial, interventions to be created. Each spatial intervention provided unique insights into the independent sensory fragments, which eventuated in the design of the final holistic sensory experience.

The final sensory design, titled Sensationalising VR, results showed how sensory balancing must be achieved before implementing new sensory experiences. Thermoception, the body’s ability to detect magnitude and direction of temperature changes, proved to be a fragile sensory fragment that requires careful balancing when being engaged with other sensory stimuli in a VR setting.

The conclusions resulting from “Experience” suggests that the human sensory system’s visual bias can be usefully augmented; it can be shifted, altered and even removed by designers. The introduction of a spatial thermal atmosphere around VR users is shown to affect the perception of presence in that space.

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THESIS INTRODUCTION

CHAPTER ONE

Outlines the origins of this research and discusses existing gaps within the relevant research fields.

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Outlines the origins of this research and discusses existing gaps within the relevant research fields.

This section introduces the research topic and outlines the relevant ideas and fields. The literature and ideas introduced are brief and create a background for the entire research paper. The context of discussion throughout this paper will refer to this section to situate the research within its relevant context.

The chapter begins by following on from the Thesis Preface, page vii, with a research motivation. This motivation serves as a breakdown of the initial considerations and thoughts that started the research interest of sensory experience and atmospheric qualities.

The fields of research discussed after the motivation are brief examinations of two key research fields: Architecture and Psychology, and, VR Immersion. Through research and critical review of the relevant research fields, this thesis was able to create a base understanding that all further research and design work could situate itself upon.

Research Motivation

Experience; more precisely Human Experience is set against the backdrop of space, yet the concept of space is so far removed from our comprehension simply because we cannot place our finger upon it. Space appears to be wholly immaterial and elusive, and yet it's existence is proven through every experience we have ever experienced (Watts, 2019). The relationship between our body and the spaces we inhabit is a fundamental necessity for any experience of architecture, and yet we often neglect the qualities of space itself. Perhaps because the human body has not been wired to experience the qualities of mediums which we cannot hear, see or touch; but can we not feel it through our skin?

Motivated by the ideas to sense the space around us, this research motivation establishes itself with the opportunity to create a new virtual spatial quality for experience, by implementing a physical, thermal space.

The digital age introduced a plethora of new technologies which offered humans new ways of communicating, exploring and experiencing. Virtual Reality (VR) especially provided us with a unique new space to experience, the virtual space. Adequate substitution of sensory data is necessary for VR systems to create a true perception that virtual "reality" is reality. Motivated by the prospect of creating a better relationship between the virtual space and the body's understanding of space is a crucial driver for this research. This research also found itself situated within the Covid-19 pandemic, which further highlighted the critical role digital technologies could have in creating a more realistic space of virtuality.

Perhaps an interest in the human connection to space and virtual reality systems would transform the way we think about virtual space and what senses we should be engaging when creating them.

Fields of research

Architecture and Psychology

From the initial interest in "the human experience", this research has found itself situated in between the fields of psychology and architecture. William Ittelson, in 1964, presented a paper to the "*Conference of the American Hospital Association on Hospital Planning*" coining the term "Architectural Psychology", a name which continued until the early 1980s as a research field linking Psychology and Architecture. Anthropologist Edward Hall introduced the concepts of proxemics and personal spaces in the book *The Silent Language*, published during this time (Pol, 2007, p. 4). These terms were continued through subsequent publications and books, one of which *The Hidden Dimension*, is a crucial focus of the literature for this research. Architectural Psychology evolved into the ideas of Environmental Psychology throughout Europe and America in early 1980, as a result of University academic programmes being created.

More recently, the views of Architectural and Environmental Psychology are most closely attributable to Architectural Perception and Spatial Experience, prominent amongst authors such as Juhani Pallasmaa and Bill Hillier. The consensus between these two authors often discusses the deployment of the human body within space as a precursor to the human experience.

Certain terminologies are critically assessed within the theoretical context section of this research which assists in delivering a final design outcome for the thesis, e.g. Fragmentation, Perception, Spatial Experience or Body and Mind. Although these terms relate to individual research topics, through research and design implementation, perhaps, the outcome of this study would help to attribute these fields closer to one another.

VR immersion

This research finds itself situated within the virtual world and in turn, Virtual reality (VR). Ivan Sutherland's *The Ultimate Display* (1965) is reported to be one of the earliest publications which addressed the opportunities that VR had for the technical community, in which Sutherland proposed that VR could become the "Wonderland into which Alice walked".

Over 50 years later, VR technology has expanded into a global operation with a wide range of implementations from medical training to gaming. Although this research utilises a gaming engine to run its design, the key focus is on how human experience can be created within the virtual world. The limitations of immersion and presence are hence discussed in a paper published by Mel Slater and Maria Sanchez-Vives, titled *Enhancing Our Lives with Immersive Virtual Reality* (2016). A critique of VR's Ocularcentric nature was at the forefront of this paper; where the authors highlighted how auditory and tactile engagement is treated as a secondary function to vision. Also discussed was the possible implications that this has had on a wide range of applicable fields, e.g. neuroscience, spatial recognition and even social and cultural experiences within VR.

The need for more immersive VR environments which creates an optimum level of 'presence' for users is a predominant concept in current VR research, and the role that multisensory stimulus plays in this creation is crucial. The need to generate more effective multisensory stimuli to create more significant presence is discussed by both Witmer and Singer and McGreevy (Ranasinghe et al., 2017, p. 1732). Both share similar arguments that presence in VR relies on the user's ability to focus on one meaningful set of sensory data and that the experience of presence can only occur if there is a continuous and connected flow between all sensory stimulus. By providing

the brain with effective substitutions for sensory data is also argued in Slater and Sanchez-Vives paper, where they discuss the role that this sensory engagement has in transforming the consciousness of the user from the real to virtual scenario (Slater & Sanchez-Vives, 2016, p. 4).

The apparent need for greater engagement between the physical and virtual body, or better space, acts as one of the key problems for this research. Through this research, it is hoped that an outcome can be produced, which helps to bridge the gap between what is real and what is virtual. Perhaps the outcomes of this research could help future VR designers to explore and implement more human senses, and eventually assist Alice to walk further into Wonderland.

**“A real piece of art is a window
into the transcendent...**

**It opens your eyes to the
domain of the transcendent...**

**and you need that in your life
because you are finite and
limited, and bounded by
your ignorance and your lack
of knowing. And unless you
can make a connection
to the transcendent then you
don't have the strength to
prevail.”**

Jordan Peterson (2017)

AIMS AND OBJECTIVES

CHAPTER TWO

By focusing the scope of this research, a framework was created for the execution of future design work.

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This chapter begins to set the framework for the entire research to follow. The definition of a narrowed scope of research, allows '**Experience**' to carefully focus its research and design work.

A carefully curated set of Aims and Objectives and Research Proposition, provide a set of criteria for the research to check itself against. This chapter becomes a set of criteria that all design research will be reflected against, allowing a succinct development process to be instilled within the project.

Through constant reflection and discussion, this project follows a partial scientific methodology for assessing the effectiveness of sensory designs at each phase of the project.

Scope of research

This research project commenced itself with the focus of creating a complete multi-sensory experience within the virtual environment. Throughout the undertaking of the research procedure, it became apparent that this scope was far too vast to be completed in the allocated time frame. To create a complete and resound multi-sensory experience which completely understands each sensory role would need more time and a wider range of researchers to be involved in multiple stages of the project to close all gaps posed within the research fields. This resulted in the scope narrowing itself to be more concerned with the role of a selected group of sensory systems; focusing on how they alter our perceptions of space, and whether or not this is enhanced within VR. This thesis does not strive to produce a formal architectural outcome, instead, it is more concerned with the human spatial experience and how this could then be applied to the architectural discourse.

The boldest refinement of research scope which occurred during the initial stages of this project was the decision of which human senses to explore. Sight and Sound were initially selected as they are currently the most widely incorporated within VR, and kinaesthesia was later added as it in itself is necessary for any movement or engagement with both physical and virtual space. The engagement with heat was the driver for this entire project; a focus which originated through both researcher curiosity, as prescribed in the preface, and inspiration drawn from Vitruvius Pollio's *The Ten*

Books on Architecture, where he writes about the warmth of fire being the origin of the human collective conscience and in essence human civilization (1960, p. 38).

For this research to be successful it was necessary for the research to initially focus on understanding both the philosophical and physical application of human thought/memory, experience and how sensory engagement interplays with spatial experience. By understanding these ideologies, the research's scope was further narrowed to understand what balance of sensory engagement is necessary within a virtual environment to accomplish greater human presence.

The term 'space' is referred to throughout this thesis, and it is worth noting that space is not in reference to the physical limitations of the medium which is often enclosed by walls; this medium, for the purpose of this research, is considered 'a room'. Space is coined in this research as a reference to the spatial qualities of space itself. To give an example we have to consider sitting alone in our own living room, and then consider; how does the spatial qualities of this space change if 10 more people were added to the room? It is this perception of space which this research is most concerned with.

This thesis seeks to produce a short final VR experience, which engages the sensory

system of the user's bodies. This research will partially seal the existing research gap highlighted in the research introduction. Applications to the architectural design process could be further explored in future research.

"The men of old were born like the wild beasts; in woods, caves and groves, living on savage fare.

As time went on, the thickly crowded trees in a certain place, tossed by storms and winds, and rubbing their branches against one another, caught fire, and so the inhabitants of the place were put to flight, being terrified by the furious flame.

After it subsided, they drew near, and observing that they were very comfortable standing before the warm fire, they put on logs and, while thus keeping it alive, brought up other people to it, showing them by signs how much comfort they got from it.

In that gathering of men, at a time when the utterance of sound was purely individual, from daily habits they fixed upon articulate words just as these had happened to come; then, from indicating by name things in common use, the result was that in this chance way they began to talk, and thus originated conversation with one another.

Therefore it was the discovery of fire that originally gave rise to the coming together of men, to the deliberative assembly, and to social intercourse."

Vitruvius Pollio (1960, p. 38).

Research Aims and Objectives

A more refined set of research aims and objects are then created, based on the previous section, to assist in narrowing the research gap highlighted in the first chapter. These aims and objectives will be used as a benchmark 'minimum result' for the research

and will be referenced throughout the design process as RO's or RO#. It is hoped that the following aims and objectives allow the research to follow a succinct design-led-research process:

1 Investigate the role of the human body in spatial experience, and further how human perception and experience have been implemented in contemporary art and architecture.

Explore the qualities of each sense and understand how these could be implemented into a design. 2

3 Design and create a system which forms a physical thermal atmosphere in response to the virtual environment.

Explore the extent to which each sense should be stimulated, and further develop a well balanced sensory experience. 4

5 Apply this research to design a virtual environment which is effectively experienced through the selected human senses.

HOW DOES A MULTI-SENSORY VIRTUAL EXPERIENCE AFFECT OUR PERCEPTION OF SPACE?

Research Proposition

Virtual reality has been heralded as an important tool for visualising architecture. The experience of the virtual space has been described as 'immersive' and 'transportive' (Schott & Marshall, 2020)(Ryan, 2001, pp. 89–114). However, this research asks, presently with the current state of technology, to what extent can VR activate the human body. The research then asks, what tools can be used to extend the current experiential condition of virtual space?

THEORETICAL REVIEW

CHAPTER THREE

Defining key terminology and creating a theoretical lens for discussion and reflection of project stages.

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Defining key terminology and creating a theoretical lens for discussion and reflection of project stages.

In response to RO1, this literature review evaluates the ideas of intangible narratives within human consciousness and architectural design. To better understand how human perception and experience influence spatial design, this review critically analyses relevant theorists. This analysis further helps to understand the extent to which the human senses can aid or inform spatial experience.

Key ideas and terminologies from this theoretical review have created the process of design in future chapters. The splitting of sensory systems and application of independent senses at different stages of the design have been formed from this review.

Framework Introduction

The nature of a causational effect dictates that it becomes nearly impossible to understand the relationship between two events without first understanding the cause and effect results. So what exactly are perception and experience? What dictates and creates these effects within the human body and mind? Is it their relationship with space? Well, then what is space? Without critically grounding these questions in architectural theory, the relationship between the human body and space cannot begin to be understood. Once the relationship between the body and space is better understood, *'Experience'* can begin to break down the role sensory experience has in spatial perception.

Perception and Experience

The process of becoming aware of physical objects, phenomena, etc., through the senses.

When we sit on a beach, the view over the ocean, sound of lapping waves, light reflecting off the water, immense heat of the sun and the coarse granularity of the sand in our hands merge to form a single experience. The human senses' contribution to perceptual experience is one of fragmentation; where individualised inputs combine to provide unabridged experiences and perceived understandings of the surrounding space.

Pallasmaa's understanding of how perception cannot be readily broken down into simple collections of geometries, activities and sensations (Holl, 2006, p. 45); is further reinforced by Merleau-Ponty's emphasis of simultaneity and interaction of the senses when locating the body within the real world (Pallasmaa, 2005, p. 21). Fragmentation is crucial to *'Experience'* as it reinforces a problem within VR research; the absence of self within virtual environments. Ocularcentric paradigms currently dominate VR systems, an issue that, according to Pallasmaa, also exists within the built environment due to the Western architectural cultures' vision-centred interpretation of knowledge, truth, and reality (Pallasmaa, 2005, p. 16).

To better understand human perception, we must also begin by accepting that the mind and body are not separate. Just like the mind, the body is an intricate network of metaphysical processes functioning in unison with one another, wherein no part is more primary or significant than another. Ashley Montagu describes his idea of *"The mind of the Skin"*, where he describes the skin, *"the mother of the senses"*, as the visible surface of this continuously interconnected system (1971, pp. 1–5).

