VISION SCIENCE AND THE VISUAL ARTS: AN ENQUIRY INTO THE SCIENCE OF PERCEPTION AND THE ART OF IMMERSION

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PhD

2008

VISION SCIENCE AND THE VISUAL ARTS: AN ENQUIRY INTO THE SCIENCE OF PERCEPTION AND THE ART OF IMMERSION

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A thesis submitted in part fulfilment of the requirements of the University of Northumbria at Newcastle for the degree:

Doctor of Philosophy

Research undertaken in the School of Arts and Social Sciences

March 2008

ABSTRACT

This research addresses questions surrounding two currently prominent visual art topics. The first revolves around the concept of immersion and perceptions of immersive art, the second concerns current interests in art and science and the practice of art and science collaboration. Current debates and theories of immersion revolve around technologically informed virtual models and interactive virtual art environments, however, the history of immersion as a creative medium has been traced to pre-technological, even pre-historical beginnings. In this study, a pre-technological concept of immersion *per se* is explored, and a new perceptual model of immersion is developed based on the scientific laws and principles of vision. This model is shown to encompass and a long history of immersive traditions and a type of contemporary art practice that until now was not recognised as an immersive art genre. Working at the interstices of visual immersive art and visual science disciplines, collaborative experimental environments are developed that embody both the concepts and definitions proposed in the thesis, and the scientific laws and principles on which they are founded. Pre-technological/visual and contemporary/virtual concepts are further distinguished by their respective scientific and technological alignments and by the types of perceptual phenomena they engender. It is shown that as a creative medium, immersion comprises scientifically informed visual and technologically informed virtual immersive sub-genres, which together provide a broader and more comprehensive account of historical and contemporary immersive art practice.

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List of Abbreviations of Technical Terms

CAVE: Computer Automated Virtual Environment
CUBE: A six-wall CAVE environment
COP: Centre of Pressure
ECVP: European Conference on Visual Perception
FOV: Field of View
ITQ: Immersive Tendencies Questionnaire
MIE: Modular Immersive Environment
NESTA: National Endowment for Science, Technology, and the Arts
SOP: Sense of Presence
PQ: Presence Questionnaire
VE(s): Virtual Environment(s)
VisLab: Virtual laboratory, Dept. of Psychology, Brown University, Rhode Island, US
VR: Virtual Reality
VRT: Virtual Reality Technology
VSS: Vision Sciences Society

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ACKNOWLEDGEMENTS

I would like to thank all members of the vision science community who took the time to encourage and accommodate this research, including Dr Franz Verstraatten, Utrecht University, Germany, Dr Villeneuve Ramachandran, UCSD, California, US, Dr Richard Gregory, UWE, Bristol, UK, Dr Fred Bonato, Kings College, NJ, US, and especially Dr James Intriligator, University of Wales, Bangor, UK, for his endless optimism, creative input, and technical expertise. I am most indebted and extend my deepest gratitude to Professor Alan Gilchrist, Rutgers University, NJ, US, for introducing me to the science of perception and for teaching me how to think critically; without his knowledge, collaborative efforts, creative inspiration, and endless encouragement and support this research could not have been realised. I am also greatly indebted to the Arts and Humanities Research Council for providing both personal guidance and the financial support that made this research possible. Finally, for going beyond the boundaries of their discipline and for never giving up, I would like to express my deepest gratitude to Dr Kev Hilton and Dr Cheryl Buckley.

DECLARATION

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work.

Name: Lucille Marie Nolan

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Date: March 2008

Chapter 1: Introduction

Introduction

This research addresses two currently prominent and closely intertwined visual art topics. The first concerns current concepts of immersion and perceptions of immersive art, and involves an investigation of the unique forms of immersion embodied in historical and contemporary immersive art environments. The second concerns a current 'art and science movement' and the recent proliferation of art and science incentives, and involves an exploration of methodological and experimental parallels in visual art and visual science. These topics reflect the practical and methodological motivation for this study, and the type of creative practice and a type of research methodology with which this study is concerned. The thesis relates the collaborative process and experimental work that developed as a result of an interdisciplinary investigation of immersion and perception. It does not offer a critique of science, scientific concepts, or scientific methods; instead, it focuses on how the knowledge and methods of visual scientists can be conducive to the knowledge and methods of visual artists. The scientific concepts and theories discussed are necessarily limited to the scientific laws and principles of vision, and relevant research on visual perception.

1.1 Personal Background

Having had previous careers in aircraft engineering and architecture, my professional background inevitably influences my creative practice and this research. The methods employed in these fields would appear less than conducive to the study and practice of visual art, a point that has been put to me by many artists in the past. However, I believe that any knowledge, especially that acquired through actual experience in other disciplines, is an invaluable tool for any artist's professional development. Dr Julia Malins of Grey's School of Art, Aberdeen, makes a similar observation with regard to visual arts research:

> *The 'artist starving in the garret' model is hopefully very rare, it is being replaced by the computer literate, media savvy professional able to work collaboratively with an understanding of the social and organisational context in which they are operating. They are expected to be able to think critically and solve a wide range of problems, be adaptable, work effectively in cross-disciplinary teams and be capable of constantly updating their own skills and knowledge in response to changing requirements.* (Malins, 2002:3)

In light of a growing interest in art and science collaboration and interdisciplinary creative practice, a level of technical competence, collaborative skills, and an understanding of disciplinary methods and practices outside the field of art have become invaluable tools for today's practicing artists.

This research is partly motivated by a long-standing interest in the confluences of art and science. The work builds on previous research conducted at MA level on the 'Culture Wars' and the academic division of creative and scientific disciplines, documented in a final thesis: '*The Culture Wars: The necessary dichotomy of science and the humanities'* (2000). Continuing this line of enquiry, the research addresses some of the questions raised by a current 'art-science movement', while raising new questions about concepts of immersion and immersive art practice. Reflecting my own creative, theoretical, and interdisciplinary interests, the former describes the type of creative methodology and the latter the type of creative practice that are the focus of this study.

1.2 Background and Motivation for the Research

> *"At all events "art and science" is now a hot topic and therefore open for analysis and questioning by those, like myself, who are naturally suspicious about trends and fashions and want to ask, "What is all this* really *about?" Are the supposed links between the two genuine, or no more than loose but attractive metaphors? Is the approach of the artist in any way similar to that of the scientist? Is a marriage of these two fields possible or even desirable? In the end, is this debate no more that hot air and is what really matters the idiosyncratic friendship and dialogue between an individual artist and an individual scientist? Or is something vitally new emerging that will embrace both art and science?"*
>
> F. David Peat, 1999

1.2.1 The art-science debate

The research methodology is motivated by a personal interest in science, and in the transfer of knowledge gained in other fields to creative practice. The notion of collaborative and interdisciplinary exchange underpins a current trend in organised art and science collaborations and related incentives that have emerged over the past ten years. The art-science movement proffers artists the opportunity to exploit a wealth of knowledge and resources within scientific and technological disciplines, and to benefit from the experience of and knowledge of experts in a number of research areas. However, not all art and science ventures have proven successful (Cohen, 1998; Arends, 2002). This is due in part to the limited exposure that artists have to disciplines outside of their own throughout their education, which in turn is a symptom of the established disciplinary boundaries that have alienated the practices of art and science for over 200 years (Kemp, 1990; Crary, 2001). It is also due in part to the motives of large corporate funding bodies such as the Wellcome Trust and the Caloust Gulbenkian Foundation. With a stake in the pharmaceutical industry, these organisations stand to benefit from presenting controversial scientific topics, such as genetic modification and stem cell research, to the general public in a more positive light, and have used highly publicised art and science collaborations as a vehicle to do this.

For artists, the incentive can also be lucrative or opportunistic in nature. With investments of up to £100,000 for a single project, the concept of art and science collaboration can be appealing even to professionally established artists and artists with no particular interest in science. The promise of large-scale publicity is also a persuasive factor. For technically inclined artists, the opportunity to creatively experiment with advanced scientific instruments, such as brain imaging devices and atomic force microscopes, can be a significant incentive. In these ventures, scientific knowledge serves as raw material for creative explorations using the technological tools of science rather than science per se. In a typical organised collaboration, the artist creatively interprets scientific data or research outcomes, then, in accordance with the requirements of the funding body, the artist serves as a vehicle for communicating aesthetically abridged scientific research to the general public in the form of public exhibitions in art galleries and an increasing number of science museums.

Although aiming to unite art and science, organised collaborative ventures such as these have often incited as much confrontation as collaboration. In the post-project reports now surfacing, both artists and scientists recount that terminological misunderstandings, conceptual disagreements, and general communication barriers served to impede collaborative work (Cohen, 1998; Ede, 2000). Although aiming to bridge the two cultures divide, the art-science movement raises new questions and cast new doubts on whether the merging of scientific and creative methods can be fruitful for either field. Some of these issues were recently summarised in the journal *Leonardo,* in call for papers that posed the following questions:

> *"What is the value of artistic practices, techniques, inventions, aesthetics, and knowledge for the working scientist? What is the value of scientific practices, techniques, inventions, aesthetics, and knowledge for the artist? When does art become science and science, art? Or are these categories useless at their boundaries and intersections?"* (Root-Bernstein, 2004:172)

These questions were an incentive to develop a collaborative strategy that could circumscribe disciplinary barriers, and also a large part of the motivation for the research itself.

1.2.2 Immersion and immersive art

In many disciplines the concept of immersion carries varied and numerous meanings, definitions, discipline specific terminologies, and even individual interpretations. This is particularly evident in the visual arts, where current discourses revolve around a virtual model of immersion that has come to dominate both art theory and art practice. Art theorists, virtual artists, and the designers, users, and researchers of VR technology commonly believe that the experience of immersion is ultimately achieved in today's state-of-the-art virtual environments (VE's). However, virtual immersion (immersion in a VE) and virtual art (artworks created for VE's) are not the only aesthetic means for generating an immersive experience. Several authors, including Erik Huhtamo (1995), Margaret Morse (1998), Barbara Maria Stafford (2002), Oliver Grau (1999, 2003), and Angela Ndalianis (2004) amongst others, have acknowledged that the concept of immersion did not appear with the invention of virtual technology, tracing the history of an 'immersive aesthetic' back to traditional panoramas, Baroque architecture, 360º frescoes, and even prehistoric cave environments. Over the past forty years however, concepts of immersion and perceptions of immersive art have developed such a strong association with interactive Virtual Reality (VR) technology and immersive VE's, that the terms 'immersive art' and 'virtual art' are used interchangeably.

Immersion is largely believed to be the foremost aesthetic quality of contemporary virtual art environments, which combine immersion and human-computer interaction to generate the subjective 'sense of presence' in a computer-generated virtual world. The defining factors of presence and immersion are the subject of ongoing scientific and technological debates, which have yet to clearly define and distinguish these concepts. We can say that the concept of 'sense of presence' pertains strictly to immersion in the context of VE's, and both virtual artists and researchers of VR technology agree that presence is a subjective quality determined by a user's level of engagement with 'believable' virtual worlds (Slater, 1997; Heim, 1999). Even though there are no set or universally agreed definitions of presence, it is generally agreed that the elements of immersion and interaction are essential factors in generating the sense of presence. The concept and determining factors of immersion however, are much less clear.

For a number of disciplines, including the visual and performing arts, literature, film, computer engineering, and the entertainment industry to name just a few, immersion is an ambiguous term that carries a number of meanings and interpretations. In most fields, it is difficult to encapsulate exactly what immersion is in a single definition. In technological and scientific fields, developers and users of VE's have focused on immersion as an objective, technologically determined, and quantifiable aspect of a VE system (Slater and Wilbur, 1997; Pausch, 1997). Slater and Wilbur distinguish immersion from presence by defining the former as a property of the technology employed in an immersive system (the VE's technological system), and the latter as an associated, qualitative, and emergent state of consciousness that is a product of an immersive system (the user's subjective experience of a VE). In the visual arts however, *immersion* is described as a subjective, qualitative aspect of an immersive artwork determined by the user's subjective experiences of a virtual (art) world (Grau, 2003; Nechvetal, 1999; McRoberts, 2006). Thus, current concepts of immersion in the visual arts are closely intertwined and more aptly described by the presence concept. These terms and concepts and their various interpretations and definitions have given rise to terminological and theoretical confusion in ongoing debates about the concept and defining factors of immersion, and what it means to 'be immersed'.

As a creative medium, immersion has only recently been addressed in the literature, the most relevant here being Oliver Grau's *Virtual Art: From illusion to immersion* (2003). In this seminal work on historical and contemporary immersive concepts and art practice, Grau traces immersion as a creative medium to ancient, and even pre-historical beginnings. In this and other recent art historical accounts, pre-technological immersive environments such as the panorama are included in a catalogue of precedents to today's immersive virtual art forms. As a pre-technological concept, it cannot be claimed that immersion is a product of human-computer interaction or virtual technology, and immersion *per se* cannot be exclusive to virtual art environments. In current art theoretical debates, historical accounts, and perceptions of immersive art in general, the concept and definition of immersion has developed and continues to revolve around strictly virtual models and virtual art practices. However, although virtual art is necessarily immersive, immersive art is not necessarily virtual.

There has always been some difficulty in categorising my own art practice and other art practices like mine. Most often, my work is referred to as 'architectural installation art', 'video installation art', 'site-specific installation art', or simply 'installation art', yet none of these labels convey what I believe is the works most salient property, which is immersion. The practical motivation for this study stems from a desire to investigate and articulate an historical immersive aesthetic that, I believe, is perpetuated in certain contemporary artworks including my own that have yet to be recognised as an immersive art genre. The research is therefore motivated and substantiated by current questions surrounding the notion of art and science collaboration, and concepts of immersion and immersive art practice.

1.3 Problem Statement

Over the past forty years, a long history of pre-technological immersive concepts and practice has been progressively eclipsed by the popularity and proliferation of immersive virtual art. Failing to acknowledge historical immersive traditions, current theories promote virtual art as the quintessential immersive achievement and the ultimate aim of all immersive artists, an assumption that is based on an incomplete account of immersive art practice. Virtual art environments focus on technologically determined aspects of human-computer interaction and subjective aspects of user engagement, neither of which are requisite immersive factors. As recent historical accounts would imply, immersion as a creative medium has an extensive pre-technological history, therefore, the concept of immersion *per se* will necessarily encompass pre-technological and virtual immersive art forms.

If we are to extend our understanding of immersion as a creative medium and develop a more comprehensive account of historical and contemporary immersive art practice, a broader, more fundamental immersive model is needed. This research steps back from technologically informed models of virtual immersion in order to develop a more prosaic but more comprehensive model based on pre-technological immersive traditions. The point of departure in this study is to abandon the imperative of human-computer interaction and computer generated VE's, focusing instead on the concept and the defining factors of immersion *per se* embodied in all immersive environments.

1.4 Research Aims and Objectives

Theoretically, the aim of this study is to develop a new perceptual model of immersion *per se* and to categorise a contemporary genre of visual immersive art that reflects this model. The practical aim was to create new visual immersive art environments based on this model. The methodological aim was to cultivate a collaborative art and science investigation of the visual and perceptual phenomena at work in immersive environments. Theoretical objectives included a survey of contemporary and historical concepts and definitions of immersion and immersive art, and the identification and classification of current immersive art practices that reflect historical/pre-technological and contemporary/virtual models of immersion. Practical objectives included the identification and investigation of perceptual factors common to all immersive art environments, and to discover where and how these factors are generated in scientific experimental contexts. The methodological objective was to combine the knowledge and methods of visual science and visual art in the development of collaborative experimental immersive environments that serve both aesthetic and scientific functions.

1.5 Premises, Claims, and Hypotheses

Premises

1. Contemporary concepts of immersion and immersive art are largely associated with interactive VR technology and immersive virtual art environments.

2. Current concepts and perceptions of immersive art fail to acknowledge pre-technological immersive concepts and traditions.

3. A fundamental concept and model of immersion *per se* will necessarily encompass all immersive art forms.

Claims

1. A new model of immersion is necessary if we are to develop a broader understanding of immersion and a more comprehensive account of historical and contemporary immersive art practice.

2. Immersion is a pre-technological concept, and in pre-technological contexts, immersion is determined by perceptual rather than technological factors, therefore, immersion *per se* is a fundamentally perceptual phenomenon.

Hypotheses

1. The identification of the perceptual factors at work in all immersive environments will provide the basis for developing a fundamental model of immersion that encompasses all immersive environments.

2. The perceptual factors generated in immersive environments are also the subject of scientific experimental studies on perception; therefore, in the generation of perceptual phenomena, immersive artists and visual scientists share common aims and experimental methods.