This fragmentation of the human experience has been a necessity for survival throughout our development. It has allowed us to process a plethora of stimuli, situate the body within reality and inherently allow the self to exist. The domination of vision within this sensory experience has only originated over the last few centuries. Previously humans had a primordial dominance of hearing, which has been gradually replaced by vision (Pallasmaa, 2005, p. 24). By applying the lens of 'perception as a combination of sensory fragments', *'Experience'* is provided with the opportunity to design and research with each sense acting as individual fragments, or better individual tools of design. Martin Jay further suggests how "technological senses have until now reinforced the primacy of vision, but the new technologies may also help 'the body' (Pallasmaa, 2005, p. 36).

To create a virtual space which engages the human body and mind will be essential to *'Experience'*. It becomes a necessity to 'help the body' by implementing the ideas of fragmentation within this research. Treating each sense as independent design tools will assist this research in creating a multi-sensory experience that can enhance and alter the user's perceptions of virtual space. Pallasmaa's views on sensory dominance, more significantly ocular dominance, is a crucial theoretical aspect of perception that will inform the extent to which this research utilises vision. To deliver a sensory experience which engages and stimulates individual senses; *'Experience'* must carefully allow individual senses to create their own experiences, not just to exist and serve the ocular paradigm.

Space.

The western conception of space is generally one of pure abstraction, often not of reality and considered an intangible aspect of the world. This is apparent when Westerners become bothered by astronomers talking about curved space or expanding space, as how can pure abstraction be curved or expanding? In his book, *Orality & Literacy*, Walter J. Ong discusses how;

“The shift from oral to written speech is essentially a shift from sound to visual space ... print replaced the lingering hearing - dominance in the world of thought and expression with the sight - dominance which had its beginning in writing” (Holl, 2006, p. 30).

Perhaps the abstract ideology of space stems from our cultural shift towards written language, one of material fact, wherein truth presents itself as something tangible, something which can be felt by the human body. Edward Sapir further reinforces the idea of language and culture driving human experience in the book *“The Hidden Dimension”*. He argues that one does not merely adjust to reality without language, and that language is not just a cultural tool used to solve communication problems or reflection. He states that “The fact of the matter is that the ‘real world’ is to a large extent built upon the language habit of the [groups culture]” (Hall, 1969, p. 92).

So as culture shifts and evolves, would we assume that our understanding of space would evolve with it? Edward Hall explains how rooms had no fixed functions in European homes until the 18th century, that the idea of private and public spaces within a home did not exist. Once the home altered its form and rooms were allocated functions, the family dynamic began to stabilise, and the present-idea of a home was formed (Hall, 1969, p. 104). The fluidity and dynamic culture are apparent through the human understanding of what Space is. Just as space within the home can change, alongside cultural norms, *‘Experience’* considers if our perception of space can change by building on the ideas of sensory perception discussed in

the previous chapter. Can a sensory experience be designed which detaches itself from the ocularcentric paradigm and instead evolve space into the other sensory realms?

Another critical aspect of Space which is notable for this research is its connection to movement. There are two theological relationships between movement and body:

1. Space has a direct influence on the body due to its action.

2. User movement affects the human perception of space.

Henry Lefebvre questions if the body can inherently create space with its capacity for action (1991, p. 170). He continues to suggest that the direct relationship between the body and space, or more concisely between the body's deployment in space and its occupation of space, allows the production of space. That body is produced within space and synchronously space produced within the body. Lefebvre's theories are reinforced through Bill Hillier's suggestion that human behaviour produces its own spatial forms (Hillier, 1996, p. 29). These ideas will prove to be a hurdle for *‘Experience’* as it needs to approach the creation of Virtual Space with a premise that the body itself is disconnected, and so the sensory sensations will need to be synchronous with the visual experience of the virtual space.

Bill Hillier presents the second relationship between movement and body in his book *“Space is the machine”*, where he discusses how a user's perspective within a space alters their overall conception of the space (Hillier, 1996, p. 33). By presenting this idea, Hillier allows us to understand that the connection between body and space is as crucial to spatial experience as the connection between the individual spaces. *‘Experience’* will need to connect the body and virtual space whilst also linking virtual and real space. The creation of these relationships will allow an interrelation to form between the different sensory spaces of vision, sound, touch, and warmth.

CASE STUDY RESEARCH

CHAPTER FOUR

*Applying the theoretical lens to case study
artists to understand how sensory design can be applied*

CASE STUDY RESEARCH

CHAPTER FOUR

Applying the theoretical lens to case study artists to understand how sensory design can be applied

This thesis uses case study artists to ground the research within the realm of contemporary sensory exploration. **'Experience'** focuses on understanding the theoretical and ontological ideas that drive a selected group of 'artists', specifically 'installation artists' works, in response to RO1 and RO2.

Installation artists have been selected for the basis of this research as existing sensory research within the architectural discourse tends to be mostly theoretical and not practically applied. Art is unique in its ability to encompass the outer fringes of research and produce unique sensory experiences which can often challenge its viewers' expectations.

This case study research helps to refine and guide **'Experience's'** research by understanding how artists have produced ephemeral qualities within sensory experiences by examining their exemplary works.

TU

TURRELL, JAMES

**“.. That place between the
awake and dream state.**

**That special quality of
consciousness is what I’m
really interested in.**

**It’s what I want to get into
my art.”**

James Turrell (Adcock, 1990, p. xxiii)

Who is James Turrell?

James Turrell is an American born artist who creates works that are fundamentally associated with exploring light and space. Turrell is interested in cosmological phenomena; an interest Turrell attributes to flights he took with his father, an aeronautical engineer. Turrell's works and exhibitions are a unique combination of art and science which attempt to understand the relationship between light and space.

Turrell's exploration of the interactivity of human spatial perception and light has been reinforced through his qualifications of Perceptual Psychology; resulting in his works altering the human perception of interior environments. In either the natural spaces of the desert or the artificial light qualities of an art space, Turrell's focus has always remained the same: he deals with perceptual space, his works of light do not promote or deliver any messages or rhetoric; instead, they focus only to distil in the viewer a personal internal response to pure luminance (Adcock, 1990, p. 208).

Art of Perception

Turrell's approach to artistic form is unique within modern art as he does not attempt to integrate specific symbolism within his works; instead, he accepts that light carries considerable power, and in turn personal symbolism for its spectators. Turrell's utilisation of a single medium, well two if we include space, allows for powerful statements and visual perceptions to be altered.

Turrell creates Art from Perception. This fixation on the perceived environment has allowed Turrell's works to be placed directly into the senses, allowing it to be fundamentally human. Light as a medium is boundless, and yet his art is bound. He presents his spectators with 'nothing' or

more so 'no-thing', depth is often missing from experience. So the observer inherently begins to see an empty medium or in fact, the empty medium (Adcock, 1990, p. 220).

Perceptual cells

The *Perceptual Cell* is the title of several mobile works created in the 1990s by James Turrell. The artworks are designed as individual experiences, wherein the user is laid down inside of 'perception capsules'. These capsules are confined domed spaces which make it possible for viewers to experience changes in their perceptions of light. Turrell uses coloured light and strobing effects to induce 'perception deprivation', as opposed to the commonly misconceived 'sensory deprivation' within his cells. The perceptual sensory deprivation reportedly causes mild unpredictable and irreproducible ganzfeld hallucinations as the spectators' neurophysiological optical apparatus are animated (Perceptual Cells, n.d., p. 306).

The ephemeral qualities of the animated ganzfeld effect result from the edgeless projection techniques utilised by Turrell. By removing any sense of horizon or edge within a perceptual experience, the spectator's body becomes an active medium within the art instead of just acting as a receiver of the projection art. Gadassik states the critical role of edgeless projection techniques in activating the body as a potential medium for extra-sensory transmission. Furthermore, through the absence of differentiation or architectural framing, the sense of an external projection screen begins to erode, collapsing the distinction between the [capsule] and the eye (Perceptual Cells, n.d., pp. 306–311).

FIGURE 0.1.
PREVIOUS SPREAD. (NATIONAL
PORTRAIT GALLERY, 2002).
JAMES TURRELL. RETRIEVED 2
2 MARCH 2021, FROM
NPG WEBSITE: [HTTPS://
NPG.SI.EDU/OBJECT/NPG_
NPG.2004.110.1.2](https://npg.si.edu/object/NPG_2004.110.1.2)

FIGURE 0.2.
RIGHT.
(TURRELL, 1989). ALIEN
EXAM. RETRIEVED 2
MARCH 2021, FROM JAMES
TURRELL WEBSITE: [HTTPS://
JAMESTURRELL.COM/WORK/
ALIEN-EXAM-2/](https://jamesturrell.com/work/ALIEN-EXAM-2/)

“Light is one of the revealing elements of life...

Rudolf Arnheim (Adcock, 1990, p. 210)

It is the visual counterpart of that other animating power. Heat.”

The psychological experience of space

Although the Ganzfeld effect induced within Turrell's perceptual cells is fascinating, their presence holds little relevance to *'Experience'* and further needs no more investigation. Instead, *'Experience'* is far more critical of the effects cause: How the psychological experience of space by the human body is influenced within the capsules.

Turrell's works famously attempt to alter spectators' perceptions of light and space; the perceptual cell is unique from all other expanded cinema experiments through its complete erasure of screen edges. The absence of horizon, film frames, reference or even the spectator's body, begins to deconstruct the idea of spatial dimensions.

By breaking down the duality of spatial qualities and the body, Turrell's capsule walls fall away from the spectator's awareness allowing the human psyche to start perceiving the space through which light travels.

FIGURE 0.3.
ABOVE.

(TURRELL, 2013). BREATHING LIGHT. RETRIEVED 2 MARCH 2021,
FROM JAMES TURRELL WEBSITE: [HTTPS://JAMESTURRELL.COM/WORK/BREATHING-LIGHT/](https://jamesturrell.com/work/breathing-light/)

As art historian Georges Didi-Huberman explained, concerning his experience of the perceptual cells: “The object of vision, *habitually in front of us*, becomes the place of our seeing. We are inside it. And yet this place presents itself only as a pure and mysterious tactility of light” (Perceptual Cells, n.d., p. 311).

Turrell combines his knowledge of psychology with his artistic talents to effectively create a piece of work in which the spectator can begin to see the space in which light transverses (Beveridge, 2000, p. 310). Usually, light is only conceived by the eye as a source or a reflection, never as a transition through space.

‘Experience’ aims to dissect and rethink the bounded virtual screen’s centrality to deconstruct the visual space in which the spectator experiences. It is hoped that by applying some of the ideas that James Turrell uses in his perceptual cells, **‘Experience’** will be able to create a form of ‘perceptual deprivation’ to enhance the essence of heat and allow users to understand that heat, much like light, exists within space too.

OLAFUR

ELIASS

Olafur Eliasson.

Olafur Eliasson is a Danish-Icelandic artist whose works aim to enhance and understand the experience of space. He uses a wide range of mediums through his exhibitions, from light to architecture. Establishing Studio Olafur Eliasson in 1995, Eliasson founded a collaborative laboratory for spatial research, which became a space of engagement between architects, engineers, craftsman and researchers. The studio allowed Eliasson to realise large-scale projects, installations, and sculptures that embodied his passions for perception, movement, light and experience.

The connection between Art and Architecture became a growing standpoint for Eliasson's works as he began to question how Architectural atmosphere and the human experience of art could be integrated better. Eliasson's works continually explore how design and architecture can postulate changes to human perception and human living conditions.

Unlike Turrell, Eliasson's works do not elude to mystery or illusion. Instead, he carries from the ideas of the early artists of the 1960s who questioned arts claim to autonomy; centralising the focus to emphasise the mechanical means in which art is produced. Eliasson uses the expressive nature of structure, and architecture, to develop his artworks into experiential environments (Eliasson, 2004, p. 36).

'Experience' establishes Olafur Eliasson as a critical case study, as his exploration of the human experience within art and architecture is fundamental to the success of this research. An analysis of the duality of art and architecture, the ephemeral qualities of spatial experience and the medians in which his art is situated will be critical to *'Experience'*. This analysis will serve as a basis for how *'Experience'* can utilise spatial experience to alter and understand human perception of their senses within virtual environments.

ON

Art and Architecture

Without active and productive engagement in space, a lack of experience for viewers is often created. This is what has driven Eliasson to understand the connection between Art and Architecture further.

The engagement between two practices offers opportunities to push both spatial experience and human experience. Both discourses are a process of ongoing experimentation, and the open-ended exploration of them allow the boundaries between the two to begin to blur and fade away. Eliasson suggests that 'we should explore the overlapping intersect between the two... as the term "art" or "architecture" doesn't add anything to [his] spatial experiments; [they're] anchored in the tissue of society to such an extent that labelling them "art" or "architecture" become superfluous (Engberg-Pedersen & Olafur Eliasson, 2008, pp. 49–50).

Spatial Experience

'Experience, Eliasson reminds us, is never unmediated (Blau, 2010, p. 99). Eliasson defines Experience as a notion which is conditioned by that which precedes and follows it, by memory and expectation.

The thought that experience is comprised of what happens before, during and after the current moment, helps to clarify how experience, or moreso spatial experience, requires constant engagement with the spectator. However, this engagement can only occur when the spectator is placed within an atmosphere which allows them to perceive the experience. Juhani Pallasmaa suggests that atmosphere is attributable to the comprehensive and sudden grasping of a situation's emotional and existential essence, whether it be social or architectural ("Architectural Atmospheres," 2014, p. 93). Through this idea, Eliasson successfully engages his viewers and

allows them to understand and experience existing atmospheres that they are often numb to. The constant active 'negotiation' between the user, work, time and space is Eliasson's most potent tool for maintaining a continuous engagement within his works.

The Weather Project (2003)

Olafur Eliasson's *The Weather Project* was a social installation artwork on display in the Turbine Hall at the Tate Modern in the early 2000s. Comprised of a large semi-circle of lights placed behind a semi-transparent foil against a mirrored ceiling, The Weather Project created a uniquely social, yet individualised spatial experience for its spectators. Eliasson drew on the four natural elements to provide an exhibition that centralised its themes around transforming our understanding of the natural environment.

Eliasson successfully created a space that sat between the thresholds of material and immaterial, allowing the object itself to become dematerialised. As Eliasson explains, this dematerialisation let the process of observation become the focus of the work, shifting the viewer's attention to the perception and experience of the atmosphere (Broeker, n.d., p. 44).

Eliasson's use of de-materialization and de-objectification allowed him to shift the focus of the works from the art itself, unto the viewer and the phenomenological principles of the experience (Broeker, n.d., p. 47). If '*Experience*' can detach the user from their preconceived ideas of virtual reality and allow them to perceive the atmosphere within; only then can a successful perception of sensory space be attempted.

FIGURE 0.4.
PREVIOUS SPREAD.
(ELIASSON, 2017). LITTLE
SUN DIAMOND. RETRIEVED 2
MARCH 2021, FROM OLAFUR
ELIASSON WEBSITE: [HTTPS://
OLAFURELIASSON.NET/ARCHIVE/
ARTWORK/WEK110331/](https://olafureliasson.net/archive/artwork/WEK110331/)
LITTLE-SUN-DIAMOND

FIGURE 0.5.
RIGHT.
(ELIASSON, 2003). THE
WEATHER PROJECT. RETRIEVED
2 MARCH 2021, FROM OLAFUR
ELIASSON WEBSITE: [HTTPS://
OLAFURELIASSON.NET/ARCHIVE/
ARTWORK/WEK101003/THE-
WEATHER-PROJECT](https://olafureliasson.net/archive/artwork/WEK101003/THE-WEATHER-PROJECT)

Your Making things explicit (2009)

The final case study project for '*Experience*' is Eliasson's 2009 exhibition titled '*Your making things explicit*'. A darkened room filled with dense fog obscured the perception of the room edges.

The only light source in the room was a single beam of light projected across the room's length. The beam of light is intersected in the middle as it passes through a fog-less glass cube.

Eve Blau explains how 'by altering atmospheric conditions, the immaterial is materialised, the invisible becomes visible, what was absent becomes present.

FIGURE 0.6.

ABOVE.

(ELIASSON, 2009). INSTALLATION VIEW. RETRIEVED 2 MARCH 2021, FROM OLAFUR ELIASSON WEBSITE: [HTTPS://OLAFURELIASSON.NET/ARCHIVE/ARTWORK/WEK100256/YOUR-MAKING-THINGS-EXPLICIT](https://olafureliasson.net/archive/artwork/WEK100256/your-making-things-explicit)

Space itself is rendered, not only visible but palpable, substantive' (Blau, 2010, p. 106). This work of art is vital for '*Experience*' as it creates an understanding of how atmosphere and experience are integral to changing the spectator's preconceived perceptions of light and space.

By allowing the spectator to perceive the imperceivable, the spatial experience of space is enhanced, and the ephemeral qualities of light can be understood.

Eliasson's theological ideas used within his works will need to influence how '*Experience*' reveals and conceals different spatial qualities, allowing '*Experience*' to alter the viewer's perception of sensory space within virtual environments.

SENSORY ANALYSIS

CHAPTER FIVE

Initial conceptual design phase which applies the previous research to conceptual sensory sketching.

SENSORY ANALYSIS

CHAPTER FIVE

Initial conceptual design phase which applies the previous research to conceptual sensory sketching.

First and foremost, this research needs to break down the sensory elements of each selected human sense to understand better what emotive, perceptual and experiential qualities they can provide to the design of this research. This understanding will form the basis of RO2. The Theoretical and Case Study research has provided this thesis with a greater understanding of how the human body responds to space, however, how this understanding can be applied within design is, initially, a source of mystery.

This chapter utilises artistic and atmospheric drawings combined with further research to provide the researcher with a higher understanding of each sense. This chapter provides '*Experience*' with a foundation of which all other designs will situate itself through critique and reflection.

This chapter breaks down each sense individually, analysing their physical manifestations, emotive qualities and atmospheric potentials before reflecting on how these ideas can further this research. Each sense is accompanied by artwork created, not as a realistic representation of each sense, instead as emotive abstract representations that provide insight and highlight how each sense can be applied within this research context.

These drawings are not created as conceptual designs, nor as definitive conclusions to the research explored so far in '*Experience*', they are purely an interpretation and abstraction of the research ideas previously discussed.

VISION

SENSORY ANALYSIS

As discussed in previous chapters, the western architectural culture has placed a primacy on vision over the other senses; however, the ideas of prominent authors such as Pallasmaa and Ratcliffe argue that Vision is simply an extension of Touch, an idea which George Berkley proposed in the 18th Century. He stated how an infant learns through touch that an object is three-dimensional with a particular texture, a specific shape, and a certain size, concluding that touch educates vision (Rock & Harris, 1967, p. 1). Vision informs us of distance, shape, size and locates objects within space; however, it cannot initially tell us how a surface feels. This relationship between touch and vision is an interesting yet critical aspect of this research. Without an understanding of how vision assists our perception of environments, it could not effectively be used as a design tool.

FIGURE 0.7.
RIGHT.
ATMOSPHERIC INTERPRETATION
OF THE DIRECTIONAL AND
WAYFINDING NATURE OF VISION

This research situates itself within the virtual realm and uses VR systems to understand virtual space. So applying standard trains of thought about vision and touch become complicated and nearly nonsensical. A replicated design of a room with a sofa could be used to test the effectiveness of vision at approximating texture within the virtual environment. However, this research does not believe that the virtual space should be a replicated reality. To properly research a sensory space within a virtual environment, we must not expect the virtual realm to be the same as the real, for then there would be no need for the virtual realm to exist.

To create an environment where the viewer can experience a virtual atmosphere, the virtual space itself needs to exist. Cathryn Vasseleu explains, *during her discussion of Merleau-Ponty and Plato*, that “the nature of light and existence are deeply entwined in the history of western thought” (2002, p. 3). Creating existence within the virtual realm will be critical to the formation of virtual atmospheric qualities, as without a form of existence, there will be no perception of space. Merleau-Ponty argues that perception and existence go hand in hand, as they both require a pre-conceived experience of a properties attributes; attributes that include texture, tactility, and colour. “For Merleau-Ponty, the reality of perception has no ultimately determinable basis; the more sensory articulations that are made, the more real the thing is perceived to be.” (Vasseleu, 2002, p. 45).

Merleau-Ponty’s ideas of sensory articulations, perception and existence are vital ideas that drive the design phases of *‘Experience’*. Through a perceptual lens of vision, what attributes can an object create within the virtual realm? Can pure light be given texture? Does temperature have texture? To what extent does the colour of light convey texture and existence? Without any visual stimuli, does the user exist within a virtual environment?

AUDITION

SENSORY ANALYSIS

The primordial sense, audition (auditory, hearing), was a crucial aspect of early human development. Its ability to locate and orient a body within space whilst alerting it to spatial environment changes allowed us to travel through space without hesitation. Auditions ability to provide directionality and causation in response to a surrounding environment is a critical focus of this research.

Audition is vital for spatial perception, as it allows us to respond to actions which occur outside of the field of vision. A study by Patrice Voss into *the auditory spatial perception ability of humans* (2016), concluded that the bodies' ability to detect auditory cues without the use of vision is superior along the horizontal axis, and is severely diminished when locating objects on the vertical axis and approximating distance. This limitation of the auditory sense is curious to this research, as you often consider your hearing to be multiaxial. Understanding and considering that its abilities limit audition for location, '*Experience*' can begin to design a sensory experience that perhaps uses auditory cues as attracting points within a virtual environment.

Much like our visual sense, Audition plays a vital role in locating the body within space. Although it has limitations in detecting actions around the body, it can give a general direction based on a horizontal plane, but not an exact location nor distance. Then '*Experience*' questions how auditory cues can attract the user to a location? Would it be precise enough? Would they move towards it, or just shift their head? Furthermore, without auditory cues at all, does the virtual atmosphere become disengaging and less immersive?

FIGURE 0.8.
RIGHT.
ABSTRACT INTERPRETATION OF
THE ENGAGING ATTRACTION OF
AUDITION.

THERMOCEPTION

SENSORY ANALYSIS

The unique aspect of the human sense for heat is how it is consistently reflecting what is happening directly to the body, for example, if you hold a warm object your hand naturally senses warm as it is getting warmer, but if you look at something orange you only see the colour, you don't become more orange. The intricate relationship between the bodies' thermal sense and the human experience is fascinating for this research, the constant negotiation between our thermal sense and the environment (Ong, 2012).

The thermal environment has many characteristics when discussed concerning our perception of them. They hold connotations of comfort, relaxation, internality and even intimacy, and we could even state that thermal spaces are attractive to people. It is common to find people huddled around a fire, but not around an icy rock. Lisa Heschong describes how *"there is something basically internal about warmth, probably because we associate it with the warmth generated within our own bodies. Warmth is what's alive at the very core of things"* (1979, p. 26). This attraction and internality of warmth is a curious thing, perhaps it dates back to Vitruvius' depiction of man's first encounter with fire, or perhaps it is a result of being conceived within the warmth of our mothers. The atmospheric quality of warmth is unique as it can invoke strong emotive qualities within the people who experience it.

The visual characteristic of warmth could be just as important as the heat itself, without a visual cue of heat are we able to truly appreciate it? If we can, how do we experience it? These are the key features of the sense of warmth which this research will need to divulge and explore.

FIGURE 0.9.
LEFT.
ATMOSPHERIC PAINTING
EXPLORING THE INTERNALITY OF
HEAT.

KINAESTHESIA

SENSORY ANALYSIS

Kinaesthesia: The bodies awareness of its position and movement in space, is one of the most important senses in the human toolkit; however, it often goes unnoticed. Kinaesthesia's role in further design stages will be critical to creating a convincing virtual atmosphere. Virtual Reality and Kinaesthesia are like chalk and cheese, not a winning combination. The limitations for movement within virtual environments create a hurdle for *'Experience'* to overcome.

As discussed in the vision section of this chapter, Merleau-Ponty's views of the correlation between existence and perception are highly relevant to Kinaesthesia applications within this project. Due to VR users' limited ability to physically move large distances, there is often a disconnect between the users' bodies and the virtual atmosphere's spatial qualities. This disconnect creates an issue for *'Experience'*, as it creates a disconnect between the theoretical ideas of Bill Hillier's relationships of movement and space, as discussed in chapter 3, and the application of virtual reality to experience virtual space.

To consider Kinaesthesia as a sense of movement, fluidity, and situation, *'Experience'* will need to carefully consider how it implements physical and virtual movement into the following design phases.

FIGURE 0.10.

LEFT.

ABSTRACTED UNDERSTANDING
OF THE FLUIDITY OF MOVEMENT
THROUGH SPACE.

EXPLORING THE SENSES

CHAPTER SIX

Building upon previous chapters, how can each bodily sense contribute to the creation of a virtual atmosphere?

EXPLORING THE SENSES

CHAPTER SIX

Building upon previous chapters, how can each bodily sense contribute to the creation of a virtual atmosphere?

Progressing from the definitive research process undertaken thus far, this chapter uses an explorative and experimental approach to further research how sensory experiences can be created in a virtual environment. Pallasmaa's theory of sensory fragmentation has informed the method of research undertaken in the following chapters. Wherein each sense is treated as a fragment, researched and then gradually introduced to other pieces. This has produced an in-depth questioning of each sense's role in virtual perceptions, whose results have informed the future design stages.

This chapter is broken into three separate stages, the first of which is composed of 3 smaller part-stages and utilises the ocularcentric paradigm to understand how we can visually perceive thermoception and audition. This process informed stage two, where a complete sensory experience was created, which stimulated each fragment. Finally, an examination into Thermoceptions role in the creation of virtual atmospheres was completed.

Taking a scientific methodology and combining it with the fragmentation methodology has allowed each stage of the process to create its own aims and objectives for the relevant research. These aims were informed by the overarching research aims and objectives stated in Chapter 2. Each stage was then researched and evaluated against its own aims to create resulting conclusions which informed the following stages. This chapter provides solutions to all research objectives.

5.2

AUDITION

5.1

VISION

6.1.1

VISUAL THERMOCEPTION

6.1.2

THERMAL ENVIRONMENTS

5.3

THERMOCEPTION

5.4

KINAESTHESIA

SENSORY PROGRESSION

EXPLORING THE SENSES

Throughout the following design stages each sensory fragment is slowly introduced with one another to produce a final experience.

6.1.3
SEEING SOUND

6.2.0
THE LIMITS

6.3.0
THERMAL ATMOSPHERES

7.0.0
SENSATIONALISING VR

STAGE ONE DESIGN

CONCEPTUAL DESIGN

Finding methods to visually represent audition and thermoception.

As the first design stage of '*Experience*', it became important to understand how the ocularcentric paradigm can be used to assist in sensory perceptions of virtual space. This stage asks if vision can assist in creating thermal and auditory environments, and if so, to what extent do these environments engage our sensory system. Through various programs, this stage was a learning curve where a range of systems had to be learnt quickly and effectively. As such, this stage is comparable to conceptual form-finding sketches in an architectural methodology.

Stage One is split into three smaller part stages, where a range of senses are combined and explored. The first stage focuses on connecting vision and thermoception through colours, which then informs the creation of Thermal Environments in Stage One_{dot}Two. Finally, an exploration of the relationship between vision and audition forms the basis of Stage One_{dot}Three.

Stage One aimed to:

1. Better understand the extent to which vision can be used to stimulate other sensory systems.
2. Develop tools to assist in the creation of finalised virtual environments.
3. Gain knowledge of how the qualities of a virtual atmosphere could be created or experienced.

VISUAL THERMOCEPTION

STAGE ONE_{DOT}ONE

Initial conceptual phase analysing the ability of the human body to visually perceive environmental temperatures.

Starting a design project using the selected senses as their own individualised design tools straight off the bat was a daunting task that would have ended in a world of design blocks and confusion. Instead, this first stage focused on connecting thermoception and vision through conceptual design.