Based on the hypothesis that creative and scientific interests in perceptual phenomena present an arena for collaborative exchange, the research set out to engage visual art and visual science in a collaborative study of immersion and perception, and the scientific laws and principles to which they both conform. To test these claims and hypotheses, the research commenced with a study of current research topics and practices in the vision sciences that might compliment, reflect, or inform my own creative practice and this investigation.

1.6 Chapter Outline

Chapter 2: Context

Chapter 2 presents contemporary immersive virtual art practices. The main focus of these works centres on the levels and means of human-computer interaction, the primary concern being subjective, psychological aspects of immersion in virtual worlds. Then, using the panorama as a key example, pre-technological concepts and practices of immersion are presented and are shown to focus on objective, perceptual aspects of immersion in the actual world, which is defined as ‘visual immersion’. The events that gave rise to today’s concept of virtual immersion are traced to the technological revolution of the 1960’s and it is shown that whereas virtual immersion is aligned with and contingent upon virtual technology, visual immersion is aligned with and contingent upon visual science.

Chapter 3: Literature Review

Chapter 3 presents theories and concepts of immersion in literature, film, technological, and scientific disciplines, and in the visual arts, where immersion is shown to be largely influenced by the potential of VE’s as a psychologically immersive medium. The value of psychological immersion is emphasised in much of the literature on immersive art, whereas the concepts and value of perceptual immersion has not yet been explored. The conclusion of this chapter will recap the proposal put forward in chapter two; that virtual art is aligned with virtual technology and that visual art is aligned with visual science.

Chapter 4: Methodology

Chapter 4 argues that studies in the visual sciences are pertinent to a study of immersion. Visual immersive art environments and environments created for scientific perceptual experiments demonstrate confluences in visual art and visual science practice. It is proposed that visual immersive art environments can be modelled on scientific perceptual experiments, thus providing an arena for collaborative work that may serve both a creative and scientific purpose.

Chapter 5: Practice

In chapter 5 three visual immersive artworks are presented. The first of these works, *Modular Immersive Environment*, involves large-scale projected imagery, that proves to have brief and insignificant immersive effects. The second work, *Vection*, is taken from an experimental apparatus of the same name, and uses the concept of a reduced FOV that is encompassed by a single projection screen. The final work was devised and constructed in collaboration with vision scientists. In *Kansas*, several perceptual phenomena, which are described in more detail throughout this chapter, were combined in a single concept for an immersive art installation that also served as a scientific experimental apparatus. This work was then exhibited in both scientific and visual art contexts.

Chapter 6: Analysis and Discussion

In chapter 6, the overall findings of the *Kansas* experiment are presented and analysed. This is followed by a summary of the defining qualities and factors that distinguish visual and virtual immersion, and the respective genres of visual and virtual immersive art. In conclusion, a perceptual model of immersion is articulated and defined based on the outcomes of the practical and theoretical work undertaken.

Chapter 7: Conclusions

In chapter 7, the overall research outcomes, conclusions, and contributions are presented, followed by a summary of the research implications, and possible future directions.

1.7 Terms and Definitions

1.7.1 Field of View/Vision (FOV)

field of vision ► noun the entire area that a person or animal is able to see when their eyes are fixed in one position.

The field of view (FOV) is a scientific term referring to the entire area that is visible to us within the combined focal and peripheral visual range with the eyes fixed in one position. In humans, this is an area extending a minimum of 120 vertically by 180 horizontally from the centre of the line of sight (the line of sight being an imaginary line drawn from the centre of the eye to the object of focus). Focal vision encompasses only two degrees on either side of the line of sight, but peripheral vision extends a minimum of 90 degrees on either side. Combined, these two components make up the field of view, or 'FOV'.

1.7.2 Interdisciplinarity/interdisciplinary

interdisciplinary ► adjective relating to more than one branch of knowledge: *an interdisciplinary research programme*

Interdisciplinarity has been a popular buzzword for several years, particularly in academic circles where interdisciplinary research is now common practice. Although the Oxford Dictionary definition is brief, there are several terms that refer to practices involving 'more than one branch of knowledge'. These include trans-disciplinary, multidisciplinary, and cross-disciplinary, all of which have various interpretations and definitions (Klein, 1996; Nissani, 1995). The concept of 'inter' disciplinary differs from concepts of 'multi' disciplinary, the latter referring to two or more individuals from different disciplines working together to solve a common problem. Nissani (1995) defines interdisciplinarity as a process where knowledge or methods from one field are found to be useful in another field. This is to say that discipline specific knowledge from one field can be exploited by another for alternate ends. A good example of this is Christopher Alexander's '*A Pattern Language*' (1976). Originally devised as a guideline for architects, Alexander's patterns have proven even more successful in the design of computer networks[1]. *Pattern Language* is now an established methodology in both architectural and computer engineering disciplines. Therefore, according to Nassani's definition, *A Pattern Language* could be called an interdisciplinary methodology, because 'knowledge, practices, or methods from one discipline have been directly transferred and applied in another to different ends'. This understanding of interdisciplinarity is implied throughout the thesis.

1.7.3 Immersion

immerse ► **verb 1.** To dip or submerge in a liquid
immersion ► **noun 1.** The act of immersing someone or something in a liquid

In the above definition from the 2006 Oxford dictionary and in other references, key descriptors of immersion are to 'dip', 'submerge', or 'surround'. An example of the experience of immersion that most of us can identify with is the experience of being submerged under water. When completely submerged we can see, hear and feel the stimuli of a new 'waterworld' that our entire body now occupies. Once we resurface, we can see, feel and hear the stimuli of our familiar world once again. If, while submerged, we were to raise an arm or a leg far enough to break the surface of the waterworld, it would not affect our

1. *Pattern Language* has had a great influence and continued following in computer programming fields, more so than in Alexander's own field of architecture, where his work was shunned for nearly three decades. *Pattern Language* has only recently gained recognition in architectural circles, mainly due to its application and popularity in other fields.

experience of being immersed in it, because we would still be receiving all of our perceptual stimuli from our waterworld environment. The reverse is also true; we would not feel immersed in the waterworld if we were to dip just our feet or hands into the water, in fact, if our entire body is submerged we will still feel present in the familiar world as long as our head remains above the surface. This element of immersion speaks to its fundamental *perceptual* rather than psychological or physiological basis. According to most interpretations and definitions, immersion always implies a type of 'surrounding', or 'covering completely', as to immerse in water or to immerse oneself in another language or culture. In all cases, to be immersed implies that one is *surrounded by what one is immersed in, to the exclusion of any sensory influences from anything outside of that in which one is immersed*. A second definition of immersion refers to a psychological or emotional state:

immerse ► **verb 2.** (immerse oneself or to be immersed) involve oneself deeply in a particular activity: *she immersed herself in her work* **|** *she was still immersed in her thoughts*
immersion ► **noun 2.** Deep mental involvement: *his total immersion in Marxism*

In this context, immersion refers to an individual's level of attention or engagement in a particular activity. For example, one could be immersed in the story line of a good novel or line of thought, or a special hobby or interest. In this instance, the word immersion can always be replaced with other terms such as 'engaged', 'absorbed', or 'involved'. Unlike the perceptual description above, in this context immersion has subjective and psychological inferences. Unless otherwise stated in the thesis, immersion will always refer to the former perceptual definition.

1.7.4 Immersive/immersive art

immersive ► adjective (of a computer display or system) generating a three-dimensional image which appears to surround the user

The adjective of immersion was recently included in the 2006 edition of the Oxford dictionary. As the definition implies, the term 'immersive' is commonly associated with computer technology and computer generated visual displays, which are created using Virtual Reality (VR)[2] technology. Immersive computer-generated visual displays are referred to as immersive virtual environments (or immersive VE's), which are three-dimensional, fully surrounding computer-generated virtual worlds. In keeping with the 'surrounding' aspect of the (perceptual) definition of immersion described above, 'immersive art' would imply that the artwork *completely surrounds the viewer, to the exclusion of all sensory stimuli other than the stimuli proffered by the artwork itself*. This would entail a visual environment or stimulus that encompasses our entire field of view (as do immersive VE's), but this does not necessarily require a computer-generated display. For example, it has been argued that some forms of installation art are immersive, simply because the architectural space and the installation space are integral. Therefore, installation art can be, and often is, immersive. However, as the dictionary definition suggests, the term 'immersive art' is largely associated with 'virtual art environments', or, artworks created for VE's.

1.7.5 Immersive virtual art ('VR art', 'virtual art')

Immersive virtual art refers to artworks created for immersive VE's, which

2. 'Virtual Reality' or 'VR' refers to the name of a type of technology used to create 'VE's'.

involves the design or creation of virtual worlds that can only be realised using VR technology. This genre of art practice is also referred to as ‘VR art’, ‘immersive art’, or ‘virtual art’, all of which can be interpreted in a number of ways. For the purposes of this thesis, the terms ‘immersive virtual art’ and ‘virtual art’ refer specifically to the type of art defined above, which is always three-dimensional (as opposed to images of ‘virtual’ objects presented on a two-dimensional computer screen), interactive (incorporating human-computer interaction through a computer interface), immersive (employing fully surrounding imagery), and realised using VR technology.

1.7.6 Interaction/ Interactive art

Interaction► noun (mass noun) reciprocal action or influence
Interactive ►adjective (of two people or things) influencing each other […] (of a computer or other electronic device) allowing a two-way flow of information between it and a user: responding to the users input: *interactive video*.

The terms ‘Interaction’, ‘interactive’ and ‘interactive art’ also carry various meanings and interpretations. What constitutes interaction in an artwork has been the subject of debate for many years; for example, many have argued that viewing a photograph requires a level of interaction from the viewer. The term ‘interactivity’ can be taken to imply any level of influence imposed on an artwork by a viewer, or on a viewer by an artwork, which then is subject to one’s interpretation of the term ‘influence’. According to the Oxford dictionary, ‘interactive’ implies a *two-way flow of information,* meaning that input from one direction elicits a response from the other direction and so on. An interactive artwork would therefore be capable of responding to a viewers input accordingly, as does an interactive virtual art environment. Most VE’s incorporate a human-computer interface (HCI) to facilitate interaction. The first virtual environments used head mounted displays (HMD's), and were considered interactive because the virtual world imagery changed in response to the participant's head and eye movements. However, VE's did not become fully interactive until the invention of the 'data glove', which facilitated a bi-directional line of communication between the virtual world and the participant, who could now directly influence objects and events in the virtual world. For the purposes of this thesis, 'interactive art', 'interaction', and 'interactivity' implies that the participant/viewer is able to influence the behaviour/appearance of the artwork/environment, and the artwork/environment is able to respond to this influence accordingly.

1.7.7 Vision Science

In order to define vision science it is necessary to first distinguish the often-confused terms of science and technology.

Science ►noun (mass noun) the intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment: *the world of science and technology*
Technology ►noun (p l. technologies) (mass noun) the application of scientific knowledge for practical purposes especially in industry.

Science and technology are commonly perceived as synonymous, and, other than in the empirical sciences themselves, this misunderstanding is endemic in many disciplines, including and perhaps especially in the visual arts. Even the above dictionary definition systematically infers that the 'world of science' and the 'world of technology' are one and the same. I propose that the difference between the two can be summarised as follows:

Technology

Technology is concerned with inventing and creating objects, and science is concerned with discovering and understanding facts. Technology is ‘invented’; it involves the design, development, and creation of new objects and tools that are used by people. The goal of technological invention is the creation of functional objects and instruments, or the improvement of existing objects and instruments such as kitchen appliances and motor vehicles. Technology is responsible for creating useful devices such as video projectors, brain imaging instruments and computers, which provide new or improved forms of entertainment and new or improved ways of working. Objects of technology, such as televisions, telephones, and satellites, *did not exist* prior to their *technological invention*.

Science

Science involves discovery. Gravity was not invented, just as television was not discovered. Unlike technological invention, scientific discovery reveals new knowledge about the world that may have no immediate practical application or function, though practical uses are often realised later. Even though science uses the objects and instruments of technology in the process of revealing new knowledge about the world, the invention, creation, or application of technological instruments is not science. Science is only concerned with acquiring new knowledge, whereas technology is concerned with the practical application of that knowledge. Science aims to reveal facts about objects and phenomena in the world that *already exist* but cannot be known prior to their *scientific discovery*.

Vision science

Vision science is dedicated to the study of vision and the visual system, and the physical, physiological, and neuropsychological factors that influence perception. Before the nineteenth century, investigations of these aspects of vision were exclusively qualitative and phenomenological[3]. With the invention of new technological instruments, the second half of the nineteenth century saw the discovery and empirical measurement of a number of perceptual phenomena (Howard, 2002a). Thus, the study of vision became an experimental science little more than a hundred years ago, making it a relatively young scientific discipline. Today, the field of vision science integrates two fundamental paradigms[4], which are a) the measurement of visual performance in humans and other animals (experimental psychology), and b) the study of neural and biological mechanisms of visual systems (neuroscience). This research is concerned with the former, which comprises a body of knowledge on how the eye and brain function to produce visual perception, and involves the experimental study of how we process and respond to visual stimuli, including how we perceive incorrectly, as we do when we experience visual illusions.

3. In his *Critique of Pure Reason* (1781), Immanual Kant declared that vision and the perception of space beyond the scope of experimental science, however, new technological instruments allowed precise measurement of these aspects of perception. See Howard, (2002b) for a chronological history of events that led to the psychology of vision becoming an experimental science.
4. The search for ways to build artificial visual systems (the field of computer engineering) is considered a third paradigm of vision science. However, such research builds on existing knowledge in order to replicate vision for practical applications, such as robotics. According to the proposed definitions of science and technology, this would fall under the umbrella of the latter, and is thus omitted here.

Chapter 2: Context

Introduction

Concepts, theories, and definitions of immersion and perceptions of immersive art, currently revolve around a technologically informed virtual model. The aim of virtual immersion is to generate a ‘sense of presence’ in interactive, fully immersive VE’s, and it is generally agreed that the sense of presence is a subjective experience determined by a user’s level of engagement with a virtual world (Grau, 2003; Slater and Usoh, 1994). Technologically determined factors including the methods and levels of human-computer interaction and the obscurity of the interface, are therefore considered key factors of immersion (Wertheim and Bless, 1998). Similarly, virtual artists emphasise technological aspects of immersion:

> *“The firsthand experience of being bodily immersed in its all-encompassing spatiality is key: when combined with its capacity for abstraction, temporality, and interaction, and when approached through an embodying interface, immersive virtual space becomes a very potent medium indeed.”* (Davies, 2004:178)

Virtual immersion and virtual art are relatively recent concepts that emerged during the technological revolution of the mid-twentieth century, and this concept of immersion stands in sharp contrast to pre-technological immersive concepts. The following chapter distinguishes the different types of immersion embodied in contemporary/virtual and historical/pre-technological immersive art environments. The events that gave rise to contemporary virtual art forms are presented, followed by historical concepts and practices, and contemporary artworks that reflect pre-technological immersive traditions. These artworks, which are neither interactive nor virtual, engender a form of *visual* rather than virtual immersion. Whereas virtual immersion entails physical interaction and the user's subjective sense of presence in a virtual world, visual immersion entails observation and objective perceptual processes in the actual world. Although the concept of immersion fundamentally and categorically connects them, visual and virtual immersive art environments are readily distinguished by the markedly different immersive experiences they engender and the methods and skills employed in their creation, which are shown to parallel technological and scientific practices respectively.

2.1 Virtual Immersion

> *"A display connected to a digital computer gives us a chance to gain familiarity with concepts not realisable in the physical world. It is a looking glass into a mathematical wonderland."*
> Ivan Sutherland, 1965

2.1.1 A brief history

Concepts of virtual immersion and virtual art practice emerged during the art and technology movement of the mid-twentieth century, when artists coupled new forms of participatory art and the ‘art environment’ with new technological methods and concepts of human-computer interaction (Krauss, 1988; Lee, 2004). Engineer Billy Kluver’s *Experiments in Art and Technology* (E.A.T) programme facilitated collaborative projects for artists and engineers eager to explore the potential of emerging technologies. Kluver’s aim with E.A.T was to realise what he believed was a ‘necessary interface for a new technological art of the future’:

> *"The purpose of experiments in art and technology, Inc, is to catalyse the inevitable active involvement of industry, technology and the arts. EAT has assumed the responsibility of developing an effective collaborative relationship between artists and engineers...."* (Kluver, 1972:1)

The artists and engineers involved in the E.A.T programme pooled creative and technological resources to realise new forms and means of human-computer interaction. In 1969, motivated by a vision of ‘total immersion’ in computer-generated, fully responsive virtual worlds, Myron Krueger and Dan Sandin developed *GLOW FLOW*, a *“computer-controlled light-sound environment that had limited provision for responding to people..."* (Krueger, 1991:12). In 1963, Ivan Sutherland documented his concept for the first 'graphical user interface' in his doctoral dissertation *Sketchpad: A Man-made Graphical Communications System.*[5] Between 197l and 1974, Dan Sandin designed and built the 'Sandin Image Processor' (IP), an analogue computer made strictly for processing video images. In 1974, combining Sutherland's concept for the human-computer interface with the concept of the 'participatory art environment' Kruger defined human-machine interaction as an art form in his doctoral dissertation *Computer Controlled Responsive Environments*[6], later published as *Artificial Reality*[7]. In the same year Krueger created *Video Place*, the first 'interactive computer-generated art environment' and the first of a new genre of 'immersive virtual art' (Kruger, 1991; Rheingold, 1998; Grau, 2003).