Google TiltBrush, a VR painting and drawing program, was used to begin research into the possibilities of visualised heat and as an educational tool on how VR environments can be created and experienced. This part stage aims to resolve part of RO2 and RO4.

Stage One_{DOT}One aimed to:

1. To understand the visual relationship between temperature and colour.
2. To learn methods of virtual environment creation for VR experience.
3. To learn methods of providing visual perceptions of temperature.
4. Begin to gain knowledge of virtual atmospheric qualities, and how to design for them.

COLOUR OF COLD

STAGE ONE_{DOT}ONE

The Tool

TiltBrush is a powerful conceptual design tool which allows a VR user to enter the canvas and design in a 360° environment. This tool played a vital role in this research through the use of the HTC VIVE Pro and hand controllers. One hand controller holds a virtual palette and tool selection, whilst the other hand becomes a powerful virtual paintbrush. The ability to change the scale of the painting and move through the scene allows the designer to continually explore different aspects of the scene and build a foundation for designing VR environments. These virtual scenes are defined as ‘drawings’ or ‘virtual drawings’ for the remainder of Stage One_{DOT}One.

The images shown throughout Stage One_{DOT}One are only aspects of the larger drawing. Whilst the designer is inside their drawings, TiltBrush can capture on command images, or screenshots, of what the user is viewing. These captured images are in the following sections based on their relevance to the aims of the project.

FIGURE 1.1. COOL VISION TESTING. EFFECT OF COLOUR ON PERCEPTIONS OF COOL TEMPERATURES.

FIGURE 1.2. COOL VISION TESTING. COMBINATION OF FORM AND COLOUR TO DEPICT COOL ENVIRONMENTS.

FIGURE 1.3. COOL VISION TESTING. TESTING THE DIRECTIONALITY OF ‘COOL COLOURS’.

The Colour

To understand how to perceive temperature visually and incorporate thermoception into future design phases, an understanding of colours' role in this perception must be made. A series of drawings using different colour palettes allowed this understanding to begin to take place. Using Blues, Whites, Purples and Greens to create 'cold' environments was the first step in this process. Three environments were created and experienced through VR to test each colour's individual and combined effectiveness in delivering temperature perceptions.

Expectations going into this exploration were that blue colours would strongly portray cold environments whilst other colours would not alter temperature perceptions. For the most part, this hypothesis was proven through the drawings. However, the drawings revealed other key characteristics of the relationship between colour and the perception of coolth:

1. When White is introduced to a blue environment, the drawing rapidly cools down and an increased level of immersivity is found. Using fog or snow like symbolism for the implementation of white was highly effective in figures 1.1 and 1.3.
2. When the colour Blue is contrasted by complementing deep colours, as shown in Figure 1.2, the blue appears more mysterious and often draws the user to enter the drawing's colder regions.
3. Interestingly, the absence of colour portrays a cold dystopian environment that neither attracts or repels the viewer. It becomes a point of mystery, something to view, but not to enter.

The Atmosphere

Trying to understand a virtual atmosphere's qualities through written text and still, two-dimensional images is as nonsensical as trying to understand the feeling of flying. The experience of being completely immersed in an environment through only visual cues is a constant battle between mind and body. The environment becomes immersive until another sense takes priority, such as when someone else walks into the room. The drawings were entered with low-frequency binaural audio being played through a set of headphones to counter this issue. Binaural audio is a type of audio which produces three-dimensional sound around the user, and the low-frequency nature of the sound played at a low volume was enough to keep the mind focused whilst inside the drawings.

The use of white fog-like textures within the drawing created a strong representation of atmospheric conditions. Perhaps because the virtual space itself appeared to be filled and visible, a perception attributable to Walter J. Ong's descriptions of how space is perceived (Holl, 2006).

Using the fog-like design to visually represent the virtual atmosphere is an important sensory design tool which is carried into later stages of design. However, relying on visual representations of the virtual atmosphere would only serve the ocular-paradigm further. Connecting the sensory fragments into a unified experience is essential to this project's success, so it is further researched in later design stages.

Hot Colours

The effects of colour for depicting cold environments explored in the previous series provided this exploration with its starting point. Drawing from the earlier findings of colour and environmental atmospheres, this series uses contrasting colours to depict the polar thermal environment. Using Reds, Oranges and Yellows to create 'hot' environments was the initial exploration for this series. Just like the previous series, three environments were created and experienced through VR to test each colour's individual and combined effectiveness in delivering temperature perceptions.

Prior research conducted on thermal representation suggested that colour alone would not be an excessive driver in producing a 'hot' virtual environment, unlike the cold series. The expectation was that colour would still provide a visual understanding of the virtual temperature, however, the extent of this understanding was unknown. After experiencing the environments through the HTC VIVE VR headset, the following conclusions, regarding colours role in the experience of 'hot' virtual environments, were made:

1. Excessive implementation of colour which covers the field of vision does not effectively simulate the feeling of a hot environment. Figure 1.4 shows this effect, where the experience seemingly becomes overwhelming as the bold yellows and reds distort the visual sense.

2. The ability to experience multiple layers of colour, and inherently temperature, is critical when producing a hot thermal environment. The introduction of a field depth adds directionality and internality to the atmosphere, as seen in Figure 1.6.

3. The introduction of symbolism into an environment simulates a 'hot' environment more effectively than colour. A sun-like figure shown in Figure 1.6 begins to give the 'warmth' a source and allows the body to visually depict the heat directionality.

4. Small indications of symbolism and heat sources produce a more dynamic environment. Figure 1.5 shows the reflection of the sun on the ground plane of the drawing. While experiencing the drawing, these small indications of symbolism allow the environment to become more immersive as you begin to experience the virtual realm's three-dimensionality.

Implementing Symbolism

Symbolising heat in the virtual environment appears crucial to developing a thermal perception of a virtual environment. The success of this symbolism within this series' conceptual sketches created an opportunity for it to be developed and tested further. The discovery of the symbolic nature of heat relates to the Sensory Analysis of Thermoception on page 51. The implementation of a heat source perhaps plays into our primordial attraction to fire, and the layering of the thermal environment created in this series relates itself to Lisa Heschong's depictions of the internality of warmth. Through further development, the unity between colour and symbolism is refined and eventually, allows for the perception of a thermal virtual environment.

COLOUR OF HOT

STAGE ONE_{DOT}ONE

FIGURE 1.4. WARM VISION TESTING. EFFECT OF COLOUR ON THE PERCEPTION OF WARM TEMPERATURES.

FIGURE 1.5. WARM VISION TESTING. INTERNALITY AND SYMBOLISM TESTING.

FIGURE 1.6. WARM VISION TESTING. EFFECT OF SHAPE AND COLOUR ON TEMPERATURE PERCEPTION.

Series Two.

Following the exploration, colour of cold, the next logical step was to understand the best ways to present warmer temperatures to the user visually.

Through TiltBrush and a contrasting colour palette, a new series of drawings were created and experienced using the same binaural methods as the previous step.

Initially, the drawings' objective was to represent hot environments through colour; however, after the drawings' initial experience, representation through symbolism became a key objective.

COLOUR

STAGE ONE_{DOT}ONE

Experimentation

Following the initial studies into the correlation between colour and temperature perception, a final conceptual drawing for Stage One_{DOT}One was created to understand if a thermal experience could be created using non-hot or non-cold colours. The same process was undertaken for this series as the previous two, where a VR headset would be used to view the drawings. There were no expectations for what type of thermal experience would be created as a result of this series.

Colour

The implementation of various colours in an *Aurora Borealis* style drew on the previous conceptual explorations, through the use of fog-like colour, symbolism and contrasting and complementing colours. Overall the wide range of colours did not attribute to any major visual simulation of a thermal atmosphere. Although the drawing was vibrant and provided a fresh experience, the drawing atmosphere was meditative and relaxing to the senses. Although the colours did not provide an adequate thermal environment themselves, the space between them began to.

FIGURE 1.7. ABSTRACT VISION TESTING. EFFECT OF COLOUR AND SHAPE ON TEMPERATURE PERCEPTIONS.

FIGURE 1.8. ABSTRACT VISION TESTING. EFFECT OF MIXED COLOUR ON THE PERCEPTIONS OF TEMPERATURE.

FIGURE 1.9. ABSTRACT VISION TESTING. EFFECT OF DISTANCE AND COLOUR ON THE PERCEPTION OF TEMPERATURE.

The Void

The contrast of colour and form against a stark black background effectively created a concentrated experience. As a large portion of the field of view was empty, the senses tended to focus on the objects' relationship with one another. The ability to create relationships by removing information in the virtual environment is a key result from this initially experimental series, as it sets a framework for future developments to draw from. If the meditative expression can be experienced in the final design, could this help focus the sensory experience and unify the fragments of our sensory system?

THERMAL ENVIRONMENTS

STAGE ONE_{DOT}TWO

Implementation of previous stages to develop VR environments which visually simulate environmental temperature.

Drawing from the previous stages' key results, this stage focuses on creating virtual environments that can be experienced through the HTC VIVE headset. By applying the design ideas resulting from previous design research, this stage is a 'proof of concept'; wherein visual, thermal atmospheres are created to test our bodies' ability to visually perceive virtual thermal environments. Through this testing this stage aims to resolve part of the requirements for RO2, RO4 and RO5.

Google TiltBrush was used once again to design the conceptual drawings of this stage, and a similar approach to experiencing the drawings with binaural audio was implemented.

Stage One_{DOT}Two aimed to:

1. Use previous design explorations to create virtual environments.
2. Test how previous ideas could be combined to create thermal experiences.
3. Strengthen knowledge of virtual environment design methods for VR application.

‘the arctic frost’

Environment One

Following the previous explorations of colour, symbolism and atmosphere, a virtual environment was designed for testing in VR.

Through the implementation of ‘cold’ colours, fog-like design and slight additions of symbolism, a small environment was designed and built for VR use. The final conceptual design placed the user in the centre of a frozen lake surrounded by high mountains and fog, an experience which was designed to closely represent the idea of being stranded in the arctic during a blizzard.

This part-stage environment provided a better understanding of how to effectively design visual perceptions of cool temperatures and generate design methods for developing VR environments.

Conceptual Idea

Combining the results of Stage One...One was crucial for the success of this conceptual environment. Creating a cold climate as the first design step was driven by prior research into warmth's layering nature. By producing a cold environment first, it was hoped that the heat could be layered upon it, creating a perceptually enhanced sensory experience.

Creating an arctic based experience allowed the user to quickly locate their body in space and set a baseline expectation for the environment's temperature. The addition of a darkened sky, with a singular light source, further enhanced the experience as it drew from the third result of the Colour of Cold tests. Fog was later added to the experience to introduce atmospheric conditions, which helped formulate the spatial perception of low environmental temperatures.

Expectations

Whilst designing this environment, it was expected that a minor visual perception of coolth would be perceived by the user, but that this stimulation would not be dramatic as the virtual environment is only engaging one of the bodily senses.

Testing the ability to perceive heat sources within a cold environment was another testing point for this part-stage, and the placement of a sun within Environment One allowed this testing to be undertaken. The sun was placed to only affect a 180° viewing angle (Shown in Figure 1.10), allowing two testing sequences to be conducted at once; visual

perception of cold environments and visual perception of heat within cold environments.

Experience

Visually, Environment One provided adequate stimulation to keep the user immersed for long periods. The integration of 'cold' colours with white fog provided a complex viewing experience which consistently changed as the user transitioned through the environment. Featured in the design was small particles which fell throughout the environment, representing snow, which further enhanced the visual complexity (Shown in Figure 1.12).

Thermoception was effectively portrayed to the user, with a definite visual perception of coolth whilst inside the virtual environment. The room temperature which the user viewed the environment altered this perception; however, even when the room temperature was set to 22°C, there remained a visually stimulated chill through the body. Perhaps this indicates the visual sense's effectiveness at altering thermoception, or maybe only at changing our perception of coolth.

When viewing the sun, the thermoception experience warmed a minuscule amount. The lack of reflections and absence of sun rays, a limitation of TiltBrush, appeared to make the sun feel out of place and unrealistic. The sun's warm glowing appearance provided visual curiosity and can be linked to the small increase in the thermoception experience (Shown in Figure 1.11).

FIGURE 1.10.
FAR LEFT.
ENVIRONMENT ONE
DEMONSTRATING
THE LOCATION OF
THE 'SUN' WITHIN
THE EXPERIENCE.

FIGURE 1.11.
LEFT.
'SUN' DESIGN WITH
LAYERING WARM
COLOURS WHICH
APPEAR TO GLOW.

FIGURE 1.12.
RIGHT.
ENVIRONMENT
VIEW WITH DYNAMIC
FALLING 'SNOW'
PARTICLES.

‘falling skies’

Environment Two

Drawing from the Colour of Hot in Stage One...One, the idea to ‘layer’ heat onto a cold environment was generated for testing in VR.

This environment exploration uses colour and symbolism as design tools to create an immersive virtual experience that begins to portray heat visually. Applying these design tools to the previous virtual environment, *‘the arctic frost’*, a dynamic experience was created. The ideas relating to the field of depth, indications of symbolism and ‘hot’ colours were also crucial in executing this part-stages virtual environment.

This part-stage design provides insight into the extent to which visual thermoception can stimulate the body to perceive warmer temperatures.

Conceptual Idea

This project's final design experience aims to be a single uniform environment that exhibits a multi-sensory experience. Creating a single experience relies on a smooth transition between the sensory inputs, and so it was decided that 'falling skies' should relate to 'the arctic frost', whether it be through metaphor, visual aesthetic or another method of connection. With those ideas in mind, it was decided that this environment's design would incorporate the previous environment. This method of design would also further test the theories of warmth being effectively executed via layering.

Visual perception of heat needs a source, a conclusion previously made in this research, which would give the environment narrative. Implementing a sun-like symbol in the previous environment provided this part-stage with an opportunity to design an environment where the sky falls into the ice lake, heating the virtual atmosphere along with it.