Fig. 1
Myron Krueger: *Video Place* (1974) Participatory environment

Both Krueger and Sandin shared a vision of 'unencumbered full body human-computer participation', or, immersion in interactive, computer-generated worlds without the aid of bulky wearable devices (Popper, 1995; Krueger, 1991). The projection techniques developed for *Video Place* were inspired by this vision, as was Sandin's later development of today's CAVE

5. Sutherland received his doctorate from M.I.T, MA, US, in 1960.
6. Krueger was awarded his doctorate from the University of Wisconsin-Madison, US, in 1974.
7.Published by Addison Wesley in 1983, and later the revised edition *Artificial Reality 2* in 1991.

system[8]. With *Video Place* Krueger realised the basic tenets of Virtual Reality (Rheingold, 1998) that saw the subsequent launch of the VR industry, and gave rise to a new genre of immersive virtual art. By the mid 1970's, concepts of 'participation' and the 'participatory art environment' emerged as concepts of 'interaction' and the 'interactive art installation' (Grau, 2003; Popper, 1995). Over the course of the following decade, new forms of interactive art, installation art, computer art, and video art developed alongside a succession of technological advances in computer processing speeds, digital and video imaging, and VR technology. Interest in VR declined during the 1980's however:

> *"By the end of the 1980s, Virtual Reality research was booming everywhere. Unfortunately, most of it was either very expensive or specialized (or both), and the image quality was very low, which made the "reality" part of VR rather dubious. […] Of course, the technology could not live up to the expectations…"* (Jalkanen, 2000:2)

With further technological advances, the late 1980's and early 90's saw a renewed interest in the immersive potential of VE's. Since then, a growing number of visual artists and virtual technologists have continued the pursuit of total immersion first envisioned by their mid-twentieth century predecessors, combining technological knowledge, technical skill, and creative intuition to create today's virtual art environments.

8. CAVE systems are explained in more detail later in this section.

2.1.2 Contemporary methods and practices

> *"A primary subject of the emerging viractual arts is immersion then: an experience identified as the indispensable characteristic of Virtual Reality."*
>
> Joseph Nechvatal, 2003

Although VE's are still costly to execute, over the past decade virtual technology has become increasingly viable as a creative medium, and since the mid 1990's, artists worldwide have been realising virtual artworks using the latest available VR technology. Amongst them are Luc Corchesne (Canada), David Rokeby (US), Charlotte Davies (Canada), Jeffrey Shaw (Australia/Germany), Maurice Benayoun (France), Christa Sommerer (Austria), Monika Fleischmann (US), Brenda Laurel (US), and also collaborative art groups including Blast Theory (UK), and Art+Comm (Germany/UK) amongst many others. The first contemporary virtual art environments were created in the early 1990's and several works were realised in 1995, with many more surfacing over the next five years. Amongst the most prolific of these are Char Davie's *Osmose* (1995) and Maurice Benayoun's *World Skin* (1997), both of which were created using two currently available virtual methods, an HMD in the former and a CAVE™ system in the latter.

Head Mounted Displays (HMD's)

The strategy of the HMD is to place images directly in front of the eyes; effectively shutting out the real world, leaving only what is presented inside the device visible to a participant.

Fig. 2
Early HMD prototype (NASA c.1978)

Fig. 3
Modern HMD (c. 2002)

The HMD's precursors include the seventeenth century peepshow, Charles Wheatstone's stereoscope (1827), and Morton Herlig's *Sensorama* (1962) (Heim, 1998; Rheingold, 1998; Grau 2003).

Fig. 4
Morton Herlig: *Sensorama* (c.1962)

The HMD reduces a participant's field of view (FOV)[9] to an area small enough that it can be filled entirely with virtual images displayed on small LCD monitors built into the device. Although they are small, these images are able to encompass the participant's entire FOV because the FOV itself has been greatly reduced by the physical structure of the HMD. Looking down a cardboard tube has the same effect; we can see only what is within the limited area of the tube's opening at any given time. Similarly, only the computer-generated imagery is visible to a participant when wearing an HMD, thus the virtual world images become the participant's entire immediate visible environment.

To facilitate interaction[10], the HMD has built in tracking sensors that communicate with a VE's computer system. The computer, being constantly informed of a participant's changing head and eye locations, generates the

9. See chapter 1, section 1.7 for a scientific definition of 'field of view'.
10. See chapter 1, section 1.7 for a definition of 'interactive'.

corresponding virtual world scenes before sending them back to the HMD's monitors. Ideally, these scenes will appear to change instantaneously, just as real world scenes change accordingly and instantaneously when we move our head and eyes in the real environment (Previc, 2000; Slater and Wilbur, 1997). Therefore the computer must be able to a) generate sufficiently detailed renderings of a virtual world, that it can b) rapidly update at speeds perceived by a participant to be instantaneous, or, that replicate as closely as possible the way we visually perceive changing scenes in the real world[11]. This is why computer imaging technology (to achieve point a) and computer processing speeds (required for point b), had to undergo a period of development before they were able to generate sufficiently realistic VE's.

Early HMD's provided only a one-way line of communication. Even though a participant's head and eye movements affected a response in the virtual world, this was only to the extent that the virtual scene would change according to a participant's changing head and eye movements. There were no means for participants to influence the virtual world directly, such as opening a door or grasping a virtual object. A bi-directional line of communication, or 'two-way interaction', was finally possible with the invention of the 'data glove', which allowed participants to influence objects and events in the virtual world at will. Working on the ergonomic principles of human hand motions, the data-glove communicates a participant's hand movements to the computer system, which responds according to a set of instructions that effect changes in the VE, such as opening a door when pushed.

11. See Slater and Usoh (1997) and Previc (2000) for scientific/technological perspectives on the effect of image realism and update speeds in generating 'believable' VE's.

Fig. 5
VE participant with HMD and data-gloves

With the data-glove[12], VE's became truly interactive, and, since its inception, the development of new methods and new devices to facilitate two-way interaction has been a principle goal of computer engineers, VE designers, VR technologists, and visual artists (Popper, 2005; Slater, 1999; Grau, 2003; Rokeby, 1998a). Virtual artists have made many significant contributions to VR's technological development in this area, particularly Charlotte (Char) Davies.

12. For a chronological account of the history and developers of VR technology including the data glove see Packer and Jordon (2002).

Charlotte Davies (b.1953- Canada)

Osmose (1995), *Ephémère* (1998)

> *"Only a few virtual-reality environments which completely immerse a viewer into an alternative world have been developed within an art context, and Canadian artist Charlotte Davies'* Osmose *(1995) and* Ephémère *(1998) are classics of the genre."* (Paul, 2003: 126)

Canadian artist and technologist Char Davies is co-founder of *SoftImage,* a VR software company in Montreal, Canada, where she has worked as Director of Visual Research since 1987[13]. Formerly a painter and filmmaker, Davies has been exploring VR as a creative medium since the mid 1980's:

> *"I have been working in "virtual space" for nearly 10 years, and during that time have produced two major works […] Integrating full body immersion, interactive 3-D digital imagery and sound, and navigation via a breathing interface, these works embody a radically alternative approach to immersive virtual space, or what is commonly known as "virtual reality."* (Davies, 2004:69)

Combining her technological knowledge and skills, Davies has focused on new and alternative methods to facilitate virtual interaction. Interface design has been central to Davies creative work, inventing innovative devices that have received as much acclaim as the virtual artworks for which they were created.

13. See http://www.softimage.com (accessed 01/15/2007)

Fig. 6
Char Davies: *Osmose* (1995): Interactive virtual environment

For her first and most renowned work *Osmose* (1995) Davie's created a breastplate device that sensed when a participant was inhaling and exhaling. While breathing in, the participant rises up off the ground in the virtual world as if flying, and when exhaling, descends. The breastplate was a radically new interface concept, however, Davies' subsequent work *Ephémère* (1998) takes interface design even further.

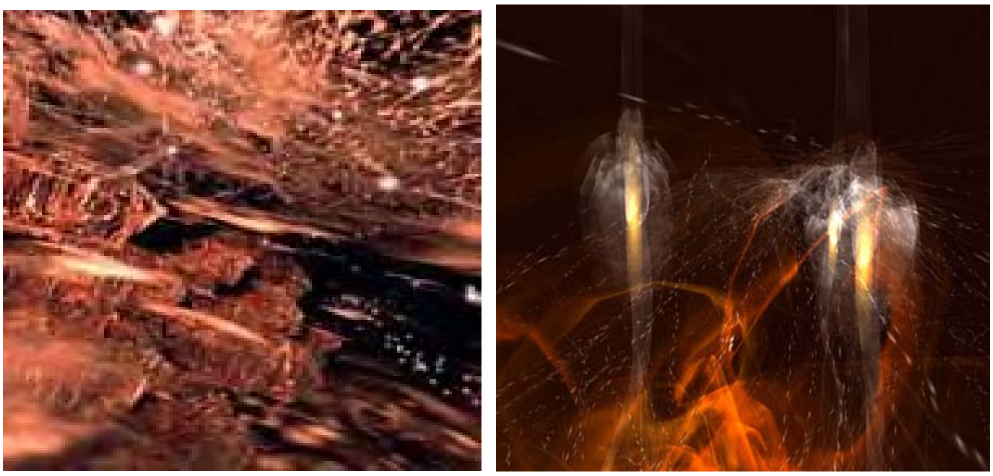

Fig. 7
Char Davies: *Ephémère* (1998) Interactive virtual environment

In *Ephémère*, participants, or what Davie's prefers to call 'immersants'

(Davies, 2004), can influence objects and events in the virtual world simply through the act of observation. This is a similar concept to links on a website. If the mouse is passed over an active link on a web page, the area will be highlighted indicating that one click of the mouse will take you to another web site. In *Ephémère,* the HMD sensors still track and send information to the computer system in the same manner, however, if an immersant gazes long enough at an object or area in the virtual scene that is a designated 'active link', the computer responds by generating certain pre-programmed events, much like the click of the mouse takes you to a different web site. If an immersant shifts his/her gaze too quickly, the event will not occur, just as the link will not activate without the click of the mouse. Thus, the HMD is serving its original purpose of communicating the immersant's head and eye locations to the system, and the system responds to this information, but also to a separate set of instructions based on the duration that a participant's gaze is maintained in one area. The use of a secondary input device (a data glove or breastplate for example) is no longer essential as virtual objects can be directly influenced by the immersant's gaze[14].

HMD's do have disadvantages, one being that only one participant at a time can experience a VE, and another being the considerable time it takes to don the equipment and become familiar with virtual navigation techniques. Davies' solution is to provide a first hand view of the 'active immersant'. By projecting virtual world images directly from the HMD onto large screens and placing the immersant behind a semi-transparent screen, those waiting to experience the work can see through the immersant's eyes and study their

14. The breastplate is used in Ephémère even though user input could be facilitated using this method alone.

physical movements as they manoeuvre through the virtual world:

> *"Here, the immersant's journey is projected on a wall in real-time, […] In addition, the shadow silhouette of the immersant's body is cast on another wall as s/he moves and gestures within the work".* (Davies, 2004:81)

The waiting room feature is intended to *"…draw attention to the body's role as ground and medium for the experience"* (Davies, 2004: 68), because, like Kluver and Sandin and most virtual artists since, Davies emphasises the importance of interactive 'full body engagements' in VE's. However, when wearing an HMD a participant cannot move freely in the virtual world because the HMD is 'hardwired' to the computer system (as can be seen in *Osmose* above), which restricts a participant's physical movements. The projection techniques used in today's CAVE systems overcome this problem.

Cave Automated Virtual Environment (CAVE)

"A common comment when people first experience the CAVE is to say that these devices would have tremendous application in entertainment and museum settings."

Daniel J. Sandin, 1992

Fig. 8
CAVE: *Computer Automated Virtual Environment* (1992)

CAVE, a second method currently used by artists to realise virtual art environments, was developed by artist Dan Sandin and engineer Tom DeFanti at the University of Illinois', US in 1992[15]. CAVE offers an alternative the HMD that involves physically confining participants inside a specialised enclosure. *CAVE* is an actual room of approximately 3 meters square made of rear projection screens, and works on the same principle as 3D cinema, where dual, two-dimensional projections become three-dimensional when viewed through stereoscopic glasses[16]. One advantage of CAVE over the HMD is that several people can be immersed at the same time[17].

15. Sandin had worked on concepts for CAVE throughout the 1970's
16. See http://www.evl.edu/CAVE (accessed 20/08/07)
17. Only one participant at a time is able to influence the virtual world however

Fig. 9
Immersive CAVE environment with multiple participants

When inside CAVE, the room's physical structure is visible, but is integrated into virtual scenes that are rear projected onto the walls, and also the floor and ceiling in some configurations[18]. Participants are able to move freely within the enclosure, which is another advantage over the physical limitations of the HMD[19]. CAVE was commercially developed as a visualisation tool for medical, architectural, and scientific training and research applications. In architectural applications, a client or a designer can 'walk through' the architectural space and experience it in every detail, even opening a cupboard door and reaching for an object inside, all before the building is constructed.

Continuing his pursuit of 'unencumbered' full body immersion, and building on the projection techniques first used by Myron Kruger in *Video Place*, artist Dan Sandin continued to develop his ideas throughout the 1980's. With the help of co-creator Tom DeFanti and the University of Illinois' Electronic Visualisation Laboratory (EVL), a commercially available unit was finally

18. The 'six wall' configuration is one of the latest VR developments known as 'CUBE'.
19. The HMD is 'hard wired' to the computer system, making it necessary to restrict movements so as to avoid participant's tripping over computer cables. Normally an assistant clears the cables from the VE participant's path as they move around within a limited area.

realised in 1992. Sandin developed unique stereoscopic glasses for CAVE that serve the dual function of polarising glasses (to generate the illusion of three-dimensional images) and an HMD (to communicate a participant's head and eye locations to the computer system).

Fig. 10: Dan Sandin with CAVE's stereoscopic glasses (c.1992)

As well as a data glove, CAVE uses a 'wand' type interface that works like a paintbrush. This allows participants to literally 'paint in 3D', as shown below.

Fig. 11: Immersive CAVE installation at the University of Calgary, Alberta, Canada (1994)

Of the artworks created for CAVE since its inception (including works by Sandin himself), Maurice Benayoun's *World Skin* (1997) is one of the more renowned, receiving international recognition and a number of art and technology awards.

Maurice Benayoun (b.1953- Algeria)

World Skin (1997)

The careers of contemporaries Char Davies and Maurice Benayoun share many parallels. Like Davies, Benayoun co-founded his own VR software company '*Z.A. Productions'* in Paris, France, where he too still works as a director. Also like Davies, he has received recognition in both visual art and technological circles for his contributions to the development of VR. For *World Skin*, Benayoun created a unique interface using a simple photographic camera.

Fig. 12
Maurice Benayoun: *World Skin* (1997) Interactive virtual environment for CAVE

A camera is given to each participant upon entering the virtual battleground of *World Skin*. When a picture is taken, the camera flash effectively ‘shoots’ the soldiers, eliminating them from the battlefield and leaving only a white silhouette where they once stood[20]. Benayoun has received several awards for virtual and interactive artworks[21]. In 2002, the first ‘CAVE Art Festival’ was held in Bonn, Germany[22], highlighting Benayoun’s work, as well as the work of Jeffrey Shaw, Christa Sommerer, and Laurent Mignonneau, as exemplars of virtual artists using CAVE technology.

Daniel Sandin (b. 1947-USA)

CAVE (1992), *CUBE* (2002)

Dan Sandin has been actively involved and a key contributor to VR’s technological development since the 1960’s. Like his ambitions for his image processor nearly forty years earlier, Sandin’s ambition for CAVE is to make it affordable and readily accessible to visual artists. Research efforts in the arts and VR technological fields have focused on a viable virtual technology system using standard home PC’s and freely available software for several years, which Sandin has finally realised with his recent portable and affordable CAVE system:

> *“The reduction of CAVE-based systems to consumer PC accessibility is making it possible to customize the conventional four-wall CAVE into new interactive museum/ gallery exhibits...”* (Anstey, 1999:89)

Sandin also co-developed the VR software programme *CANVAS* (downloadable free of charge from EVL’s website), which he believes will be as revolutionary to the development of virtual art as ‘*portable video cameras were*

20. See: http://www.worldskin.fr [Accessed 15/10/07]
21.These include prestigious awards from the annual Ars Electronica, Imagina, Nicograph, and Siggraph festivals, all of which recognise artists for new and innovative applications of the latest technology.
22. See http://www.iais.fraunhofer.de/775.html ; [Accessed 15/10/07]

to the development of video art' (Sandin, 2002: 287). The portable CAVE system promises to give future artists the opportunity and technological means for creating virtual art environments that can reach a much broader audience. The most advanced VR technology available today is an advanced CAVE system housing six projection surfaces. CUBE uses an interface similar to a small backpack with built in motion sensors connected to stereoscopic glasses. The wand and data glove have been replaced by a small hand held computer that gives the participant complete control over virtual world content. Once the door is closed all four walls, the floor, and the ceiling become a synchronised single projection surface that requires millions of dollars to operate[23]. When inside *CUBE*, participants are not only able to influence events and objects in the virtual world; they are also able to choose which virtual world they would like to experience. The handheld computer allows participants to change the virtual world programme at will without leaving the room's confines. CUBE is perhaps the closest that VR technology has come to a real world 'Holodeck'. As virtual technology rapidly becomes a mainstream medium, an increasing number of artists and VR technologists are coming closer to the 1960's immersive ideal that the fictional Holodeck, and now the factual CUBE, have come to symbolise.

23. See http://www.evl.edu/CUBE [Accessed 20/08/07]

2.1.3 Virtual immersion and virtual technology

> *"I have always pointed to physical participation as the key distinction of virtual reality."*
>
> Myron Kruger, 2005

The aim of VR technology and virtual art is the same today as it was forty years ago; to achieve full body interactive engagements with convincing virtual worlds that incorporate greater levels and methods of human-computer interaction, and increasingly obscure human-computer interface devices[24] (Davies, 2004; Grau, 2003, Rheingold, 1998). The immersive artists above also believe interaction to be a key and indispensable factor of immersion, which is why most have used their creative and technical proficiency to develop new interface devices and new methods of interaction, as artist David Rokeby argues:

> *"…it is artists, and not engineers, working with interactive media who explore interface. By employing interaction design to support creative expression artists work to understand this new medium and in many cases require audiences (users, participants) to reflect on the interface itself."* (Rokeby 1998b)

In his later article *Transforming Mirrors: Subjectivity and control in interactive media,* Rokeby compares the efforts of virtual artists to that of VR engineers:

> *"While engineers strive to maintain the illusion of transparency in the design and refinement of media technologies, artists explore the meaning of the interface itself, using the various transformations of the media as their palette."* (Rokeby, 1998a)

Such is the emphasis on interaction that some artists believe meaning can only be derived through it. Immersion, as artist Bill Seaman claims, engages a '*techno-poetic mechanism*' where meaning emerges '*only through the*

24. David Rokeby argues that the interface is explored by artists as a medium in itself (Rokeby, 1998b), whereas engineers aim to make the technology invisible, however, artists and technologists both strive for greater levels of 'naturalness' and 'obscurity' with reference to the ergonomic design of an interface. See Davies (1998; 2002)

interaction of the participant.' (Seaman, 1999:7). Like the emphasis on audience participation in the 1960's and 70's, the element of human-computer interaction is foremost for today's virtual artists. It could be argued that VR engineers, technologists, and virtual artists consider technological aspects of human-computer interaction to be at least as important as immersion itself (Davies, 1998; McRoberts, 2006; Nechvetal, 1999). The technological manifestos of the 1960's are thus as relevant to today's virtual artists as they were to their mid twentieth century predecessors. As the art practices described above testify, the central aim of virtual immersion and the principle goal of virtual artists and VR technologists is to create VE's that are able to facilitate a sense of presence by means of full body interactions in believable, fully surrounding, and fully responsive computer-generated virtual worlds.

Today's virtual artists represent a new generation of technically inclined and technologically competent practitioners who continue to contribute to the development, proliferation, and popularisation of virtual immersion, and, consequently, to the general perception of immersion as an exclusive property of virtual art. Virtual art is a relatively recent immersive art genre that depends upon VR technology and VE's, yet VE's are not the only means for generating an immersive experience. The pre-technological environments described in the following section are acknowledged precursors of immersive art, yet they engender a markedly different type of immersive experience.

2.2 Pre-technological Concepts

> *"To encounter the cave paintings was to immerse the self in an otherworldly domain […] Here, in the prehistoric caves, the human concept of virtual reality began with the multisensory, totalizing experience that engaged sight, sound, smell, and touch—the first conscious virtualization of the physical world."* (Packer, 2002: xxii)

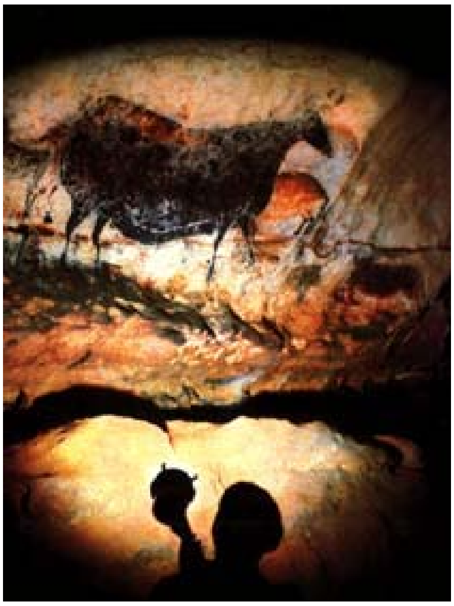

Fig. 13
Prehistoric cave paintings, Lascaux, France

2.2.1 Historical immersive environments

It has been argued that today's virtual art environments are the ultimate immersive achievement to which all immersive artists aspire (Nechvetal, 1999; Grau, 2003; McRoberts, 2006), yet at the same time the history of immersion as a creative medium has been traced by many scholars to the first art forms themselves, in the pre-historic caves of Lascaux:

> *"There is an evocative echo in virtual environments of the earliest known form of human expression – the prehistoric cave paintings found at such sites as the caves of Lascaux in the south of France. These immersive environments, dating from 15,000 BC, are thought by scholars to have been theatres for the performance of rituals that integrated all forms of media and engaged all the senses."* (Packer, 2002: xxii)

In the case of Lascaux, immersion was quite possibly a consequence of certain known factors. We know that painted images of animals covered the entirety of the cave's deepest grottos that could only be accessed through a series of winding, increasingly confining tunnels (Ziter, 2003). We also know that once inside the grotto, the images would have filled an occupant's entire FOV, and that they were made visible only by means of open flamed torches (Ruspoli, 1987). In such confined and dimly illuminated space, with an intermittent, flickering light source, the images would have appeared distorted, perhaps even animated. It is speculated that spearhead damage to the walls is the result of primitive hunting rituals, which suggests the animals did indeed appear to move (Ziter, 2003; Lewis-Williams, 2004).

Many analogies have been made between immersion in this context of these caves, and immersion in today's CAVE system:

> *"The CAVE System also returns full circle to the earliest attempts at virtualization and multisensory experience, as practiced in the prehistoric caves of Lascaux, seventeen thousand years earlier."* (Grau, 1999:6)
>
> *"… participants in the CAVE are surrounded by an immersive, digital "cave painting" -- which brings the evolution of immersion full circle, back to the prehistoric caves of Lascaux…"* (Nechvetal, 1999:191)

Although such connections are tenuous, there is one feature that today's CAVE system, the caves at Lascaux, and the traditional panorama share, which is the illusion of a fully surrounding alternate world that is integrated into the fabric of the real world environment. In the caves of Lascaux, the cave walls themselves became part of the illusion, just as the actual structure of today's CAVE system is incorporated into the virtual world imagery so as to appear integral to it. Similarly, in traditional panoramas the structure of the architectural enclosure that housed them and real world three-dimensional objects were merged with the two-dimensional painted image of the panorama.

2.2.2 The Panorama

> *"Panoramas were of course visual entertainments par excellence in which pleasure was produced by the medium's ability to fool the eye."* (Ziter, 2003:7)

Fig. 14
The Battle of Sedan Panorama (1870-71)

The panorama is a familiar example of a pre-technological concept of immersion. Invented by Robert Barker in 1787, it remains a popular attraction even in today's technologically driven society. The development of the panorama stemmed from the earlier invention of spherical painting, both being motivated by the same vision of an 'all-encompassing image' evidenced throughout history in 360° frescoes, panoramas, dioramas, the Cinéorama, today's Omnimax and IMAX cinemas, the HMD, and CAVE, (Grau, 2003; Nechvetal, 1999). The difference between the contemporary HMD and pre-technological methods is that in the latter, the image is integrated into the real world environment; the effect being a three-dimensional, fully surrounding, illusory world that has an immediate, but unmediated, immersive effect. Panoramas were so successful at this because the real world environment they occupied was a 'purpose built' architectural structure.

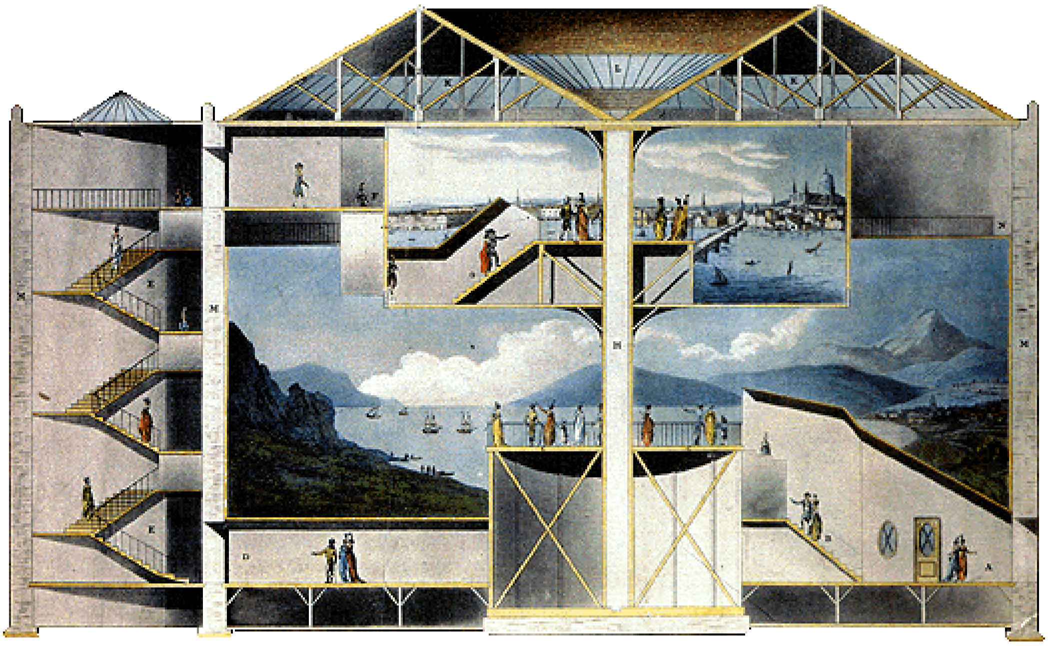

Fig. 15
Robert Burford: *Leister Square Rotunda* (sectional view, c.1781)

These architectural enclosures were specifically designed to block out all visual clues from the external world, allowing the illusory image to appear continuous and uninterrupted, a kind of 'veiling' of the illusory (painted) world over the fabric of the real world:

> *"At no point could the spectator break from the image and examine the surrounding reality; the panorama completely filled the field of vision, blotting out anything that might reveal its artificiality."* (Ziter, 2003:25)

> *"The intrusive element of the spectators surroundings being blacked out, the world in which they were entwined consisted exclusively of the landscape or cityscape depicted on the canvas...."* (Atlick, 1978:132)

The illusion of an alternate reality[25], depicted in a 360º painting covering the walls and curved ceiling of the rotunda, was reinforced by strategically integrating three-dimensional objects and architectural elements into the content of the two-dimensional panorama image:

25. Although early panoramas depicted battle scenes, foreign landscapes came to dominate later panoramas. See Atlick (1978) and Oettermann (1997).

> *"The effect of total immersion in the depicted scene was enhanced by the panoramas skilful manipulation of perspective, lighting, and […] three dimensional effects that blended with the two dimensional foreground of the painting to create the illusion of additional depth."* (Oettermann: 103)

Robert Barker described the panorama as "*a kind of pattern for organising visual experience*" (Oettermann: 104), and recent accounts still emphasise this element of 'visual effect':

> *"Like the kaleidoscope, panoramas offered a disorientating optical experience."* (Plunkett, 2004:78)

> *"Queen Charlotte reportedly grew seasick when attending Barker's first panorama in Leister Square '*The Grand Fleet at Spithead*' in 1791. [...] Spectators attested to the disorienting effects complaining of "dizziness and nausea" caused by the impossibility of withdrawing from the delusion."* (Ziter, 2003:25)

As an acknowledged precursor of today's immersive art, immersion in traditional panoramas has been compared with immersion in contemporary VE's. Oliver Grau, for example, sees pre-technological associations in Benayoun's *World Skin*:

> *"Thus Maurice Benayoun reveals himself as an exegete of the panorama, who, using the latest image technology, takes up the idea and aesthetics of the panorama again and develops it further."* (Grau, 2003:238)

The connection here however, lies in the works content rather than an immersive aesthetic or method. What *World Skin* and most historical panoramas share is their subject matter, which is warfare. The war scenes in *World Skin* convey the political comments of the works creator, whereas the *Battle of Sedan* reflected the political agenda of the work's patron (Oettermann). Grau makes similar associations with Jeffrey Shaw's 1989 installation *Place*[26]. Here the connection lies in the work's construction rather than its content, which, like the traditional panorama rotunda, is a 360º enclosure.

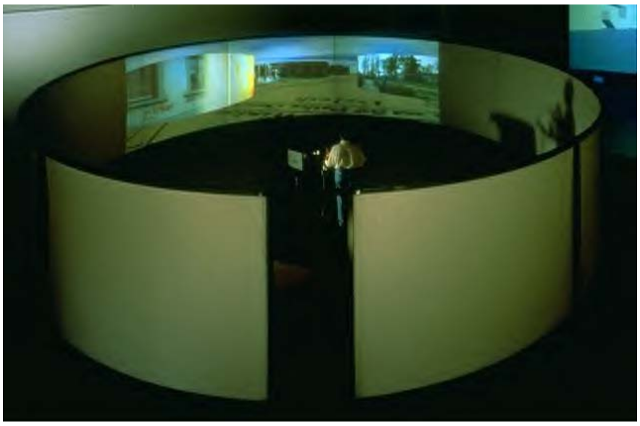

Fig. 16
Jeffrey Shaw: *Place* (1989)

It is generally agreed that the salient feature of virtual art is human-computer interaction, the success of which lies in the levels and methods of interaction employed and the obscurity of the interface (Grau, 2003; Davies, 2004; Nechvetal, 1999; McRoberts, 2006). However, as pre-technological immersive environments neither employ virtual technology nor incorporate interactivity, these factors are unique to concepts of virtual immersion and virtual art. To compare immersion in the context of pre-technological environments with immersion in contemporary VE's raises questions as to when and why the concept of immersion became enmeshed with concepts of interaction. It is not possible to properly address this question within the scope of the thesis; however, it is important to note that historically, descriptions of immersive environments have included terms such as 'perceptual effect', 'visual illusion', and 'fully surrounding image'. It was only in the mid-twentieth century that terms such as 'interface', 'interaction', 'full body engagement', and

26. *Place* is actually an interactive video installation, often incorrectly referred to as an immersive artwork.

‘responsive environment’ were introduced to the lexicon of immersive terminology. Therefore, to relate the concept and experience of immersion engendered in pre-technological/historical and contemporary/virtual immersive art environments is to necessarily relate a non-technological, non-interactive, strictly visual immersive property.

The concept of *visual* immersion describes an aesthetic embodied in immersive environments throughout history, including contemporary virtual art. However, this concept of immersion *per se* has been progressively eclipsed by the popularity and proliferation of interactive VE’s. Concepts of interaction and the advent of VR technology in the 1960’s and 70’s saw a fork in the historical path of immersive art, and visual and virtual immersive art forms have developed along separate paths ever since.