Layers of 'hot' coloured fog throughout the environment created extensive depth to the experience, whilst large rock-like craters resembled the crashing point of the falling sky. The sun's large scale made it necessary to develop new heat sources at a relatable scale for the user. Therefore fire was drawn inside the craters. This scale was added to help locate the user's body within the virtual space, an idea that originated from Bill Hillier's discussion of space in the theoretical review on Page 25.

FIGURE 1.13.
FAR RIGHT.
IMPLEMENTATION OF
SYMBOLISM THROUGH
THE INSTALLATION OF A
BURNING TREE INTO THE
ENVIRONMENT.

FIGURE 1.14.
NEXT PAGE SPREAD.
'HOT' COLOURS LAYER
THE VIRTUAL THERMAL
ATMOSPHERE CREATING
A VISUAL PERCEPTION
OF HEAT.

Expectations

Implementing the design tools created through 'The Explorations of Colour' in this environment provides promising expectations for this part-stage. The extensive use of altered fog, colour and depth of field expects that a strong visual perception of heat would be created. Through scale, symbolism and resemblance, the virtual environment should enhance immersivity and allow a perception of virtual atmospheric qualities through its engagement with the user's body.

There will be limitations to heat perception, as this conceptual design phase relies purely on visual stimulation to portray the virtual atmosphere.

Experience

Environment Two provides a stimulating visual experience, and the dynamic attributes of the environment create a visually exciting scene to traverse. The thermal environment's layering is highly successful in the visual perception of heat (Shown in Figure 1.14) whilst also creating spatial atmospheres within the virtual realm. As the user moves through the scene and incidentally through the atmospheric layers, the spatial experience evolves, creating a dynamic virtual space that changes in response to the user's body.

The incorporation of symbolic gestures, such as the flaming tree shown in Figure 1.13, encapsulate small thermal moments within the experience. These moments assist in locating the body in space and building the thermal experience visually. By providing different heat sources of altering sizes, the virtual thermal environment consistently shifts, which inherently creates a more immersive experience than Environment One.

Environment Three
'voiding space'

The discovery of 'the void' in Stage One...One resulted in the need for a third environment to be created and tested. Environment Three's focus is limited in its capacity to develop visual thermoception, as it directs itself towards understanding the idea of the void, the idea that the absence of form within the virtual environment allows our sensory fragments to become heightened and more united.

Generating form through the absence of form is the critical focus of designing and testing this environment. A particulate field was created using Google TiltBrush, which focused on inserting a small number of coloured particles within a sizable spatial atmosphere. Intricate flowing forms dissected the generated field and allowed the placement of different sized platforms of light to be inserted within (Shown on the next page in Figure 1.15).

This Environment underwent testing that aimed to better understand the void, restrict physical movement inside the virtual environment, and assess whether the absence of form and colour creates the concentrated experience discussed on page 69.

FIGURE 1.15. PARTICULATE FIELD WITH PLATFORM STRUCTURES.

FIGURE 1.16. PARTICULATE FIELD DEMONSTRATING FORMATION OF PATTERNS.

Particulate field

The final environment of Stage One_{or}Two aims to better understand the relationship between form and perceived form within the virtual environment. The most effective way for this to be explored was through the use of particles within TiltBrush.

The particles were drawn on a cosmic scale, which allowed the design to transcend reality and scale whilst maintaining immersion and sensory focus.

Placed within spherical bounds, the particulate field covered the 360° field of view, allowing it to

encompass the user and detach the body from space. The detachment was an approach used in this design as it allowed the visual focus to be concerned with form alone and to remove expectations of the environment.

The particulate field had a randomised application within

FIGURE 1.17. PARTICULATE FIELD
VIEWED FROM SPHERICAL BOUND.

the spherical bounds, which created abstract patterns as it was viewed by the user.

The particulate field appeared to align in areas, and the user could see geometric patterns, even though no patterns were designed or implemented (Shown in Figure 1.16).

It became apparent through the design and testing of the particulate field that ‘the void’ was an idea that could extend further design stages. The body’s ability to draw patterns and forms out of the absence of particles created heightened levels of immersion and awe.

By maintaining immersion and engagement with the voided space, there lies an opportunity for the sensory fragments to be united as they begin to experience space itself. A discovery comparable to the case study research findings into Olafur Eliasson’s *Your Making Things Explicit* (2009).

FIGURE 1.18. PLATFORM CONNECTION
WITH PARTICULATE FIELD.

FIGURE 1.19. LIGHT PLATFORMS.

Restricting Space

The disconnection of body and space within the particulate field was necessary for better understanding the voided space. However, the body and space connection is crucial for further design stages, so large light platforms were designed throughout the particulate field centre.

Flowing arms stretched out from the platforms to the edge of the amorphous form, creating strong relationships between the places we stand and the places we inhabit (Shown in Figure 1.19).

The relationship between vision and the virtual environment appeared to be enhanced by providing the user with a grounding. Immersion and relationship of body and space, two key focuses of *'Experience'*, dramatically improved through this connection.

FIGURE 1.20. CONNECTION OF BODY
AND SPACE WITHIN VOIDING SPACES.

The introduction of platforms in the experience allowed the designer to severely limit the users' physical movements. Combining the particulate field's cosmic-scale and the human-scaled platforms invoked sensations of vertigo when the user viewed over the edge of the platforms.

This is an impactful result from this environment design as it provides future designs with a toolkit to influence the way the user moves through real and virtual space.

Due to a limitation of VR, the size of the physical spatial bounds that the user experiences the virtual environment within, this influence is key to future design stages' success.

SEEING SOUND

STAGE ONE_{DOT}THREE

Exploration of the bodies ability to visually understand audition through the virtual environment.

Visually representing Audition was the next critical step for '*Experience*', as it would allow future design stages to better implement the auditory sense. This stage draws from the prior research into Audition, and applies it to the virtual environment. By selecting audio samples and creating a program which can systematically analyse and break down certain frequencies, an environmental exploration was undertaken.

This stage utilises a new program, SideFX's Houdini, to achieve its aims. Through Houdini an visual audition environment was designed and tested, creating a greater depth of knowledge in recognition of RO2.

Stage One_{DOT}THREE AIMED TO:

1. Implement previous Audition research into the virtual environment.
2. Design a virtual environment which actively represents Audition Visually.
3. Provide greater understanding of how audio samples can be dissected and analysed within computational programs.

Visual Audition

Proceeding the exploration into visual thermoception, it becomes necessary to understand the role visual audition will have in this project. Patrice Voss's stance on the limited ability of standalone audition in recognising space's vertical axis on page 48, has created an opportunity for this part-stage (2016). The approach to exploring visual audition was to create virtual environments that are driven, or animated, by an audio sample. The audio samples frequencies, pitches and amplitudes are broken down to create dynamic environments which aim to maintain engagement and allow the user to understand the spatial qualities of the auditory environment along all 3 axes.

For this part-stage, a new program would need to be learnt, one that could analyse audio tracks, create invigorating animation and handle huge amounts of data being transferred between the audio and points on an environment's surface. It was concluded that SideFX's Houdini would be the best possible option to achieve this. Houdini can support VR equipment; however, it was decided that implementing this equipment would be too difficult for this conceptual design. Instead, moving images were created to test the effectiveness of creating an evolving virtual environment in response to audio samples.

Houdini.. What?

SideFX's Houdini is a 3d animation software which is most often implemented for procedural design in the moving image industry. The attraction of Houdini for this project was its comprehensive CHOP network, which can sample audio tracks and break down different variables from the sampled clip. These resulting variables can then be interpreted by the program

to run a plethora of surface and point commands, such as thickness increasing, point movement and even evolving colour gradients.

This stage used an audio track created by a colleague, Keep Open by J.IA (2020), in its own CHOP Network. The network begins by analysing the song and then tears apart five frequency ranges:

20-50Hz. *Infrasonic Bass. The unheard tone, this range creates emotion and feeling through the body.*

50-100Hz. *Bass. The foundation tone, Bass forms the depth of the music as it is the lowest frequency that audition recognises.*

100-400Hz. *Low-Mid. The body tone, the range that creates warmth and texture to the music.*

400-2000Hz. *High-Mid. The clarity tone, audition uses this range to define the musical piece.*

2000+Hz. *High. The tone of presence, without this range the music would lack sibilance and engagement.*

These frequency ranges are then evaluated for tone, a combination of pitch, quality and strength. This evaluation results in a series of numerical values for each range which are assigned to an attribute *height*.

The *height* attribute is a self made attribute which allows each changing numerical value to be assigned to a single, or collection, of points on an environment's surface. This process is an oversimplified explanation of the process undertaken to create a morphing virtual environment which is driven by audio, but provides an overall outline for how Houdini is used for the context of this design stage.

FIGURE 1.21. STAGE 1.3 ENVIRONMENT SURFACE, WITH ENLARGED CENTER TO SHOW POINT LOCATIONS.

FIGURE 1.22. AUDIO DISPLACEMENT OF NODE POINTS ON THE INTERIOR SURFACE OF THE ENVIRONMENT.

0:00:00

0:00:10

0:00:20

0:01:00

0:01:10

0:01:20

0:02:00

0:02:10

0:02:20

The Environment.

Designing an environment through sound sampling is a dynamic way to produce a virtual experience which changes as the audio track does. The conceptual nature of this stage provided some freedom for the complexity of the environment shell design. It was decided that a sculpted shell with two openings at each end would be sufficient. The simplistic shell allowed more focus to be placed on the design and fine-tuning of Houdini systems which drove the environmental changes. Carefully selected lighting and granular textures allow the environment to be abstract and displace itself from expectations.

Figure 1.23 demonstrates the environment's ability to adapt and change over time. As the pitch of different frequencies increases or decreases, the surface points move inward or outwards from the center of the environment. The occurrence of an adapting environment in three-dimensions provides this conceptual design phase with a good understanding of how these techniques could be applied to VR systems in later stages.

FIGURE 1.23.
LEFT.
ENVIRONMENT TIMELINE
DEMONSTRATING THE
ADAPTABLE NATURE
OF THE AUDITION
ENVIRONMENT.

Experience.

Visual Audition was an interesting exploration that helped reinforce the ideas previously explored in *'Experience'*. Audio integrated simulation allows environments to become more engaging and overall visually exciting. An environment can become more dynamic through the simple integration of audio driving, which allows small design decisions to create large results. In short, this procedure is very effective for creating faster, more engaging virtual environments.

The ability to locate yourself within a virtual auditory environment, creates avenues for increasing directionality in the future design stages, especially if the environment also utilises spatialized audio. The use of all five frequency bands, although visually stunning, does create a fast-paced, rapid environment wherein the user could possibly get lost or overwhelmed. When the audio sample is refined to one or two frequency bands, the experience could become more focused and distil accents of curiosity within the viewer. Moving forward it may be more effective to design environments using certain frequency bands to control different forms of animations, allowing more refined virtual environments to be created.

STAGE TWO DESIGN

THE LIMITS

Implementing sensory experience to understand the limits of sensory stimulation.

This stage builds upon the previous research results to introduce individualised sensory stimulation as a response to the ocularcentric paradigm, RO3, RO4 and RO5. Stage One highlighted the limitations of the visual sense in reproducing sensory sensations, so this stage incorporates the five selected senses to create a virtual environment which actively engages the body's sensory system.

Previously used programs such as TiltBrush and Houdini, were presented as displaying a number of computational limitations which would have prevented a continuous sensory experience to be created. In response to these limitations a new program, Unity, was selected to create the virtual experience.

Stage two aimed to:

1. Create a complete sensory experience which actively engages all five senses.
2. Understand if the sensory system would be comfortable whilst being continuously stimulated.
3. Provide future design stages with tools that would allow the successful creation of virtual environments.
4. Learn C# coding so that the final experience could run smoothly and allow a seamless virtual environment to be created.

the approach

p.112	vision	2 _{oot} 1
p.118	audition	2 _{oot} 2
p.124	thermoception	2 _{oot} 3
p.126	kinaesthesia	2 _{oot} 4
p.134	results	

Creating a complete sensory experience is a key objective of not only stage two, but also 'Experience'. As previously discussed the fragmentation of the body's senses causes a major issue for spatial perception however, they have produced a design methodology opportunity for the next design stages. By carefully designing for each sense individually, and then developing these designs together; it was hoped that a complete sensory experience would be created.

This design methodology was implemented for this stage, as a test to see whether or not fragmentation could play a role in virtual design. This stage is laid out to reflect the design methodology, with final results concluding the entire experience as opposed to each individual sense.

the systems

Designing a complete sensory experience, a large development from the singular explorations previously researched, set a requirement for a more powerful program to be integrated into '*Experience*'. Houdini had proved to be a powerful tool, however it had limitations with VR and an average 110 hour render time for a 3 minute video, making it mundane for a final experience.

Unity is a game engine which is often used by developers to create video games. The integration of GPU rendering, a vast network of help forums and integration with C# (C Sharp) code allows the program to have a wide range of possible applications.

Unity is primarily an asset based program, where 'assets' or plug-ins are downloaded and installed into the project file. These assets are pre-built programmatic scripts with a wide-range of applications, and further editing of the assets is possible through C# scripting.

A key asset used in this stage is the VFX graph, a GPU based particle system which allows for large numbers of particles to be simulated at once. This system is further elaborated on in Stage TwoDOTOne.

C# coding was also widely used in this stage, a coding type that was self-taught during the course of this project. C# delivers an endless number of applications and was critical for the conjoining of all the sensory systems for this stage.

VISION

STAGE TWO_{DOT}ONE

Overview

So far the visual sense has been the most widely explored through prior research. The results of the previous tested environments have provided a better understanding of how the visual sense can be used to affect the other sensory systems. This stage built on the previous research with a new powerful tool, the VFX Graph, which has allowed more dynamic experiences to be designed and implemented for VR application.

The ideas of colouring, layering and temperature perception have been key players in this stage, providing the groundwork for how the experiences would ultimately be perceived by the user.