2.3 Visual Immersion

> *"The act of art has turned to a direct examination of our perceptual processes. […] What we are really dealing with is our state of consciousness and the shape of our perception."*
>
> Robert Irwin 1972

> *"Nothing is more beautiful than a person's own perception…I try to push it to its limits"*
>
> Ann Veronica Janssens 2003

2.3.1 Perceptual background

When Myron Kruger and other E.A.T participants were exploring the medium of interaction, James Turrell, Robert Irwin, and artists commonly associated with the 'Light and Space' movement, explored the medium of perception (Popper, 1995; Thea, 1998). As practicing artists during the art and technology movement, Turrell and Irwin also participated in the E.A.T programme. Unlike other technologically inclined collaborations however, Turrell and Irwin focussed on the science of perception, working with experimental psychologist Edward Wortz on the development of 'sensory deprivation' environments:

> *"For several months the three pursued whatever interested them: they sat in anechoic chambers; they played with light; they discussed ideas. Neither the art hardware nor the fascination with spectacle of the E.A.T. projects coincided with the true focus of Irwin's interest however. He took a more physiological approach in which perception precedes conception."* (Thea, 1998:172)

Fig. 17
James Turrell (left) and Robert Irwin c.1968
The laboratory of Edward Wortz, University of California, US

The work and philosophy of Irwin and Turrell[27] typified a 1970's fascination with the medium of perception and the art of 'perception-bending' recently described by Michael Rush in his article *Virtual reality art: Beyond technology*:

> *"Mimicking the real is generally not what interests artists. Altering perception is. When Bruce Nauman, Michael Snow and Peter Campus turned to video technology in the 1960s, they did so to challenge viewers' expectations by tipping them off balance, providing an ambiguous experience rather than a familiar one. Nauman's "Spinning Spheres" from 1970 is a large and immersive four-screen projection featuring a spinning steel ball. Its effect is truly dizzying. Experimental film artists of that period shared a similar fascination with perception-bending."* (Rush, 2006: 2-3)

As with many similar works of the time, immersion in the context of Nauman's *Spinning Spheres* is a product of strictly *visual* stimuli and *perceptual* effect. Certain contemporary art practices maintain a link with the perceptual strategies of the Light and Space artists, and also with a long history of immersive traditions.

27. Amongst others including Dan Flavin who cannot be covered here. Of the Light and Space artists, Turrell and Irwin were selected because their philosophy and their creative work best reflects the concept of visual immersion, as will become clearer later in this section.

2.3.2 Contemporary methods and practices

> *"My work is about your seeing…there is a rich tradition in painting of work about light, but it is not light – it is the record of seeing. My material is light, and it is responsive to your seeing."*
> James Turrell 2005

We are used to immersion in the actual world, accordingly, entering a visual immersive art environment amounts to entering an alternate world, which, like the panorama, has an immediate but *unmediated* immersive effect. Working beyond the limits of perception, visual immersion renders the invisible visible, and gives rise to what artist Anne Veronica Janssens describes as *"…experiences that act as passages from one reality to another …"* (Janssens, 2003:178). This type of alternate reality is markedly different than the virtual worlds described above, and it is embodied in the work of artists James Turrell, Robert Irwin, Veronica Janssen, and Olafur Eliasson (amongst others) who collectively illustrate a pre-technological concept of immersion in contemporary visual immersive art environments.

James Turrell (b.1947- USA)

Afrum Proto (1968) *1st Moment* (2003)

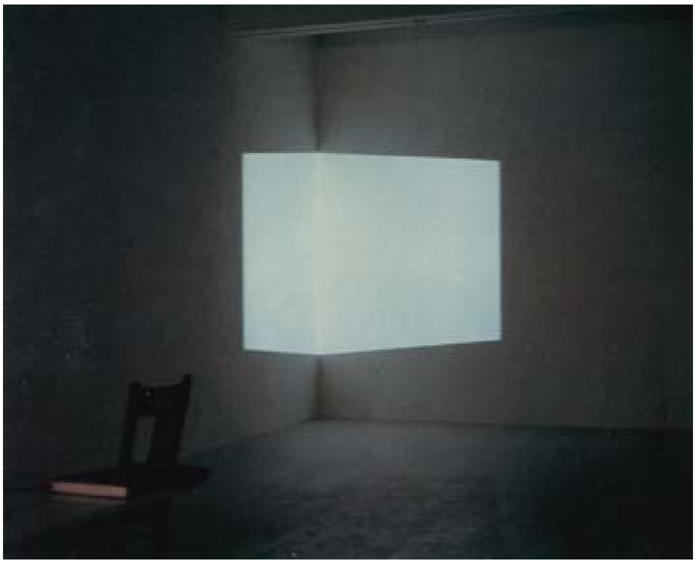

Fig. 18
James Turrell: *Afrum Proto* (1968)

James Turrell has been developing methods for generating perceptual phenomena throughout his career in artworks that reflect an acute awareness of human vision and the perceptual process. Turrell's method could be called 'perceptual minimalism', whereas the visual information available to observers is reduced to the degree that the visual system 'fills in' ambiguous or missing details (Dennett, 2002; Gregory, 1997). In doing this, the visual system often makes mistakes, and we experience 'perceptual error' (Gilchrist, 2006; Galloway, 2000). A constant thread throughout Turrell's forty-year practice has been the manipulation of perception in visually abridged real world environments. The effect, such as perceiving a solid volume where there is in fact an empty space, is evidenced in Turrell's works throughout his career, from his earliest installation of *Afrum Pr*oto (1966) to recent works like *1st Moment* (2003). In these installations, perceptual error often manifests as a sense of disorientation.

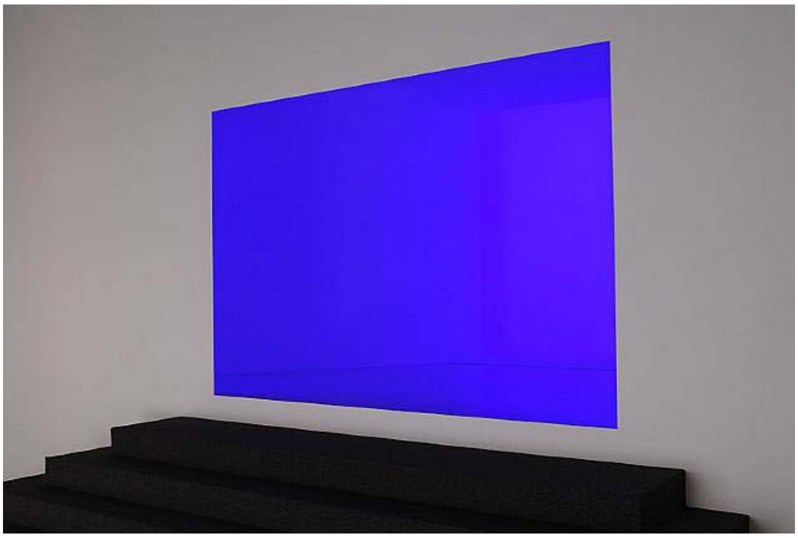

Fig. 19
James Turrell: *First Moment* (2003)

The methods of virtual immersion include replicating in the virtual world how we *correctly* perceive in the real world (Duh et al, 2002; Slater and Usoh, 1994; Heim, 1998), and presenting a condition of *visual saturation* (Laurel, 1991), or what Jonathon Steuer describes as '*breadth of information*' (Steuer: 81), and Joseph Nechvetal as "…*aesthetic immersion is about stimulation through excess of our internal perceptual circuitry*." (Nechvetal, 1999: 378). In sharp contrast to virtual methods, the method of visual immersive artists is to *reduce* visual information, to the degree that we *incorrectly* perceive the real world. Artist Anne Veronica Janssens uses this strategy of 'perceptual minimalism':

> *"My intervention being limited to the creation of the minimum conditions, that is to say, almost nothing, every one is free to explore and interpret the meaning of his or her personal experience."* (Janssen, 2004:103)

Ann Veronica Janssens (b. 1957-UK)

Untitled (2003)

Fig. 20
Anne Veronica Janssens: *Untitled* (2003)

In her essay, *Ann Veronica Janssens: Light in Life's Lab* Mieke Bal describes Janssens work as:

> *"…an image of perception that resonates remarkably with the bodily dizziness produced. […] Ann Veronica Janssens interrogates the conditions of perception on yet another level."* (Bal: 91)

Janssens describes her creative inspiration as being driven by situations of 'dazzlement' and 'the persistence of vision', aspects of perception that "*allow us to structure ourselves around a threshold of visual /temporal/ physical/ psychological instabili*ty" (Janssens, 2004:113). Visitors to Janssens' mist filled room (*Untitled*, 2003, above) have described the experience as 'entering another world':

> *"…you came in through that door and you found yourself in a different universe, but when you came out again everything seemed very brutal…"* (Harmanci, 2003: para4*).*

Comments on Janssens work echo descriptions of panoramas a century earlier:

> *"Creation left viewers disoriented and doubting their perceptions of up and down, moving and static, real and illusory as they rejoined the frenetic world outside."* (Walker 1904: 517).

Mieke Bal and Marie Brayer have attempted to categorise Janssen's' work in the context of contemporary sculpture, which, as Bal admits, is difficult. Janssens work, like that of Turrell and Irwin, involves perceptually evoked experiences that are "…*induced by the paradoxical visual invisibility of space*." (Bal: 97), which is "*beyond the threshold of perception and beyond categorisation*" (Bayer, 1996: 445). If there were an established category for Janssens and Turrell's genre of art practice, it would also include the work of Danish artist Olafur Eliasson:

> *"… contemporary works like Olafur Eliasson's* Room for One Colour 2002--*an installation of sodium-yellow lights that rendered a section of the institute's library nearly monochrome, or Ann Veronica Janssen's* Phosphenes, *1997, a work inviting viewers to torment their eyeballs and generate phantom objects in the space between eyelid and retina, functioned as rapidly absorbable, cleverly minimal gestures..."* (Withers, 2002:178)
> *"A significant portion of Eliasson's practice can be considered as influenced by Turrell, and many of his pieces follow similar lines of investigation."* (Byrne, 2005:5)

Olafur Eliasson (b. 1967- Denmark)

The Mediated Motion (2002), *Your Colour Memory* (2004)

Fig. 21
Olafur Eliasson: *The Mediated Motion* (2001-)

> *As with other landscape-inspired sculptors, such as Robert Irwin, Eliasson's work represents complex, elusive forms in works that are, themselves, temporary phenomena.* (Smith, 1996:178)

Like Irwin, Turrell, and Janssens, Eliasson takes perception, and perceptual minimalism, to new levels. Like the environments in Turrell's *1st Moment* and Janssens mist filled room, the smoke filled room of *The Mediated Motion* works on the ganzfeld principle[28], presenting a homogeneous and fully surrounding visual environment that offers little to no visual stimuli. In this condition, the human eye can find nothing to focus on in the visual scene, the consequence of which is visual illusion, disorientation, and even hallucination (Howard, 2002a). For *Your Colour Memory* (2003) Eliasson employs the same

28. The ganzfeld device is described later in this chapter and also in chapter five.

strategy, creating large homogeneous surfaces with rear projection screens.

Fig. 22
Olafur Eliasson: *Your Colour Memory* (2003)

When close up, the screens fill the FOV with a field of gradually changing colour. In his catalogue essay, Jonathon Crary describes Eliasson's aim as *"…to do away with most of the orienting or stabilizing functions."* (Crary, 2004:1-2) And, like Grau, Crary finds analogies between *Your Colour Memory* and the traditional panorama:

> *"In a very general sense, he is working with a 'panoramic' situation, but he has radically modified some of the elements of the archetypal nineteenth-century panorama."* (Cray, 2004:3)

For Turrell, Irwin, Janssens, and Eliasson, visual perception is the medium of choice, and all four employ the same perceptual strategies to unveil aspects of vision that we are not consciously aware of under normal conditions. It is generally agreed that the technological art of the 1960's and 70's is perpetuated in today's genre of virtual art. Similarly, it could be argued that the immersive environments of Irwin, Turrell, Janssens, and Eliasson perpetuate the Light and Space art of the same era, creating immersive environments in which, reflecting Irwin's personal philosophy, '*perception precedes conception*' (Irwin, 1972b).

2.3.3 Visual immersion and visual science

One way to distinguish the different concepts of immersion and immersive art described above is to consider the interdisciplinary knowledge and skills applied in their creation. It has been shown that virtual artists are generally technically competent and knowledgeable about the VR technologies they need to realise their work. Unlike virtual immersion, visual immersion functions according to the scientific laws and principles of vision. Visual immersive artists have also acquired the skills necessary to create their work, however, rather than technical aptitude; their work benefits from a science of perception. The work of all four of the above artists has at some point been linked specifically with science and/or experimental methods:

> *"… [Eliasson's] installations are experimental, aiming to provoke visitors to reflect upon their own processes of perception."* (Crary, 2004: 7).
> *"Eliasson invites comparison to the artists Robert Irwin and James Turrell and the idea of "seeing yourself seeing." […] Eliasson consistently uses mechanical artifice to create his effects in art interventions, photographs, installations, and exhibitions that are often more like optical experiments than art shows."* (Zarin, 2006:2)
> *"Janssens' installation [...] can be conceived of as a laboratory in which everything that happens when we perceive becomes an object of experiments."* (Bal, 1999:90)

Janssens openly acknowledges the connections between her creative process and the process of experimentation:

> *"My projects are often based on technical or scientific facts […] Cognition, reflexes, meanings and psychology lie at the heart of these experimentations."* (Janssens, 2004:113)

The fundamental tie between the works of these artists is summarised in the words of experimental psychologist James J Gibson:

> *"Experiments on perception with reduced information are very frequent in psychology. […] It has been the hope of the investigators to cut back the sensory basis of perception so as to allow the perceptual process to come into its own - to reveal in relatively pure form the laws of its operation."* (Gibson, 1966:298)

Recently, Eliasson worked in collaboration with vision scientist Boris Oicherman on *Your Uncertainty of Colour Matching Experiment* (2006); an immersive environment that doubled as a 'scientific laboratory'. Oicherman gathered scientific data during the exhibition that was exhibited alongside the installation, showing varied individual responses to the same visual stimuli. For Eliasson, subjective reports from individuals revealed how the work was perceived and experienced by different viewers, and for Oicherman they shed light on scientific aspects of colour perception. Thus, Y*our Uncertainty of Colour Matching Experiment* is a visual immersive environment that was both motivated and realised by the common aims, methods, and pooled resources of visual art and visual science.

The confluences of visual science and visual immersive art are perhaps most evident in the work of James Turrell, which, in the below image, is juxtaposed with the experimental work of vision scientist Alan Gilchrist.