VFX Graph

Unity's VFX graph is a visual coding system which provides the opportunity to produce real-time particle systems at a grand scale. The system can take a variety of input float and variable values to affect the overall form of the particle field. The ability to create dynamic, large-scale virtual environments quickly through particle systems was important for this design phase. It not only allowed quick production of experiences for testing, but the qualities of the particles themselves, with voiding spaces appearing between them, allowed the experience to draw on the previous results of 'voiding space' in stage one.

Figure 2.1 and 2.2 demonstrate the particles ability to transform the virtual environment over time, allowing a dynamic changing

virtual experience to be created. Once the VFX graph was built and was producing an appropriate environment, the research into colour and thermoception was applied to the experience.

Colour

The application of colour to the VFX graph was approached through two methods: Layering of warmth over Coolth and the Emission of Warmth through Coolth.

Figure 2.1 demonstrates the first of these two methods, Layering of Warmth over Coolth. This experience used a rotating particle emitter which emitted 'cool' particles that changed colour over their lifetime, creating a layering effect. By layering the warmth gradually over time, the resultant thermal environment constantly fluctuates and evolves. However, because the particles die out once they reach maximum temperature, the environment becomes monotonous and repetitive.

The second method of applying thermal colours to the environment was through a torus shaped emitter, as seen on the next spread in Figure 2.2. The environment begins with a constant emittance of cool colours which grow outward from the torus edges. Warmth is then added to the environment through micro-explosions of particles from the surface of the torus. By emitting warmth through a cool environment, the virtual atmosphere is allowed to consistently shift and change, especially as the velocity of the particle explosions is altered. This method of thermal emittance is diverse and was pushed further through the design stages to combine with audition and thermoception.

FIGURE 2.1.
RIGHT.
TIMELINE OF VFX GRAPH
PRODUCING A PARTICLE
FIELD WHICH EXPLORES
THE LAYERING OF HEAT.

FIGURE 2.2.
LEFT ON NEXT SPREAD.
TIMELINE OF VFX
GRAPH PARTICLE
FIELD EXPLORING THE
EMITTANCE OF WARMTH
AGAINST COLD COLOURS.

FIGURE 2.3.
SIDE PROFILE OF
HOW THE LAYERING
EXPLOSIONS BEGIN
TO CREATE THERMAL
ATMOSPHERES.

Virtual engagement

The effectiveness of the VFX graphs and colour mapping is demonstrated through the image on the right. With over One Million particles being generated for this experience, the relationship between form and void becomes dynamic and visually engaging. The particles

all share a common 'spawn point', however each particle's movement is based on the result of emittance velocity and collisions with other particles. This scale of calculation is only possible on the GPU as it uses a huge amount of computational power.

However, the final result of each visual environment is a unique experience which changes after every explosion, allowing unique virtual engagements to be created between the environment and the user.

FIGURE 2.4.
DEMONSTRATION OF THE
START OF A LAYERING
EXPLOSION THROUGH A
COLD ENVIRONMENT.

AUDITION

STAGE TWO_{DOT}TWO

Overview

Applying the same ideas generated during Stage One_{DOT}Three, and developing a system similar to the Houdini CHOP network was the clear first process for this stage. The large-scaled particle systems produced in Stage Two_{DOT}One influenced the selection of a larger scale orchestral music piece to be used for this design stage. Orchestral music is full-ranged and consistently varies between frequency bands, which would allow for more immersive and diverse environments to be produced. The audio score Atlas by Camo and Krooked (2020) was selected for this environment as it's tonal range widely evolved over the duration of the song.

The unity asset KLAKE was used for the sampling and analysis of the selected audio clip, with broader frequency bands being created; Infrasonic Bass and Bass were combined, as well as High-Mid and High tones. The analysed audio frequency bands outputted a floating number value between 0 and 1, which increased when the tonal range exceeded a set decibel value.

C# coding was then used to tie the floating number value to attributes of VFX graphs, allowing dynamic visualisations to be created. The decibel value, attributes and intensity of visualisation methods is fine tuned through the C# coding and furthermore through the VFX graph settings.

KLAKE

The KLAKE asset uses an audio input, which is sourced from a spatial audio source located within the virtual environment, to analyse. The asset uses high-pass and low-pass filters to remove unwanted frequencies from the analysis spectrum, these filters were modified through C# code to deliver accurate analysis in accordance with the new broader frequency bands discussed above.

It was decided that continually updating a VFX graph attribute with a frequency range would produce too many changes to the virtual environment, as the audio clips frequencies change rapidly. As a result a Dynamic range was added to the analysis which isolated a 'volume range' that the frequencies would have to be within to be outputted. When an analysis sat within the dynamic range, it outputted a proportional value from 0 - 1. However, if a frequency kicked and exceeded the range, it outputted a value of 1.3 which allowed more instantaneous visualisations of audition to be produced.

C# Connection

Integrating the Klak output to a VFX graph was the first introduction of C# to this project. Learning C# was a large obstacle for this design work, and allowed some unexpected results to occur. However, the power of C# began to reflect itself through the virtual environments it began to create. Through the application of vector calculus and basic coding principles, the following coding script was generated to introduce audition as the driver of vision within Unity. A driver which created dynamic virtual experiences that began to produce the first VR sensory experience for 'Experience'.

first script which assigns the amplitude of a frequency range to be outputted as a float value.

```
public class AudioInput : NodeBase
{
    public float output;

    float _amplitude = _peak;

    void Update()
    {
        output = _amplitude;
    }
}
```

second script which integrates the audio and vfx graph.

series of inputs where the vfx graph components and audio components are placed within unity.

if the audio output exceeds 1, then the vfx graph receives a value of 1.3.

otherwise (else) the vfx graph receives a value which is between 0 and 1.

```
public class VFXAudioController : MonoBehaviour
{
    public AudioInput audioInputVFX;

    [SerializeField]
    private VisualEffect visualEffect;

    [SerializeField, Range(0, 1)]
    private float AudioFloat = 0;

    void Update()
    {
        if (AudioInputVFX.output < 1)
        {
            AudioFloat = 1.3f;
        }
        else
        {
            AudioFloat = audioInputVFX.output;
        }

        visualEffect.SetFloat("AudioInput", AudioFloat);
    }
}
```

FIGURE 2.5.
ABOVE.
 TIMELINE OF AUDITORY SYSTEMS INFLUENCE ON PARTICLES. THE
 TOP LINE DEMONSTRATES HIGHER TONES, WHILST THE BOTTOM
 LINE INDICATES THE BASS TONES.

Tonal mapping

The auditory processing system was initially applied to a single emitting point to understand how each of the frequency ranges would affect the spread and visual aesthetic of a particle system. This exploration showed how bass tones were often used more frequently within the audio

sample, and created a more consistent firing of the particles. Whilst, the high tones had more range to them allowing a more engaging particle system to be produced.

As a result of this initial conceptual application of visual audition, the auditory system was applied to the second iteration of Stage Two_{of}One (See Figure 2.4).

The consistent emittance of the bass tones, shown in Figure 2.3, was applied to the emittance velocity of the cooler coloured particle system; whilst the more diverse ranged high tones were applied to the velocities of the warmer colours.

By applying the more frequent tones to the cooler particles, the ideas of layering began to become prevalent in this stage's design. This allowed a virtual thermal atmosphere to be created visually which was both engaging and sensational.

FIGURE 2.6.
NEXT SPREAD.
TIMELINE OF AUDITORY
SYSTEMS INFLUENCE ON
A PARTICLE SYSTEM,
ASSISTING TO PRODUCE
A VISUAL THERMAL
EXPERIENCE.

THERMOCEPTION

STAGE TWO_{DOT}THREE

Overview

The creation of a physical thermal stimulation of the user was the next logical step for *'Experience'* to achieve RO3, and its ability to work in real-time with the virtual environment was critical for an effective immersive experience to be created. The conceptual nature of the first thermal system led to a single heat lamp being used by a 'puppeteer', who would actively warm the user in response to what was being visually experienced inside of the virtual environment (as demonstrated in Figure 2.7).

By introducing a thermal atmosphere around the user, it was hoped that the virtual experience would be more sensationalised and create a more immersive understanding of the virtual space. A key focus of this first physical thermal stage was to understand the extent to which a VR user would experience external heat sources whilst immersed in a sensory environment.

Approaching thermoception

The initial approach to developing stimulation of thermoception was to apply Peltier elements to the skin on the back of the neck. Peltier elements are small thermoelectric coolers, about the size of a two dollar coin, which have the ability to heat up and cool down depending on the direction of the current. These systems have been implemented in VR before, with promising results demonstrating the stimulation of thermoception whilst experiencing virtual environments (Kim et al., 2017; Ranasinghe et al., 2017, 2018).

Although this method would be an effective way of providing stimulation to thermoception, it was decided to instead create a physical thermal atmosphere around the user. Through the introduction of infrared heat lamps, a spatialised heat could be formed; which not only allows a tactile response to the virtual environment but also develops thermal atmospheric qualities within the virtual environment. Drawing from the research into James Turrell and his understanding of how we can experience space itself, not just the cause and effect of said space; the implementation of a thermal atmosphere allows us to experience virtual space itself.

Delivering thermoception

A single 375w heat lamp was used for this stage's exploration of the thermal atmosphere. A puppeteer held the heat lamp in front of the user, whilst watching a live monitor which relayed what the user was viewing within the virtual environment (See Figure 2.7). By moving the heat lamp towards and away from the user, the puppeteer could effectively mirror the distribution of heat originating from the visual experience which has been developed throughout stage two so far.

FIGURE 2.7.
ABOVE.
PUPPETEER PROVIDING A HEAT SOURCE TO THE VR USER.

KINAESTHESIA

STAGE TWO_{DOT}FOUR

Overview

A major limitation of VR systems is the ability to actively move throughout the virtual environment, as the room bounds tend to restrict active exploration. This limitation has been further exacerbated due to the puppeteer's role in delivering a thermal environment, and the cosmic-scale of the particle system. The implementation of a Microsoft Kinect 2.0 Sensor was critical to the implementation of Kinaesthesia within *'Experience'*. The Kinect's gesture recognition allowed certain gestures to trigger movement of the head-mounted-display through the virtual environment.

The choice to use gestures over traditional point and click transportation, usually activated by a vr remote, helped avoid two sensory issues that would have arisen:

1. Use of a VR remote would have blocked the ability to experience the thermal environment through the palms.
2. Traditional transportation would not have actively engaged Kinaesthesia.

Kinect

The Kinect sensor has a wide range of inbuilt gesture commands which it can recognise, however it also has the ability to create new gestures. The inbuilt gestures were mostly hand movements which would have been common whilst a user was exploring a virtual environment, such as the waving of the hands; as a result of this it was decided that two commands would be created for this stage.

1. Moving Forward. Arms start straight out from the chest and move outward into a T-Pose.

2. Moving Backward. Arms start in the T-Pose and hands are then moved together.

The created gestures were then integrated into a C# coding system which interpreted the overall speed the gesture was actioned to move the user forward or backward in a relational speed. The direction of movement was scripted to follow where the user was looking. Initially, the user was able to move vertically as well as horizontally; however, this led to issues wherein the user would get lost in empty space, so the code was adjusted to limit the user along the ground plane.

Journeying through space

Providing the user with a journey as they transitioned through the virtual environment became apparent as being critical in the creation of a sensory experience. A series of audition controlled visualisations were laid upon a virtual movement path. As the user moved from one to another, the next series of visuals would begin to emit particles. This allowed a consistently evolving sensory journey to be created, as the user was consistently engaged with their journey through cosmic space (See Figure 2.8 and 2.9 on the next page).

script which connects the KinectSensor to the game camera (VR headset).

assigns the Kinect gesture detection to a unique name of gestureListener.

rate calculates the movement speed based on the speed that a gesture is performed.

defining variables for moving forward through space.

defining variables for the movement backward through space.

when the moving forward gesture is detected, user is transformed forward.

detection of movement backward gesture moves user backward.

```
private MovementGestureListener gestureListener;

[SerializeField]
private GameObject Camera;

public int speed;
public float rate;
public Vector3 localSource;
public Vector3 localDestination;
public Vector3 localDirection;
public Vector3 worldDirection;
public Vector3 localDestinationRepel, localRepel, worldRepel;

void Start()
{
    gestureListener = MovementGestureListener.Instance;
}

void Update()
{
    rate = (gestureListener.GetMovementFactor() * speed) * Time.deltaTime;
    localSource = new Vector3(Camera.transform.position.x, Camera.transform.
        position.y, Camera.transform.position.z);

    localDestination = new Vector3(Camera.transform.position.x, Camera.transform.
        position.y, Camera.transform.position.z + 100f);
    localDirection = (localDestination - localSource);
    worldDirection = Camera.transform.TransformDirection(localDirection) * 1000f;

    localDestinationRepel = new Vector3(Camera.transform.position.x, Camera.
        transform.position.y, Camera.transform.
        position.z - 1000f);
    localRepel = (localDestinationRepel - localSource);
    worldRepel = Camera.transform.TransformDirection(localRepel);

    if (!gestureListener)
        return;
    if (gestureListener.IsMovingForward())
    {
        transform.position = Vector3.MoveTowards(transform.position,
            worldDirection, rate);
    }
    else if (gestureListener.IsMovingBackward())
    {
        transform.position = Vector3.MoveTowards(transform.position,
            worldRepel, rate * 3f);
    }
}
```

FIGURE 2.8.

ABOVE.

THE BEGINNING OF THE SONG CREATES AN EXPLOSIVE
ATMOSPHERE WHICH COMBINES WARMTH AND COOLTH TOGETHER.

FIGURE 2.9.

ABOVE.

AS THE USER MOVES THROUGH THE PARTICLE FIELD, THE AUDITION DRIVER CREATES AN EXPANSIVE EXPERIENCE.

FIGURE 2.10.

ABOVE.

AFTER ENTERING THE EYE OF THE FIRST PARTICLE SIMULATION, A DANCING 'FIREBIRD' CREATES AN INTENSE THERMAL ATMOSPHERE.

Results

This stage highlighted the first successful sensory experience of this project. Through excessive stimulation an experience was generated that continually engaged and stimulated the human body. Although this stage produced an environment that was highly immersive and engaging, the experience often became overwhelming causing the unified sensory fragments to shatter back into their own areas of experience. Stage Two has demonstrated the need for a more refined virtual experience which focuses on the creation of a more delicate balance of sensory stimuli. The creation of a thermal atmosphere was at times successful, however, it became quickly apparent that this is the first sense to slip away when the sensory system is being overloaded with engagement. The need for a larger, more dynamic thermal environment will be critical for the future design phases.

STAGE THREE DESIGN

THERMAL ATMOSPHERES

Can Thermoception be individually stimulated to create virtual spatial perceptions

The results of Stage Two created a significant issue for **'Experience'**, wherein the excessive stimulation of the sensory systems resulted in fragmentation. As discussed in Stage Two, Thermoception was the first of the senses to significantly fragment. The need for a larger, more dynamic physical thermal system became apparent after Stage Two, and so a small room was allocated for a complete thermal experience to be created inside of. This stage focuses on understanding the effectiveness of thermoception in perceiving a virtual environment, and tries to understand the extent to which thermoception can detect changes in the thermal environment. This stage incorporates all prior research to resolve RO3.

This stage has adopted a new set of computation systems which have allowed a continuous real-time thermal environment to be created. Unity remains as the key modelling and scripting program, with the introduction of Hog4Pc, a TheatreLight Dimmer and a refined set of Unity assets.

Stage Three aimed to:

1. Develop a thermal system which responds in real-time to a virtual environment.
2. Explore the limits of thermoception, and understand the extent to which the sense can be engaged.
3. Develop a set of tools which can be used to create a final virtual sensory experience.

Overview

Creating a multi-sensory virtual experience is the key objective of *'Experience'*, an objective which requires dynamic integration of all the sensory systems to create an effective virtual environment. The prior research into thermal systems was underdeveloped and did not properly test the bodies ability at perceiving atmosphere through thermoception. This created the need for a more dynamic 360° thermal environment to be created that would act in real-time with the virtual environment. By creating a 360° real-time atmosphere, it is hoped that the user can maintain engagement with the virtual environment whilst participating in a complete complex sensory experience.

Creating a thermal environment

To create the needed thermal environment it was decided that four heat lamps would be introduced around the user. Fortunately, a room was made available in the DARA lab which could accommodate a system of this scale. The Heat Lamps were installed onto the walls of the room, and were powered by a TheatreLight dimmer. Dimmers are a piece of technology which are used in theatre shows to control the intensity of stage lighting by lowering and increasing the flow of current to the light. The integration of a dimmer pack allowed each individual heat lamp to be controlled by itself, and be able to have ranging intensities of 0-100%.

The dimmer pack was then controlled through Hog4Pc, a virtual lighting desk program which is once again often used in theatre performances to control the stage lighting. The integration of the Hog4Pc allowed a system to be set up between Unity and the heating system, creating a real-time link.

Real-time updates

Creating a real-time workflow between Unity and the thermal system was essential for the success of this research. As previously discussed, thermoception is a sensitive sensory system that can easily be fragmented whilst inside a virtual experience, so the development of this workflow was crucial to the success of *'Experience'*. The coding displayed on the Right, is a small portion of how one heat lamp can be activated through the developed system. Unity uses OSCMessages to send Macro commands to the Hog4Pc software, which then interprets the commands and sends data to the dimmer via a hog node. But let's break that down:

Say we want to turn the first heat lamp on at 60%.

First the Hog must be informed, this is where OSCMessages come in. OSC or Open Sound Control is a protocol which essentially sends messages between two devices or programs. So an OSC link is created between Hog and Unity, just like setting up a cup and string between two windows.

Next we must have a message to send, this is where Macro commands come in. Macro commands are set up in the Hog console for every heat lamp. Each heat lamp was given 10 macro commands that could be called through OSC, where each command related to increasing intensities such as 60%, 70%, 75%, 80% etc..

So how can we turn heat lamp one to 60%?

OSC sends a message to Hog saying ("/hog/midi/on/1/5*") ; Where *1* refers to heat lamp one, and *5* is the macro command for 60%.*

Easy as that. Kind of.

public void can be called from other scripts to begin a 'coroutine'.

the coroutine TransmitHeatOne has an input called heatOne.

this input integer will match an action. such as TransmitHeatOne(2) will run (heatOne == 2).

when an action is triggered, a single oscmessage is outputted to the lighting system.

the coroutine is then stopped to prevent the repeated messages.

each heat lamp has its own coroutine with heatOne values ranging up to 10.

example of how the heat controller can be triggered from another script.

```
public void HeatOneActivate(int heatOne)
{
    StartCoroutine(TransmitHeatOne(heatOne));
}

IEnumerator TransmitHeatOne(int heatOne)
{
    if (heatOne == 0)
    {
        var message = new OSCMessage("/hog/midi/on/1/1");
        message.AddValue(OSCValue.Int(1));
        _transmitter.Send(message);

        StopCoroutine(TransmitHeatOne(heatOne));
        yield return null;
    }
    else if (heatOne == 1)
    {
        var message = new OSCMessage("/hog/midi/on/1/2");
        message.AddValue(OSCValue.Int(1));
        _transmitter.Send(message);

        StopCoroutine(TransmitHeatOne(heatOne));
        yield return null;
    }
    else if (heatOne == 2)
    {
        var message = new OSCMessage("/hog/midi/on/1/3");
        message.AddValue(OSCValue.Int(1));
        _transmitter.Send(message);

        StopCoroutine(TransmitHeatOne(heatOne));
        yield return null;
    }
    else if (heatOne == 3)
    {
        var message = new OSCMessage("/hog/midi/on/1/4");
        message.AddValue(OSCValue.Int(1));
        _transmitter.Send(message);

        StopCoroutine(TransmitHeatOne(heatOne));
        yield return null;
    }
    else if (heatOne == 4)
    {
        var message = new OSCMessage("/hog/midi/on/1/5");
        message.AddValue(OSCValue.Int(1));
        _transmitter.Send(message);

        StopCoroutine(TransmitHeatOne(heatOne));
        yield return null;
    }
}

void Awake();
{
    heatController = GameObject.FindObjectWithTag("OSCManager").GetComponent<HeatController>();
}

void Start();
{
    heatController.HeatOneActivate(3);
}
```

Thermal Atmospheres

Throughout the development of the thermal system, a test was constructed in unity that simulated a sun rising over the user and setting to the west. This simulation was chosen as it proved to be a simple experience that the user could relate to, introducing a preconceived conception of what the thermal environment was. For testing the user was placed into the virtual environment with the VIVE Pro VR headset, however, the headset was turned off. The removal of audition and vision allowed the testing of the thermal environment perception to be effectively undertaken.

Experience

The introduction of a thermal atmosphere without any other sensory stimuli was both effective and experiential. Throughout the experience a perception of the virtual atmosphere was produced, with a wayfinding trait of thermoception becoming apparent. Throughout the experience the user was able to locate the approximate location of the sun, introducing the idea that, much like audition, thermoception is a directional sense. By introducing a common heat source motif to the experience allowed the experience to feel natural and relaxed, allowing thermoception to take control of the body's sensory system. Providing a common thermal experience to the viewer may be essential in allowing thermoception to get acquainted with the virtual environment, prior to any abstracted environment being introduced.

FIGURE 3.1.
LEFT
DEMONSTRATION OF HOW
THE HEAT LAMPS CREATE
A THERMAL REPLICATION
OF A SUNS MOVEMENT.

SENSATIONALISING VR

CHAPTER SEVEN

Building upon previous chapters, how can each bodily sense contribute to the creation of a virtual atmosphere?

SENSATIONALISING VR

CHAPTER SEVEN

Building upon previous chapters, how can each bodily sense contribute to the creation of a virtual atmosphere?

This chapter incorporates the tools learnt to impart sensory experiences through the prior research to produce a final multi-sensory experience. Through the integration of a physical thermal atmosphere, colour, symbolism, auditory cues and VR, a complete sensory experience was designed which aims to resolve all the remaining gaps in '*Experience's*' research objectives.

Initially each sense was addressed as fragments and integrated with one another gradually. This final design was then tested and experienced to answer the question:

How does a multi-sensory virtual experience affect our perception of space?

This chapter will break down how each sense has been designed and catered for, before presenting the final designed environment. A brief discussion of the results of this design stage is situated at the end of this chapter.

FINAL DESIGN

Where to begin..

Creating a sensory experience which is balanced, delicately engages the senses and creates a perception of virtual atmospheres is the critical aim of this final design. Throughout the research so far the ideas of fragmentation have been reinforced multiple times, with some design phases causing their own form of fragmentation to occur. This final design aims to combine the results of the previous research whilst producing a unique sensory experience that allows the viewer to transition their body into the virtual realm. So where to begin..?

Results of the past

A brief gloss over the conclusions made so far, in regard to each sense is crucial to understanding the design moves and stances taken for each sense in this design. These senses will be addressed later in this design phase, however their explanations will all attempt to resolve the issues recognised so far.

Vision

The ocular-centric paradigm was first identified during theoretical research, which has proven to be a difficult task to overcome. The explorations into colour and visual audition furthermore proved that the human body relies heavily on vision to provide understanding of the spaces around us. The prominence of vision within our sensory system has made it intertwined with almost every other sense under investigation in this project. Audition tells you where to look, kinaesthesia assists you in looking, and changes in temperature make you look around to see why the spatial conditions are changing. Through the research voided spaces were identified as a way of limiting this reliance, as well as the introduction of fog-like atmospheres for layering perceptions upon each other.

Audition

The primordial sense, this was identified early on in the research and since it appears that Audition is primarily our second sense. It works optimally as a locating tool, however this is only effective along the horizontal axis. Research into visual audition allowed an understanding to be formed of how we can very easily perceive audition visually, especially when it is animated visually. The dynamic ranges of audio has caused issues throughout this research, however this was easily fixed by narrowing the scope of audition to only address two frequency bands. Audition is a strong sense which is harder to fragment from the others, however, it is still possible and so needs to be carefully designed around.

Thermoception

The delicate sense, the sense of internal its and the most likely to shatter away from the sensory system. Throughout this research, different aspects of thermoception have been thoroughly explored; colour, symbolism, physical manifestations and the limits of it. Through this research an understanding of the need for a greater physical thermal environment was addressed and resolved. The delicate nature of thermoception makes it one of the primary senses which needs to be designed for in this chapter.

The presentation of this final virtual experience, which has been specifically designed for Virtual Reality, through third person images is a decision made to counteract the ocular-centric paradigm. The presented final images are placed within this research to provide insights into what the environments appear to look like, but are not replications of what the environments are like to perceive. To perceive these environments, the viewer must be engaged in a complete sensory experience which provides real-time virtual atmospheric qualities. *This is just not possible in a book.*

Kinaesthesia

The enhancing sense. Kinaesthesia has been identified as a significantly important sensory system which often assists other senses. Kinaesthesia is however, a sense which is hard to address in VR systems due to the limitations of room sizes and people walking into tables. Through this research, different methods of addressing these limitations have been explored. However, these explorations have not been very successful, due to the actions of the body enhancing and driving the ocular paradigm forward, and thus further pushing the bias towards vision.

Develop

Through development of each sensory result, this chapter develops a final 2 scene environment where the user is first taken through a sensory tune up; a realistic replication of a real environment with the expected sensory stimuli, before a more abstracted sensory experience is presented. The development of each sense will be broken down across the rest of this chapter, before static images of the final experience are presented in third person.

VISION

FINAL DESIGN

Overview

Creating a sensory experience which is not heavily reliant on vision was crucial to the success of this virtual environment. After the results of Stage Two design, where the limits of the sensory system were engaged and fragmentation occurred, it was decided that this final design should focus on slowing down the user and providing them with a meditative approach to sensory experience.

Slowing down

This design phase builds on the Stage Three, by introducing a rising sun as the basis of the sensory tuning. Providing the user with a scenario where the sensory stimuli is easily expected allows heightened presence to be introduced. The first environment was designed to replicate a sensory lake ideology wherein the user is situated in a shallow endless lake under the starry night sky. This experience aimed to reduce vision through the meditative qualities of serene moments.

Forming meditative experiences

The endless sensory lake provided a good starting point for the final experience, allowing vision to step back and enhance the other senses. The same ideology was applied to the second environment, where the user remained in the same endless lake. However, the second approach uses fog-like atmospheres and a ring of coloured light (See Figure 4.1) surrounding the user to form an endless mist of sensory experiences.

FIGURE 4.1.
ABOVE.
RING OF LIGHTS PLACED AROUND USER (CENTRE). THE LINES INDICATE
THE ANGLE OF EACH LIGHT.

AUDITION

FINAL DESIGN

Overview

Developing audition from the results of the previous experiences, this stage aims to use Audition stimulation to serve two purposes; *Create sensory tranquility and drive sensory experience.*

Creating Sensory Tranquility

The ability of Audition to situate the body within space has been discussed throughout *'Experience'* as being a successful method of creating presence. The prominence of audition within Stage two design, where music drove the experience, was one of the key reasons why sensory fragmentation occurred.

The first scene of this final experience aims to use simple audio sampling to assist in creating a narrowed focused sensory experience which is common to the user. The implementation of a spatialised sound component at the base of the platform emits the sounds of calm lapping water colliding with rocks. The creation of a common local sound source assists in creating the meditative experience which the first stage aims to achieve.

Increasing the influence

As the experience transitions into the second scene, it was decided that the audio should remain the same to create continuity between both experiences. However, the second scene begins to draw on the audio sampling used for stage two design.

Transitioning the same audio source between the two scenes maintains sensory balance and thus enhances the sensory experience of the second scene. The audio source in this scene drives the intensity of the lighting as well as the heat lamps, providing the viewer with a sensory experience of rippling water.