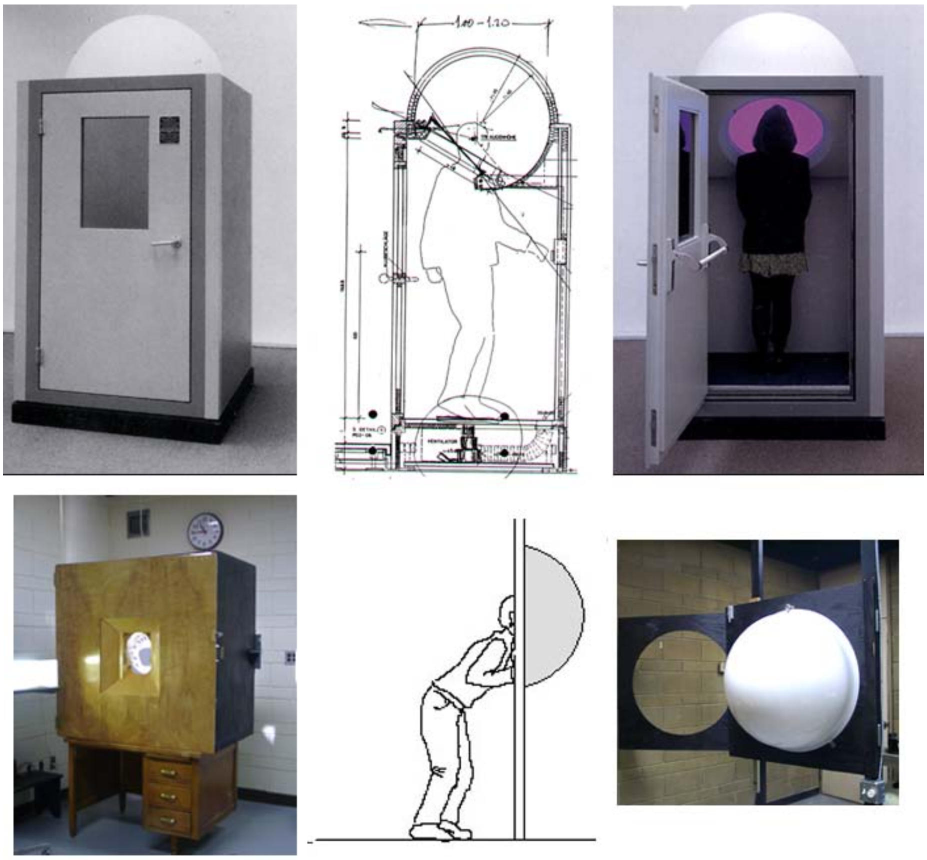

Fig. 23
Top row: James Turrell: Perceptual Cell (2003)
Bottom row: Alan Gilchrist's perceptual apparatus (2002)

The images in the top row are of James Turrell's *Close Calls,* one in a series of 'perceptual cells' created between 2002 and 2003. The bottom images were taken in the laboratory of vision scientist Alan Gilchrist at Rutgers University, NJ, in 2003[29], and show a scientific apparatus used by Gilchrist for experiments on lightness perception. Both employ a ganzfeld device, which, for Gilchrist, serves the scientific purpose of isolating particular perceptual mechanisms from other perceptual influences. For Turrell, the ganzfeld serves the aesthetic purpose of eliminating visual information, as vision scientist Shinsuki Shimojo describes:

> *"Naturally enough the Ganzfeld has become one of the favourite techniques of Turrell, who advocates 'neutralization,' that is the emphasis on light and space by minimizing image or surface.*

29. Gilchrist made the first version of this apparatus in 1976.

> *Also it seems to be a matter of course that Turrell has no interest in so called technology art because it tries to build up rather than eliminate forms."* (Shimojo, 2004: Para 5)

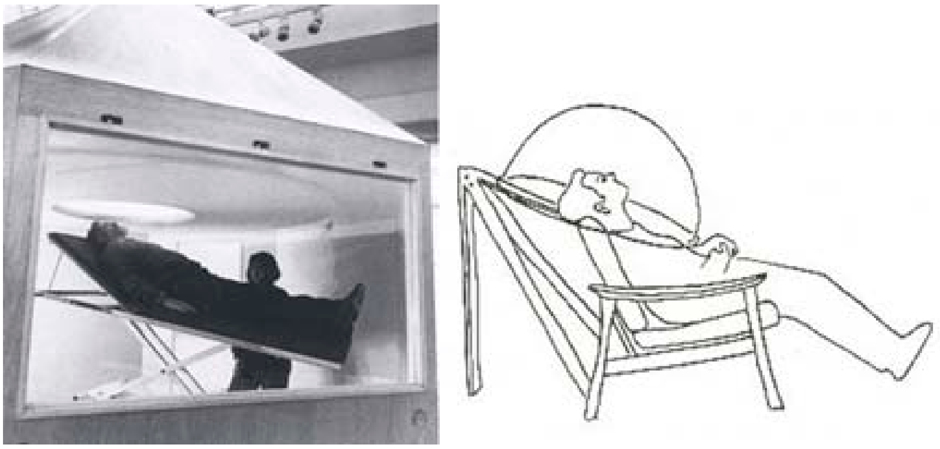

Fig. 24
Left: James Turrell: *Perceptual Cell* (2002-2003)
Right: Alan Gilchrist: Apparatus for presenting visual stimuli (1987)

Turrell and Irwin's collaborative work with scientist Edward Wortz in the 1960's focused on the ganzfeld for its potential to "…create strange percepts such as the greying out of color, loss of vision, inability to tell if the eyes are open, and loss of balance." (Solso, 2003: 52), and it has been a recurring theme in Turrell's work ever since. In the above images, the work of Turrell and Gilchrist exhibit the same remarkable similarities. In both an art and science context, the ganzfeld serves the same purpose, which is to present a visually diminished condition to reveal aspects of perception that are hidden from during normal perception. The striking parallels in these works speak to the confluent methods of visual immersive art and visual science practice, and to the influence that Turrell's background in experimental psychology has had on his creative work[30].

2.4 Summary

30. Turrell received an undergraduate degree in experimental psychology before studying for a graduate degree in visual art.

Like the confluent aims and methods of virtual artists and VR technologists, the aims and methods of visual immersive artists can be seen to parallel those of visual scientists, and a key distinction between virtual and visual immersive art environments can be seen in the respective technologically and scientifically informed methods and skills employed in their creation. Using strictly visual stimuli and perceptual phenomena in the real world, visual immersive art perpetuates the legacy of the mid twentieth century Light and Space movement, which in turn perpetuates a long history of pre-technological immersive traditions. Collectively, the work of Irwin, Turrell, Janssens, and Eliasson amongst others, reflects an ancient concept of immersion *per se* that has yet to be defined and distinguished from recent concepts of virtual immersion and immersive virtual art.

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Chapter Three: Literature Review

Introduction

Immersion carries a number of meanings and even individual interpretations both within and across disciplines, all of which cannot be addressed in the scope of this thesis. The literature review is narrowed to those fields that have some connection, influence, or relevance to visual art practice and/or this research enquiry. The reader will be directed to further literature in areas that cannot be comprehensively covered here. Within the creative disciplines, the literature on immersion has only recently begun to surface. As in other disciplines, this has so far focused on concepts of virtual immersion, emphasising technological factors that are exclusive to immersion in VE’s. Within the field of VR technology, there is a wealth of literature on the concept and defining factors of immersion, which is intertwined with the closely related concept of presence. The wide-ranging literature on presence cannot be addressed within the scope of this thesis; however, the topic will be presented to the extent that it is implicated in current concepts and perceptions of immersion.

Of the various discipline specific interpretations, definitions and conceptions of immersion, two schools of thought emerge in the literature on immersion that reflect subjective/psychological and objective/perceptual schools. The first and more widely held school considers immersion a subjective, psychological state; the second and much less prevalent argues that immersion is an objective perceptual condition. In technological and scientific disciplines, subjective/psychological perspectives consider immersion a measure of emotional engagement in VE’s. In the field of literature, this school considers immersion a measure of a reader's emotional involvement with a story in either traditional texts or in the evolving narrative of interactive VE's. In film, subjective/psychological approaches describe immersion as a type of absorption that arises from emotional empathy towards a film's fictional characters. In technological/scientific fields objective/perceptual descriptions see immersion as quality of the technology employed, which involves encompassing the FOV with realistic and rapidly updated images. In literature, an objective/perceptual school sees immersion in a traditional text as a reader's ability to block out the perception of real world certain distractions such as noise. Objective/perceptual approaches in film consider immersion a perceptual aspect of cinematography, such as perceptual tricks used in the filmmaking and editing process.

In all of these fields, subjective/psychological perspectives consider immersion a qualitative aspect of conscious experience, and objective/perceptual perspectives consider immersion a quantitative aspect of subconscious perception. In the visual arts, concepts, debates, and assessments of immersion and immersive art reflect the former school, focusing on the subjective experience of engagement with a virtual art world, which is more aptly described by the presence concept. The literature review reveals that, unlike other disciplines, in the visual arts an objective/perceptual account of immersion has yet to be articulated.

3.1 Some Disciplinary Definitions

3.1.1 Immersion in the context of VE's

In scientific and technological fields concerned with the development and scientific application of VE's, a number of authors have written on the concepts of immersion and presence. These include Mel Slater (1994; 1997; 1999; 2003), Thomas Sheridan (1992), Witmer and Singer (1997), Michael Heim (1993, 1996, 1998) and Jonathon Steuer (1992), to name only a few. These accounts offer varied definitions and interpretations of both concepts. The body of literature on presence is vast and cannot be thoroughly addressed in this review, however, concepts and definitions of presence are closely associated with immersion, and are therefore pertinent to this thesis. Immersion is considered a crucial component of VE's, and thus for the technological developers and users of VE's what constitutes immersion is a highly pursued and highly debated topic. Although it is generally agreed that presence describes a 'feeling of being there' in a virtual world (Steuer), there are also varied interpretations of what constitutes the feeling of being there. Schloerb (2008) divides presence into 'subjective' 'objective' presence. Heeter (1992) describes three presence types as 'subjective personal presence', 'social presence,' and 'environmental presence' (4). Zahorik and Jenison (2008) define presence as "*successfully supported action in the environment*," referring to 'correct' responses from the virtual environment in to a user's input. Witmer and Singer (1998) define presence as:

> *"…a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences."* (72)

Jonathon Steuer claims that *'the sense of presence is the defining experience of virtual reality'* (73). According to Steuer, presence is driven by many factors:

> *"Sense of presence may be driven by the vividness of an experience (i.e., the sensorial richness) and the level of interactivity or degree to which a participant can manipulate objects and move about in a virtual world."* (76)

Steuer's definition focuses on the subjective, qualitative aspects of experience in a VE, and this is now a commonly accepted definition of the term. Descriptions of presence usually include terms such as 'psychological engagement' and 'emotional involvement', referring to a participant's individual and subjective experience with a virtual world (Zahorik & Jenison). Debates on the factors of presence often refer to the behaviours and responses in the virtual world, which are ideally equivalent to behaviours and responses in the real world. Lombart and Ditton (1997) claim that presence emerges as a result of 'the illusion of non-mediation'. This (somewhat idealistic) proposition suggests that if the participant is no longer aware of the technological devices employed, that it is possible for them to actually *believe* they have left the real world[31]. Henry Lirn Duh (2002) sees the quality of the 'all-encompassing' display as critical to the sense of presence. Although descriptions are varied and many, a consistent thread can be seen in the subjective attributes assigned to presence, and it is largely agreed that the sense of presence is a qualititative, psychological, and subjective factor of VE's.

What constitutes immersion is much less clear, descriptions continue to be

31. This ideal immersive environment (like a real world 'Holodeck') is difficult to imagine with currently available virtual technology, which is still heavy and cumbersome and far from invisible to VE participants.

confused or used interchangeably with presence, and also with the concepts of interaction and engagement. Sadowski and Stanney (2002) describe immersion as:

> *"The feeling of immersion, whether physical or psychological in nature, allows the sense of belief that the user as left the real world and is now "present" in the virtual environment*."

Thus, immersion, which is a facilitator of presence, is a 'feeling' that can be either psychological or physical. In *Virtual Realism* (1998), Michael Heim describes 'immersion' 'interaction' and 'information intensity', as the three 'i's' of virtual reality:

> *"Approaches which aim at providing the illusion of "being in an alternative reality" accent the realisation that the more elaborate the possibilities of interaction of the participants with the objects in the environment, and the subtler the responsive abilities (behaviours) of objects in the environment with respect to user's actions and navigation, the better the immersion in the virtual world."* (6)

According to Heim, without the element of a realistically rendered virtual world, immersion could not be supported. He describes immersive devices as "*devices that isolate the senses sufficiently to make a person feel transported to another place*" (7), and claims "*VR immersion must immerse the psyche as well as the senses if it is to fascinate.*" (55). Thus, immersion is first a property of technological devices, but Heim goes on to say that immersion '*makes a person feel transported*', and is a property of both the '*psyche as well as the senses*', which are subjective factors more closely aligned with presence.

The factors and descriptions of immersion and presence therefore overlap, with the former often being subordinated to the service of the latter, such as in Richard Bartle's (2003) account of immersion in the context of interactive video games:

> *“It's an important facilitator, but that's all that is [...] it's not immersion that itself is intoxicating, rather, it's what immersion helps deliver”* (157).

Bartle describes two forms of ‘perceptual immersion’ and ‘psychological immersion’, the former attributed to objective, technological factors and the latter to emotional psychological states. According to Bartle, designers of interactive games see perceptual immersion as secondary, and only one of several possible ways to achieve the primary aim of psychological immersion. Witmer and Singer (1998) have devised qualitative methods for measuring presence and immersion[32], but fail to clearly distinguish presence from immersion and interaction:

> *"Immersion is a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences."* (232)

Like presence, immersion has no agreed definition, and this is due to a lack of distinction between very different factors, including presence, immersion, involvement, engagement, and interaction. Depending on the author’s specific area of interest or research, one finds different emphases placed on different properties of different concepts, which contributes to the terminological and conceptual confusion surrounding these terms. Although this confusion is recognised, little has been accomplished with regard to clarification. In technological and scientific fields, it has therefore proven difficult for immersion to be pinned down to any given set of criteria.

With research interests that span both human and computer vision, Mel

32. Witmer ands Singer devised a presence questionnaire ‘PQ’ and immersion questionnaire ‘ITQ’, as a qualitative measure of immersion and presence in VE’s. See Witmer and Singer (1998), and Slater’s response to Witmer and Singer (Slater, 1999).

Slater is a key player in the presence-immersion debate, and he asserts that the confusion could be avoided if a clearer distinction were made between the two concepts:

> *"This confusion is hampering progress in the field. There can be no advancement simply because when people talk about presence they are often not talking about the same underlying concept at all. No one is 'right' or 'wrong' in this debate, they are simply not talking about the same thing. I would like to propose a terminology that may clear up the confusion, and prevent arguments over essentially non-issues. If researchers are talking about different things then there is no point arguing. Let's just use different terms for these different concepts."* (Slater, 2003:1)

Slater (1999) criticises Witmer and Singer, suggesting that they confound the objective properties of immersion with the subjective properties of presence. According to Slater and Wilbur (1997), presence can be described as a 'state of consciousness', which is the '*psychological sense of being in the virtual environment'*, and an 'impression' that is "*constructed through mental models and representation systems typically employed by the person in everyday reality*" (605). In other words, presence is related to an individual's overall feeling of being there in a virtual world, which is in line with Steuer's generally accepted definition. Presence is therefore a subjective and non-quantifiable experience that cannot be directly perceived by the senses (Steuer, Slater and Usoh, Witmer and Singer, Heeter). To clarify, there is general agreement about the subjective nature of presence, which is desirable factor of VE's that requires immersive technology, but it cannot be measured by or linearly related to that technology. Therefore, Slater agrees that presence is a subjective, psychological factor of VE's that is best measured by self-report (such as Witmer and Singers PQ and ITQ questionnaires). What Slater disagrees with is Witmer and Singer's use of the same qualitative methods (albeit a slightly different set of questions) to measure levels of immersion.

In sharp contrast to presence, Slater and Wilbur (1997) claim that immersion lends itself to objective and technologically quantifiable assessments:

> *“These include the size of the human visual field, the stereoscopic aspects of the simulation, the "surround" aspects of the sound, that is the extent to which the computer displays are extensive, surrounding, inclusive, vivid and matching. The term 'immersion thus stands for what the technology delivers from an objective point of view. The more that a system delivers displays (in all sensory modalities) and tracking that preserves fidelity in relation to their equivalent real-world sensory modalities, the more that it is 'immersive'.”* (609).

Thus, Slater’s concept of immersion is quantifiably determined by what the technology of a particular VE system can provide:

> *“…*[immersion] *is the extent to which devices and displays are capable of replicating the physiological sensations of the real world equivalent of the VE in which the person is interacting and the extent to which computer displays are capable of delivering an inclusive, extensive, surrounding, and vivid illusion of reality to the senses of the VE participant”* (604).

Daniel Mestre (1997) similarly describes immersion as a function of the technology responsible for ‘blocking out’ the external world:

> *“In a technical acceptation of the term, immersion is achieved by removing as many real world sensations as possible, and substituting these with the sensations corresponding to the VE”* (362)

As does Biocca and Delaney (1995), claiming that immersion is determined by “*the degree to which a virtual environment submerges the perceptual system of the user*” (57), which can be objectively measured by the number of senses that are provided with input (such as aural, haptic, and olfactory stimulation), and the degree to which these inputs remove or ‘block out’ their real world equivalents (58). According to these descriptions, the key defining factors of immersion include the effectiveness and design of the computer interface, the provision of high quality, fully surrounding virtual images, and the accurate simulation of real world responses and behaviours, all of which are contingent on the technological capacity of the VE's immersive (computer) system. If Bartle's concept of psychological immersion and the definitions offered by Witmer and Singer are considered instead to be descriptions of subjective presence, the terms become somewhat less intertwined and begin to reflect the immersion-presence distinction made by Slater. By assigning specific objective and subjective attributes to immersion and presence respectively, Slater's distinction goes some way to clarifying the confusion.

In summary, in scientific and technological fields, those that have attempted to define and distinguish presence and immersion are in general agreement about some of the fundamental attributes of each. Immersion is seen as an objective aspect of the VE technology employed, which is necessary for removing or isolating an individual's everyday (principally visual but also physiological) perceptions of the real world[33]. Assessments of immersion as such are based on a set of objective, perceptual criteria, including the technological capacity to fill a participant's FOV (the HMD/CAVE) and facilitate interaction with the virtual world (the human-computer interface), which can effectively respond to a user's input in real time (the computer system). Assessments of subjective *experiences* in VE's however, are based on a significantly different set of psychological, qualitative criteria. Therefore, from the standpoint of the developers of VR technology, scientific researchers using VE's, and designers of entertainment applications for VE's, the principle

33. VE's remove the individual from contact and interactions with the real world by replacing them with those of the virtual world, however, without the removing the individual from all sensory perceptions of the real world (mainly visual but also haptic and aural), interaction would be rendered ineffective as an immersive factor.

goal is not immersion *per se*; it is the generation of a sense of presence in perceptually and psychologically believable virtual worlds, of which immersion is only one (albeit an important) factor.

3.1.2 Literary immersion

> *"There are no days more full in childhood than those days that are not lived at all, the days lost in a book. I remember waking out of one such book [...] to find my sisters all around me. They had unlaced and removed one of my shoes and placed a straw hat on my head. Only when they began to move the wooden chair on which I sat away from the window light did I wake out of the book, to their great merriment."* (McGahern, 2000:4)

> *"The most talked-about, and potentially the most significant consequence of recent advances in electronic technology for the practice and theory of literature is the promise of interactivity."* (Ryan, 1997: 667)

It is not possible to present a comprehensive review of the literary immersion in the scope of this thesis. Pertinent to this study is Marie Ryan's *Immersion vs. Interactivity: Virtual Reality and Literary Theory* (1994), and *Narrative as Virtual Reality: Immersion and Interactivity in Literature and Electronic Media* (2001), which cover literary immersion in the context of traditional texts, and in the context of interactive story telling. In the former, a traditional type of perceptual immersion is described, as experienced when 'wrapped up in the storyline of a good book'. In the latter, a form of 'digital' psychological immersion is described that is experienced when actively involved in, and interacting with a storyline, such as the evolving narrative of hypertexts or interactive VE's:

> *"The reader of a classical interactive fiction - like Michael Joyce's* Afternoon *- may be fascinated by his power to control the display, but this fascination is a matter of reflecting on the medium, not of participating in the fictional worlds represented by*

> *this medium."* (Ryan 1994:34).

Thus, in the literary fields, there are different meanings for immersion that depend on the type of medium employed:

> *"Hypertext will not realise its potential unless it provides for the reader both the pleasure of immersion in an imagined world (the achievement of realistic fiction) and the pleasure of instrumental action in that world (the goal of virtual-reality technology)."* (Travis 1996: 116)

Ryan offers a description of both, the first a perceptual condition induced while reading, and the second as a psychological state induced while interacting. Ryan describes three aspects of immersion that apply to both states, which are *spatial*: the reader develops a sense of being on the scene of the narrated events, *temporal*: the experience of a reader caught up in narrative suspense and the anticipation of knowing what happens next, and *emotional*: the phenomenon of developing a personal attachment to characters and empathising with their experiences. Although these are manifest, according to Ryan, in both conditions, immersion that involves ‘a passive reading that is taken over by the world a text represents’, is distinguished from an ‘active, deconstructive reading that involves participating in the creation of a storyline’. Ryan describes the former as the ability one has when immersed in the storyline of a text to block out perceptual stimuli from the outside world, for example, the sound of a dog barking in the distance can go unnoticed when deeply engrossed in a text’s storyline. This phenomenon is also noted by Ron Rodaski in *Virtual Reality Madness* (1993):

> *“For centuries, books have been the cutting edge of artificial reality. Think about it: you read words on a page, and your mind fills in the pictures and emotions--even physical reactions can result.”* (2)

A similar observation is made by Ken Pimentel and Kevin Texeira (1993) in *Virtual Reality: Through the New Looking-Glass*, who compare immersion in a VE to the 'mental shift' that occurs when reading or playing a video game:

> *"The question isn't whether the created world is as real as the physical world, but whether the created world is real enough for you to suspend your disbelief for a period of time. This is the same mental shift that happens when you get wrapped up in a good novel or become absorbed in playing a computer game."* (15)

This condition involves subconscious processes, such as, using Ryan's example, shutting out sounds from the real world without the aid of artificial devices (such as earplugs), a perceptual phenomenon that is abruptly halted by sudden interruptions, such as the sound of a telephone ringing nearby. The moment this happens, the barking dog can be heard once again. Thus, Ryan's description of certain aspects of literary immersion (the barking dog) and Rodaski's comments on the physiological effects of immersion ('physical reactions can result') are perceptual factors that reflect Slater's objective, technological factors of immersion in VE's, which involves a similar 'blocking out' of perceptual input from the real world.

Although Ryan discusses psychological aspects of immersion in interactive texts (including descriptions that echo presence factors such as emotional empathy, psychological engagement, and suspense) she also claims that in the literary domain, contrary to perspectives in technological and scientific fields, that interaction and immersion are conversely proportional and cannot occur at the same time:

> *"…this combination of immersion and interaction is not possible with literary texts. Literary texts that force the reader to participate actively inevitably shatter the effects of realism experienced by the read*er" (Ryan 2001:284)

Objective and subjective descriptions of literary immersion parallel the theoretical poles of literary criticism. Proponents of formalist literary theories assess the meaning of a text only by what is within a text. The intention of the author or the psychology of the reader are superfluous to an assessment of the text itself, which can be understood ‘objectively’, and free from subjective influences (of culture or gender etc.) imposed by the reader (Groden and Kreiswirth, 1994). In opposition to this approach, reader-response theory, championed by Norman Holland and Stanley Fish[34], emphasises the importance of the reader as actively imparting meaning through his/her subjective interpretations. The poles of literary criticism mirror the presence-immersion conundrum in that formalist theories consider the text as ‘object’ (an immersive system) which is assessed based on a set of traditional literary conventions (objective, technological factors of an immersive system), whereas reader-response theories consider the text as ‘response’ (the effectiveness of an immersive system), which is assessed on the basis of individual and subjective interpretations of a text’s meaning (the level of presence experienced in an immersive system). Both are equally valid arguments because, as Slater points out with regard to immersion and presence, they are addressing two different aspects of the same thing. Slater clarifies this using an analogous scientific debate on colour perception:

> *“I am making the distinction here similar to that in colour science. A colour can be described objectively in terms of a wavelength distribution. However, the perception of colour is an entirely different matter. […] If immersion is analogous to wavelength distribution in the description of colour then 'presence' is analogous to the perception of colour. Presence is a human*

34. A name notoriously associated with the ‘Sokal Affair’. See Sokal (1996) and Sokal and Brickmont (2003)

> *reaction to immersion. Presence and immersion are logically separable, but I would contend that empirically they are probably strongly related. Part of the study of presence is to understand this."* (Slater, 2003:4)

There is no doubt as to the importance and validity of both concepts in literary studies and in the study and development of VE's.

3.1.3 Immersion in the context of film

> *"Serres proposes that subjective activities, such as narration, are intertwined with objective processes, such as motion, whereby narrating becomes navigating and navigating is narrating."* (Shaw, 2006:313)

> *"…synaesthetic cinema creates an awareness of the process of ones perception that is structured by paradox, a kind of sensory stimulation laboratory* (Youngblood, 1979:359)

Again, the literature on immersion in film and cinema is extensive and cannot be entered into in any depth in the scope of the thesis. A brief overview reveals that like literary immersion, theories of immersion in film also revolve around practices employing a traditional medium and those employing interactive technologies. However, in the latter, the debate on 'Interactive Cinema'[35] as opposed to a traditional viewing of films are closely intertwined with debates on traditional and interactive narratives in literature and 3D video games. For the purpose of this study, a more pertinent distinction is analogous with objective and subjective descriptions of immersion in VE's. As in the analogy of formalist/reader-response theories in literary fields, illusionist and realist perspectives in film are also analogous with descriptions of immersion and presence in technological/scientific fields. An illusionist school focuses on quantifiable perceptual factors, whereas realist accounts focus on qualitative

35. See http://www.interactivecinema.html [Accessed 10/10/07]

psychological factors. Norman Holland's concept of reader-response theory in literature is extended to film in *Meeting Movies* (2006), where he relates the same type of psychological immersion that stems from experiences of empathetic emotion toward a film's fictional characters. In *Hamlet on the Holodeck* (1997), Janet Murray considers interactive video games[36] as embodying this form of psychological immersion:

> *We seek the same feeling from a psychologically immersive experience that we do from a plunge in the ocean or swimming pool: the sensation of being surrounded by a completely other reality, as different as water is from air, that takes over all of our attention, our whole perceptual apparatus*" (pp. 98-99)

Murray's description at first relates subjective factors, as described by Witmer and Singer and Bartle's psychological immersion, claiming that a psychologically immersive experience '*takes over all of our attention*', but then describes objective aspects that '*takes over our whole perceptual apparatus'* that echo Bartle's concept of perceptual immersion, and Ryan's immersion in traditional texts. Generally, Realist accounts emphasise qualitative factors of an individual's emotional and psychological engagement with fictional characters or events, which are the same subjective criteria applied to assessments of presence in VE's[37].

Illusionist theories focuses on immersion as an objective phenomenon related to cinematographic effect. Film theorist David Bordwell (1985) claims *"…any theory of the spectator's activity must rest upon a general theory of perception and cognition."* (30). Similarly, writing from an evolutionary

36. The concept of immersion in interactive 3D video games, although an area of study in itself, is closely intertwined with literature and film theories. See Alison McMahan's *Immersion, Engagement and Presence* (2003) for a description of the implication of presence and immersion terminology and concepts as applied to 3D video game design.
37. See http://www.interactive-film.com/ [Accessed10/10/07] for a detailed account of interaction (as opposed to immersion) in the context of film.

perspective, psychologist and film theorist Joseph Anderson (1996) also endorses an illusionist approach, as does Ed Tan (1985), both claiming that there are certain 'perceptual universals' available when making and viewing film. Anderson analyses immersion in relation to 'established rules of visual perception'. He discusses 'perceptual devices' used in the depiction of three-dimensional space and the strategies of manipulating visual information during the filmmaking and editing process. According to Anderson, filmmakers have developed conventions that are "*potentially acceptable to every human being on earth*" (11). Similarly, Stephen Boyd-Davis (2002) describes a type of immersive effect generated by perceptual minimalism in film: "*We can say that film imitates vision, but only in the sense that it aspires to evoke visual experience, real or imagined, not to imitate optics"* (75). Boyd-Davis interestingly notes that in the field of VE technology, designers have much to learn from the traditions of film:

> *"Even when a film is opulent or poetic, no spatial or pictorial device in the fiction film is used gratuitously: designers of digital interactive media have a great deal to learn from its informational economy and its suppression of every extra-diegetic device."* (75)

He attributes this to certain filmmaking techniques, using the work of Peter Greenaway and Ridley Scott as examples of artists who adopt a 'perceptually economical approach' that is less concerned with the psychological immersion generated by a film's content, and more with 'perceptual effect':

> *"Greenaway exploits his [art school] training to objectify the screen image—making the viewer media-aware […] precisely because it deliberately prevents the psychological immersion which is the essence of mainstream film-making."* (76)

This again stands in sharp contrast to the goal of VR technologists, who aim to replicate the behaviours of the real world, and our perceptions of it, by rendering the virtual world with as much detailed information as possible. Generally, illusionist theories of immersion in film (Anderson, Tan, Boyd-Davis, Bordwell) are largely informed by the psychology of perception, whilst Realist perspectives (Holland, Murray) described immersion from a social psychological perspective. Thus, theories of immersion in relation to film mirror theories of immersion and presence in technological and literary fields, the former being concerned with objective/perceptual factors (immersion/Formalist/Illusionist), and the latter with subjective/psychological factors (presence/Reader-response/Realist).

In the context of film, literature, 3D video games, and VE's, immersion has discipline specific terminology, definitions, and meanings; however, all can be ascribed to one of two general schools of thought that revolve around 'perceptual/objective' or 'psychological/subjective' models. As a consequence of the strong association of immersion with interactive VR technology and virtual art environments, a psychological/subjective model has come to dominant art theoretical debates and the emerging body of literature on immersion in the visual arts.

3.2 Immersive Art

> *"Immersion is a component of the ideal state of presentation and viewer experience that is aspired to by virtual artists and theorists of new media technologies."* (Deitz, 2002: 510).

3.2.1 Concepts and terminology

The literature on immersion in the visual arts has only recently begun to surface, and a once sparse number of publications have been augmented over the past few years by a number of PhD theses, conference proceedings, and academic journal articles worldwide. Of the contributions made by creative practitioners, the literature reveals a recurrent thread of theoretical and philosophical concepts and terminology. These include terms such as 'psychological absorption' (Davies, 2004), 'emergent meaning making' (Seaman, 1999), 'embodied awareness' (McRoberts, 2006), and 'immersive consciousness' (Nechvetal, 1999), in writings that are often punctuated with quotes by Lyotard, Baudrillard, and (even more so) Deleuze and Guattari. The following paragraph is taken from Joseph Nechvatal's 1999 PhD thesis entitled '*Immersive Ideals/Critical Distances: A study of the affinity between artistic ideologies based in virtual reality and previous immersive idioms*':

> *"Moreover, with this immersive vision there is a shift to a more conscious peripheral mode of perception which entails a deautomatisation of the perceptual process (whereby more emphasis is placed on what is on the edges of sight and consciousness. This emphasis on the peripheral utilises the Deleuzian broad scan; Deleuze's non-linear dynamic conceptual displacement of a view along any axis or direction in favour of a sweeping processes in space-time. Hence immersive vision may acquire an increasingly computational-like encompassing range useful in expanding the customary (120 vertical by 180 horizontal) FOV outward so as to increase situational awareness*." (377)

Nechvatal's thesis typifies many of the research contributions made by creative practitioners, who most often endorse relativist philosophical views or stress the political and cultural ramifications of immersive VE's[38]. There is also a tendency to inflate the potential of immersive virtual art to idealistic and unachievable levels:

> *"This challenge to find new expanded boundaries of self-representation is accompanied by a vibrating meta-consciousness of being immersively conscious where the immersant senses unity or wholeness in relationship to the work and (by extentuation) the universe"* (Nechvatal: 392)

Char Davies and Laurie McRobert make similar claims, such as the following comments on Davies' installation *Osmose* (1998):

> *"Response to the experience of* Osmose *is often a feeling of its ineffability, its indescribable nature, an unfathomably poetic flux of comings-into-being, lingerings, and passings-away within which our own mortality is encompassed"* (Davies in Ascott 1998:28)

> *"…the computer it seems is turning out to be a 'consciousness-heightening' instrument in the hands of some talented artists. Immersive computer art handily reveals its complicity with underlying biochemical human nature, not only with the consciousness of human beings, but with cosmic consciousness itself"* (McRoberts in Ascott 1998: 78)

> *"The medium's paradoxical qualities may effectively be used to redirect attention from our usual distractions and assumptions to the sensations of our own condition as briefly embodied sentient beings immersed in the flow of life through space and time."* (Davies, 2004:70)

The same trend can be seen in the literature on interactive art, 3D video games, and VR technology, all of which describe the potential of immersive VE's rather than immersion *per se*:

> *"The trans-human aspects of VR can appropriate something that shamans, mystics, magicians, and alchemists sought to communicate."* (Heim, 1993: 67)

> *"Designing human-computer experience isn't about building a better desktop. It's about creating imaginary worlds that have a special relationship to reality—worlds in which we can extend, amplify, and enrich our own capacities to think, feel, and act."*

38. See Ascott (1998).

(Laurel,1991: 33).

> *"VR is shared and objectively present like the physical world, composable like a work of art, and as unlimited and harmless as a dream. When VR becomes widely available, around the turn of the century, it will not be seen as a medium used within physical reality, but rather as an additional reality. VR opens up a new continent of ideas and possibilities."* (Rheingold, 1991:154)

For Char Davies, Laurie McRoberts, Joseph Nechvatal, and Oliver Grau amongst others, immersive virtual art is not simply the quintessential model of immersion and ultimate aim of all immersive artists, but it also promises to realise new and unimaginable forms of 'human consciousness', a word that occurs no less than 448 times in Nechvatal's thesis:

> *"Indeed the negative dialectical confrontation with non-knowing typical of immersive total art's aorist excess is an important component of immersive consciousness' intellectual satisfaction, as the entire benefit of addressing the espoused ideal inherent in immersive omni-perception exists in attempting to adhere to an exciting transmissible hyper-state which exceeds, transcends, and overwhelms our former inner territory"* [sic](381)

> *"Hence the aesthetic, immersive paradigm both expresses and retifies a synthetic state of non-representational consciousness in which experiences of the unitive alimentary depths of enchanted being may not be systematically extinguished"* [sic] (386)

Even if one can decipher Nechvatal's comments, it is difficult to tease from them any useful contribution to the clarification of immersive concepts and definitions:

> *"In virtual-immersion potentially unimpeded vast opposing directions lose their position and meet in an enhanced rhizomatic/holonogic cognitive-ocular space of circling connectivity"* [sic] (80)
> *"Examined through the hermeneutic tradition of communicative symbolic interaction, immersions prevalent terriltorialising/ deterritorialising configuration thus far appears to me to be roughly the inscribed parabolic space we saw in the Apse of Lascaux, in Newgranges vault, in the psychic circle of ornament and in the domes and niches of Arabic sacred spaces, in that they all suggest the cultural construction of a rounded geographical/non-geographical sense of an extra-sensory field,*

> *or in other words, a returnable virtual space embedded within an actual location."* [sic] (182)

Of the modest amount of literature available, no one has addressed the notion of immersion *per se,* and this is due to the fact that the debate on immersion in the visual arts has taken place entirely within the framework of interactive VE's and immersive virtual art .