These two approaches to audition present the viewer with two different aspects of audition, wherein it locates the body with sensory space, and then creates sensory space within the body. Two approaches which are linked to the theological relationships between body and space presented by Henry Lefebvre in the theoretical review chapter.

KINAESTHESIA

FINAL DESIGN

Overview

The engagement with Kinaesthesia throughout '*Experience*' has consistently been limited by the bounds of the room which the VR environment has been experienced within. The development of the Kinect movement system was a success as it allowed a vast distance to be transverse within the virtual realm. However, as this final design stage moves into a slower meditative experience which allows the user to focus on the sensory space they are placed within, the approach to engaging Kinaesthesia needs to be revised.

Ocular slave

The first consideration of Kinesthesia in the final design stage was reviewing one of the results from Stage Two. During the experience it became apparent that when the bounds of movement within virtual space are increased, the reliance on vision increases along with it. This enhanced reliance on vision is traceable back to the idea that Kinaesthesia is an enhancing sense which provides the viewer with the opportunity to explore an environment; an exploration which relies heavily on the visual bias.

FIGURE 4.2.
RIGHT.
PLATFORM DEMONSTRATING HOW
KINAESTHESIA CAN BE LIMITED.

Limiting Kinaesthesia

There exists a need to limit Kinaesthesia within the virtual experience, to allow the other sensory systems to take precedent. The need for limiting movement within the physical space was also driven by the hazard factor of having four heat lamps surrounding the user. Limiting Kinaesthesia allows a sensory experience to be formed wherein the spatial qualities of the virtual environment are experienced primarily through the hands. It is hoped that by limiting Kinaesthesia within the virtual environment, the visual bias will be reduced and Bill Hillier's ideas on *the production of space* will begin to become prominent. Drawing from the idea that spatial qualities can be produced by allowing the body to be deployed within the space, or in this case virtual space. Capturing the hands as a primary sense of Kinaesthesia allows a scale to be added to the space that was absent during the kinect experience.

Forming Limitations

This design phase draws on the results of voiding spaces to create a small platform that the user is situated upon (See Figure 4.2). The platform shape was informed by the idea that the user had risen 10 metres above the DARA room; each corner of the platform edges were drawn back to the location of the heat lamps and then solidified to create the platform's legs.

The deployment of this platform that is approximately three metres tall within the first environment creates a sense of vertigo, and thus restricts complex movement by the user. The second scene of the final design features the same platform, however the '*sensory lake*' has risen to meet the edge of the platform. This scene tests how Kinaesthesia can still be restricted through the introduction of different mediums. The aim is to maintain the users location, so that thermoception can be enhanced.

THERMOCEPTION

FINAL DESIGN

Overview

The success of the thermal system created in Stage Three provides this final design with a developable tool to effectively create a real-time 360° thermal environment. Through this environment it is explored how thermoception can be used to effectively affect our perception of space.

Control

Allowing Unity to have real-time control of the thermal system was crucial for the success of this design, as it allows the experience to become succinct thus reducing the possibility of sensory disengagement. Virtual environments are often prone to small changes, caused by dropping computer power, lagging frames and many other possible computational limits; so allowing the computer to actively control the thermal environment ensures accurate virtual atmospheric qualities can be formed around the user.

C# coding

The implementation of C# coding to create a set of controls for the heating systems became crucial for this final design due to the large amount of information which needed to be processed every second. Through a combination of calculus and vector coordinates, a real-time system calculated the current sun position and generated a thermal environment through the heat lamps.

Although the code gets much of the credit, a large amount of fine tuning was undertaken to ensure that the heating sequence was accurate when the sun passed between two heat lamps. The ability to vary intensities of the heat lamps became crucial during these moments, due to the previous results of stage three where thermoception was found to be relatively directional.

This fine tuning was accomplished through a series of tests where the virtual environment was experienced whilst tracking the perceived location of the sun. This perceived location was then measured against the actual intensity of heat lamps at a five second interval. Through this trial and error an accurate system was created which could approximate the intensity of the sun through two heat lamps at once (See figure 4.3).

calculation of suns position on the ground plane as an angle from east.

when the calculated sun position is within the heat lamps bounds, the light void is triggered.

each heat lamp has its own public void. here we only look at heat lamp number 3.

every second the h3Angle is updated and fed into this void.

when h3Angle is within certain bounds, such as 20° and 30°, the heatController script is called upon.

part of the heatController script was demonstrated on page 141.

triggers are used as 'switches' so that once the angle is within bounds, the heat lamps intensity only changes once.

if the sun is not within the heat lamps bounds, a return function cancels the void and turns off the heat lamp.

```
void Update()
{
    lightRefIntensity = lightRef.Intensity;
    sunWorldPos = sun.transform.position;
    Vector3 projectedSunPos = Vector3.ProjectOnPlane(sunWorldPos - this.transform.position, Vector3.up);
    float Angle = Vector3.Angle(projectedSunPos, Vector3.right);

    h3AngleFloat = ((Angle - 75) / 90) * 100;
    h3Angle = Mathf.RoundToInt(h3AngleFloat);

    if (Angle > 80 && Angle < 170)
    {
        lightThreeRunning = true;
    }
    else
    {
        lightThreeRunning = false;
    }

    if (lightThreeRunning == true)
    {
        HeatThreeRunning();
    }
}

public void HeatOneRunning() {}
public void HeatTwoRunning() {}
public void HeatThreeRunning()
{
    if (h3AngleFloat > 0.01f && h3Angle < 6 && h3TriggerTwo == true)
    {
        for (int i = 0; i < 1; i++)
        {
            heatController.HeatThreeActivate(7);
            h3TriggerTwo = false;
            h3TriggerOne = true;
        }
    }
    else if (h3Angle > 20 && h3Angle < 30 && h3TriggerOne == true)
    {
        for (int i = 0; i < 1; i++)
        {
            heatController.HeatThreeActivate(8);
            h3TriggerOne = false;
            h3TriggerTwo = true;
        }
    }
    else if (h3Angle > 30 && h3Angle < 60 && h3TriggerTwo == true)
    {
        for (int i = 0; i < 1; i++)
        {
            heatController.HeatThreeActivate(9);
            h3TriggerTwo = false;
            h3TriggerOne = true;
        }
    }
    else if (h3Angle > 70 && h3Angle < 75 && h3TriggerOne == true)
    {
        for (int i = 0; i < 1; i++)
        {
            heatController.HeatThreeActivate(5);
            h3TriggerOne = false;
            h3TriggerTwo = true;
        }
    }
    else if (h3Angle > 100 && h3TriggerTwo == true)
    {
        for (int i = 0; i < 1; i++)
        {
            heatController.HeatThreeActivate(0);
            h3TriggerTwo = false;
            h3TriggerOne = true;
        }
    }
    else return;
}

public void HeatFourRunning() {}
```

FIGURE 4.3.
DEMONSTRATION OF
PHYSICAL THERMAL
ENVIRONMENT BEING
CONTROLLED THROUGH
UNITY.

FIGURE 4.4.
ABOVE.

THE BEGINNING OF THE FIRST SCENE PRESENTS THE SUN RISE
BEING BROKEN APART BY TREE COVER.

FIGURE 4.5.

ABOVE.

AS THE SUN RISES, THE HEAT GETS MORE INTENSE ALLOWING IT
TO TAKE OVER AS THE PRIMARY SENSE.

FIGURE 4.6.

ABOVE.

THE SUN RISES OVER THE ENTIRE HORIZON BEFORE SETTING IN
THE WEST.

FIGURE 4.8.

ABOVE.

AS THE WATER RIPPLES, THE LIGHTING AND HEAT OF THE ENVIRONMENT RIPPLES ALONGSIDE IT.

DISCUSSION

FINAL DESIGN

Overview

This final design phase drew on the research developed throughout *'Experience'* to create a two-part sensory experience which aimed to answer the question:

How does a multi-sensory virtual experience affect our perception of space?

The knowledge and computational tools which have been gradually developed over three stages of developed design provided Sensationalising VR with multiple avenues of enquiry when designing its virtual sensory experience. By carefully developing each sensory fragment, Sensationalising VR formed two experiences which focused on creating an evolving sensory experience which avoided fragmentation.

Sensory Balance

The first scene of Sensationalising VR used the idea of sensory balancing, a way in which the senses can become acquainted with an environment through expected stimulus. It was hoped that providing a scene which had relatable symbolism, the sun rising, the lapping wave sounds, would immerse the user into the experience and reduce conflicting sensory experiences.

The first scene was a success in its ability to engage and create presence within the body. The simplistic sensory stimuli effectively created an experience which felt natural and relatable. Implementation of the real-time thermal environment was critical to this result. Through meditative processes this stage successfully calibrated all the sensory systems, effectively reducing the reliance on vision and thus fighting against the ocular paradigm.

Sensory Experience

The second scene of Sensationalising VR was developed to build upon the viewers newly calibrated senses to create perceptions of virtual space. Through fog-like design and coloured light, ideas drawn from James Turrell, Olafur Eliasson and the conceptual design research, a tranquil atmosphere was created within the virtual environment. The endless horizon line of this second scene drew on the ganzfeld effect discussed on page 32, allowing a sense of absence from reality to be induced, thus shifting the sensory reliance from vision to thermoception.

The success of this scene was only made possible through the sensory tuning which occurred during the first scene. Testing of only one scene did not provide the same intensity of sensory experience, nor a valid experience of spatial atmospheres.

FIGURE 4.10.
RIGHT.
DEMONSTRATION OF THE
HEAT AND INTENSITY OF
THE SUN DURING ITS RISE.

SENSORY EXPERIENCES

CHAPTER EIGHT

*A critique of the sensory research undertaken
in this thesis, evaluating the resulting sensory experiences*

SENSORY EXPERIENCES

CHAPTER EIGHT

*A critique of the sensory research undertaken
in this thesis, evaluating the resulting sensory experiences*

CONCLUSION

SENSORY EXPERIENCES

'Experience' began for me with a love for the weightless sensory experience of swimming. This research took that affinity and started to question how multi-sensory experiences affect the human perception of space, how we can experience the medium of space in a parallel to the way we experience the medium of movement, propulsion and immersion in water. My research aims and objectives were formed from readings and exploration into the field of sensory experience, particularly in Virtual space. Through an analysis of relevant theorists and case study artists, *'Experience'* built a foundation of knowledge to begin creating virtual environments for VR sensory experience.

Sensory fragmentation became a key aspect of *'Experience'*, where each sense was treated as an independent fragment of the total sensory system - each fragment needing to be individually researched before assembling them. Through conceptual and developed design phases the approach towards combining sensory fragments was reinforced and resulted in a final sensory experience being created. *'Experience'* is, consequently, an architectural design thesis that focuses on better understanding the relationship between body and space, when experienced through the medium of virtual reality.

The development of a real thermal environment that responded to the sensory stimulations inside of virtual spaces allowed this relationship to be reinforced. Overall, the final design of *'Experience'* enabled the formation of a sensory experience which rebalanced emphasis against the ocular-centric paradigm that is prevalent throughout the western architectural culture.

Some aspects of our sensory system are fragile, thermoception especially so; in my work in cases of sensory overload, visual cues were reverted to as the dominant sense. In response to these results, a final design was developed, wherein an extra experiential stage was added that allowed a sensory calibration to take place before the primary sensory space was experienced. It was found that the sensory calibration stage is needed before experiencing more complex sensory spaces, that engage multiple sensory systems, can be best experienced. Through continual learning and design development this research proposed a new approach complement to sensory simulation in virtual space where the spatial qualities of the virtual space itself can be enhanced.

REFLECTION

SENSORY EXPERIENCES

Through five years of studying Architecture, the relationships between the human body and space only get touched upon briefly. I wondered if this was because understanding spatial experience requires personal encounters of spatial experience. This project acted as this experience for me. Prior to starting *'Experience'* I had never coded, touched game design or even been inside of a VR environment, it's safe to say this was a steep learning curve of a year. The start of *'Experience'* was a rocky approach to research as the globe dove head first into lockdowns, due to COVID-19. Lockdown was a time of reflection and habitation of small places. The limitations imposed, resulted in a flat of six design students living upon one another, a very intense spatial experience. However, this was the start of *'Experience'*, where spatial experience became vital to understand and design for.

How can spaces be designed for continuous occupation. This was the first line of my drawing book for the year, the first thought towards how my research would approach spatial design. Once normality returned this research plunged into breaking down each sense, space itself, the human connection to space and perceptions of space. This research taught me a lot about how our sensory system perceives the environments we are placed within. Through the testing of the sensory experiences, the qualities of what virtual space could be began to formulate themselves. I began to fight against this idea that virtual reality should replicate reality. Why would it? It's completely different.

Through the application of my coding skills I had learnt, architectural design methods and the constantly expanded wealth of knowledge about our sensory system, I began to develop the final design which aimed to create a unique meditative sensory experience; in which the qualities of the virtual space itself began to reveal themselves. The qualities of the heat, audition, vision and kinaesthesia fragments began to assemble themselves into an experience of space, an experience which is often lost within western architectural culture often because it's inconceivable.

Exploring new ways of perceiving spatial environments, especially within VR stimulates new excitement for designers, clients and the public by creating better unison between VR scenarios and the human body. The virtual environment creates a richer picture for the human brain to process, and thereby creates an environment that is more fully furnished with the senses; employing them to actively attempt to understand the environment they are inhabiting. By implementing more comprehensive atmospheric qualities in VR we can begin to design more completely immersive and engaging forms of virtual art and architectural design.

I didn't set out to change the world with this thesis, nor revolutionise the building industry. Instead, I wanted to create a unique piece of research that encourages you to think more in depth about the qualities of the spaces we inhabit. Think of the room you're in right now, what is the experience of that space like? Now imagine adding twenty more bodies to that room, and tell me that our experience of the same spatial bounds is the same. It wouldn't be, it would evolve and change; because our body, and inherently our senses, create space, and that creates **EXPERIENCE.**

***SENSORY
EXPERIENCE.***

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CHAPTER NINE

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