Assessments of immersion in the context of virtual art have so far focussed on technological factors of mediation, human-computer interaction, and the subjective, psychological aspects of experience in a virtual world. From the perspective of artists, (and in theoretical and philosophical analyses of virtual art) immersion and presence, as in other disciplines, are concepts that often overlap, are combined, seen as interchangeable, or one is subverted to the service of the other. For example, the philosophical analysis offered by Laurie McRoberts in *Char Davies: Immersive Virtual Art and the Essence of Spatiality* (2006) implies that presence is a factor of immersion, thus reversing the roles attributed to immersion and presence by Richard Bartle, while combining objective/technological and subjective/psychological factors in her description of what it means to be immersed. Oliver Grau (2003) similarly combines attributes of the two concepts:

> *"Immersion can be an intellectually stimulating process; however, in the present as in the past, in most cases immersion is mentally absorbing and a process, a change, a passage from one mental state to another"* (13)

> *"Immersion arises when artwork and technologically advanced apparatus, message and medium, are perceived to merge inseparably."* (339)

Thus, the visual arts equally contribute to the terminological and conceptual confusion surrounding concepts and definitions of immersion.

3.2.2 A history of immersion

> *"The idea of virtual reality only appears to be without a history; in fact, it rests firmly on historical art traditions, which belong to a discontinuous movement of seeking illusionary vision spaces […] It is surprising that until now so little attention has been paid to it"* (Grau, 2003:339)

Several authors maintain that immersive environments did not appear with the invention of VR technologies. Erkki Huhtamo (1995), Barbara Maria Stafford (2002), Oliver Grau (1999; 2003), Jay David Bolter and Richard Grusin (2000), Joseph Nechvetal (1999), Roy Ascott (2001), Angela Ndalianis (2004) to name just a few have all traced the origins of immersion as a creative medium to traditional panoramas, dioramas, Baroque ceiling paintings, ancient frescos and pre-historic cave environments, all of which are included in a catalogue of precursors to today's virtual art. Although immersion is generally perceived to be a relatively new and technologically contingent medium, according to these and other authors, immersion *per se* is a pre-technological concept. However, although acknowledged as such in the literature, little research has focused on the concept of immersion in a pre-technological context, instead, this notion of immersion has been touched upon only for the purpose of contextualising immersive virtual art.

In *Virtual Art: From illusion to immersion* (2003) Oliver Grau claims that the history of immersion as a creative medium '*has yet to be fully engaged'* (p.12)., and his claim is supported by the sparse amount of information available on the concept, history, and practice of immersion prior to the 1960's, and the advent of virtual technology. Grau's book traces the development of immersive art forms from their pre-technological roots through the 1960's and into the present day, presenting an historical trajectory of an 'ancient pursuit of the ideal form of representation', which, according to Grau, is ultimately achieved with today's virtual art.

Rather than clarifying historical concepts and immersive traditions, Grau tends to focus on technological achievements, such as spherical painting, the panorama, photography, moving pictures, computers, and VR technology that led to today's virtual art. Grau's linear history culminates in the interactive VE's of the 21st century, emphasising the ultimate achievement and creative potential of the human-computer interface:

> *"Besides interactivity, in the virtual work of art it is design of the interface, the intuitive or "natural" interface, that is the main artistic achievement; it may be either emancipative or manipulative for these two alternatives are very closely linked. The interface is the variable point of contact with the computer; its profile and design are freely determined, it connects hard and software, and thus determines the character and dimensions of the interactions and essentially the level of psychological absorption in the digital artwork — the immersion."* (368)

In Grau's historical account, there is a definitive emphasis on interaction, and this is reflected in much of the literature on immersive art:

> *"…it is artists, and not engineers, working with interactive media who explore interface. By employing interaction design to support creative expression artists work to understand this new medium…"* (Rokeby, 1998b: Para2)

Another problem with Grau's survey is the implication that the history of immersion is also a history of illusion. Visual illusion in the arts is a well-researched topic in many fields including philosophy (Richard Gregory, James J. Gibson), art history (E H Gombrich, Richard Gregory), and particularly the visual sciences (Rudolph Arnheim, Nick Wade, Richard Gregory, James J Gibson) with contributions by authors too numerous to mention. Grau fails to define or explain exactly what is meant by illusion or how it is implicated in his understanding of immersion. Peter Lunenfeld (2003) also noted in his review that Grau "*never really defines illusion for us"* (3). This is especially problematic when Grau attempts to draw virtual immersion neatly into the historical trajectory of immersion and illusion in the visual arts by presenting it as the embodiment of both. Grau never offers a clear definition historical immersive concepts and traditions, and tends to oscillate between perceptual/objective and psychological/subjective descriptions, another observation made by Lunenfeld:

> *"[Grau] chops and changes between his understanding of immersion as 1) an effect typically involving "diminishing critical distance to what is shown and increasing emotional involvement in what is happening" and 2) "an intellectually stimulating process. Furthermore, he often uses these two concepts in tandem, and seemingly interchangeably—adding more ambiguity to his terminology."* (3)

As Lunenfeld observes, the terminological and conceptual ambiguity surrounding immersion in other disciplines is also evident in the available literature on immersion in the visual arts:

> *"He goes into fascinating detail about the process involved in the panorama's creation and political objectives, but Grau's argument about immersion is quite muddy and ambiguous."* (3)

Interestingly, Grau's argument only begins to falter at the point where he promotes virtual art as the immersive exemplar and claims it is the quintessential aim of all immersive artists. Although Grau provides a comprehensive and unprecedented[39] body of research on the history of immersion, there is little to no correlation between the historical, pre-technological concepts and practices that he surveys and the immersive virtual art that he champions. This is perhaps because those attributes of immersion that *do* tie historical and contemporary concepts and practices, are to be found

39. Grau's book is the first of its kind in that it surveys the medium of immersion itself rather than the history of cinema or a specific genre of art practice.

in scientific descriptions offered by Slater, Wilbur, and Usoh, which are perceptual (rather than technological) and objective (rather than subjective) in nature.

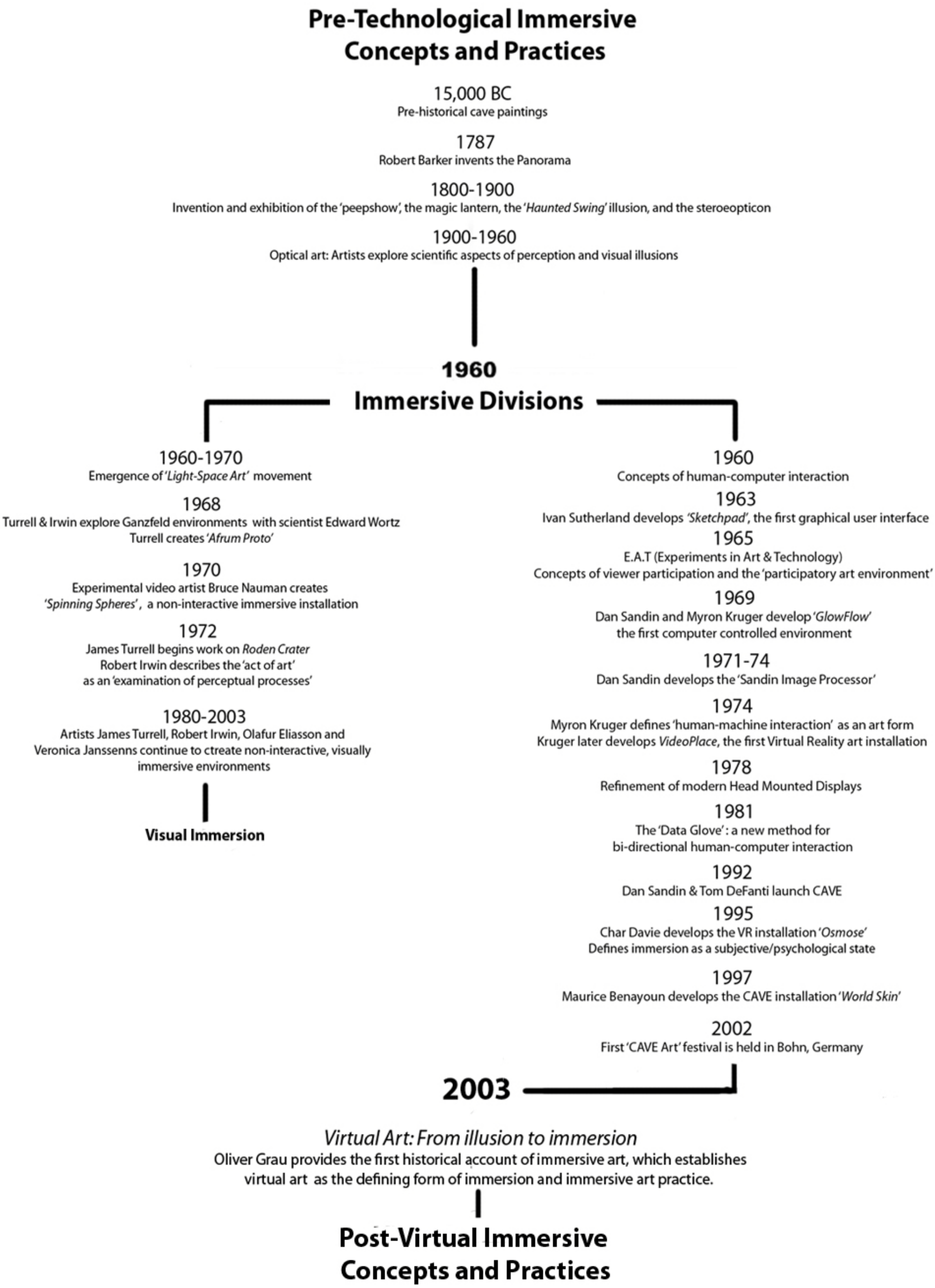

Fig. 25: Diagram showing division in immersive concepts and practices 1960-present

Grau, like most virtual artists, is clearly partial to the technological aspects of human-computer interaction and the subjective psychological aspects of engagement unique to virtual immersion.

It has been argued that immersive virtual art induces a 'dream-like state' (McRobert, Heim, Rheingold) and 'realises new aspects of 'subjective consciousness' (McRobert, Davies, Nechvatal), which elevates virtual artists to a 'shamanistic position in society' (Grau, Nechvatal, McRoberts, Heim). With this in mind, Grau's comments on the empirical sciences and the scientific method, reflecting the perspectives of Nechvatal, Davies, McRoberts and many other artists, comes as no surprise:

> *"The natural sciences 'science of nature', with their tendency to view things from a distance, to 'objectify', represent the opposite of constructing subjects, feelings and dreams"* (324)

Grau calls for a new 'unified knowledge' (325) that he claims is realisable through the merging of immersive art, technology, and the social sciences, which speaks to Grau's socio-technological bias:

> *"The scientistic and conservative outlook that has grown out of theories of Dawkins, and before him the social biologist E.O Wilson are not adequate to meet the needs of the unified knowledge that we require for the future."* (326)

In order to promote his unified knowledge concept, a concept already proposed by Edward O. Wilson in 1999, Grau necessarily attempts to connect the empirical sciences with the visual arts, and his connection is noticeably weak and perfunctory:

> *"Science is, in its mechanisms and methods, in its systems of truth and proof, a social construct. Art is too, and in this sense they are comparable."* (325)

Grau is not alone in his contempt for the methods of empirical science, which, I believe, is an unfortunate consequence of the two cultures divide that is endemic in the field of visual art practice:

> *"Especially in as much as I am involved in the humanities, I am reluctant to model my conclusive methodology on a mechanistic model of an earlier power-oriented science, even though the philosopher Werner Heisenberg maintained that the difference between art and science are minimised if one views both art and science from the more general vantage point of the zeitgeist. This emerging and theoretical paradigm makes no pretensions to scientific methodology as it, by its very nature, must retain its speculative character because of the impossibility of attaining conclusive omnijective immersive experimental data"* (Nechvetal, 1999: 373)

Unlike the allegedly opposed worlds of immersive art and the empirical sciences, immersive art and virtual technology are intimately interconnected. Reflecting the manifestos of their mid-twentieth century predecessors, the liaison between virtual art and virtual technology is a recurring topic in the literature. Artist and theorist Roy Ascott, like engineer Billy Kluver, envisaged this relationship forty years ago:

> *"Technology...is not only changing our world, it is presenting us with qualities of experience and modes of perception which radically alter our conception of it. The artist's moral responsibility demands that he should attempt to understand these changes."* (Ascott, 1964:37)

As Frank Popper (1995) observed over forty years later, virtual artists are as committed to the development of their technological medium as they are to the art environments they create:

> *"What is new about virtual art is its humanisation of technology, its emphasis on interactivity, its philosophical investigation of the real and the virtual, and its multisensory nature. […] What distinguishes the artists who practice virtual art is their combined commitment to aesthetics and technology"* (xxii)

Virtual art is contingent upon virtual technology, which is why virtual artists work in collaboration with VR technologists, and why most have acquired the technological skills and experience necessary to realise their work. Unlike the anti-scientific perspectives that are a logical consequence of the two cultures divide, the continued affair between virtual technology and virtual art is a logical consequence of the VR technologies required to create VE's. The problem is that virtual art and virtual technology have become so enmeshed with the concept of immersion, that historical immersive concepts and traditions have been overshadowed in a newly emerging body of literature on immersive art. This is especially evident in *Virtual Art: From illusion to immersion,* which is currently credited as the first comprehensive historical account of immersion as a creative medium; however, it is ultimately the story of virtual art.

Grau has provided an authoritative but as yet unchallenged account of the history of immersion and the goals of immersive art. As such, his work has been cited in several subsequent publications and academic papers that serve to strengthen the association of immersion with interaction, VR technology, and immersive virtual art environments. Grau has thus taken a seminal role in shaping a new body of literature on immersion as a contemporary art medium, however he fails to acknowledge and fully explore two significant areas relevant to his own and to this thesis. The first is the value of the scientific studies of perception to the theory and practice of immersive art; the second concerns a genre of contemporary art that perpetuates the historical immersive traditions that Grau originally sets out to promote.

3.3 Summary of the Literature

In summary, the discipline specific concepts and definitions of immersion presented above offer an analysis of immersion as either a subjective/psychological experience (Holland, Laurel, Witmer and Singer, Nechvetal, McRobert, Grau, Davies) or as an objective/perceptual condition (Ryan, Slater and Wilbur, Meister, Bordwell, Anderson, Tan). Both schools offer valid assessments and definitions of immersion in the context of their respective areas of study, one describing the conscious, subjective, and psychological experience, and one describing a sub-conscious, objective, and perceptually determined condition. The former is a view largely held by those in the creative and humanities disciplines, and the latter view is generally held by those in technological and scientific fields, which raises three points of interest with regard to this research.

First, comparing pre-technological immersive concepts and traditions with contemporary concepts of virtual art raises questions as to how, and why, the concept of immersion became enmeshed with concepts of virtual interaction, when the continuous thread linking immersive environments today and throughout history are the objective, perceptual factors required for immersion that are present in all immersive environments.

Second, in other disciplines, the debate on immersion takes place between two schools of thought that revolve around either a perceptual/objective or psychological/subjective model; however, in the visual arts, debates on immersion revolve around the latter alone. Again, this is because immersion is strongly associated with interaction, VR technology, and virtual art, and is perceived and assessed in relation to psychological, subjective aspects of engagement in virtual art worlds. From this perspective, like psychological descriptions of immersion in literature, film, and 3D video games, immersion is more aptly described by the presence concept. Therefore, beyond its function as facilitator of presence, a perceptual/objective model of immersion *per se*, or ‘visual immersion’, has yet to be articulated and addressed in the literature. The visual immersive artists presented in chapter two, and the objective/perceptual schools of thought in other disciplines presented above, testify to the need for such a model if we are to develop a broader understanding of immersion, and a more comprehensive account of immersive art practice.

Third, the relationship between virtual art and technology is patently clear in both the literature on immersion and in virtual art practice, which has been dominated by a succession of technically qualified and technologically proficient artists ever since concepts of virtual immersion emerged in the 1960’s. It is also clear that this relationship does not extend to the scientific disciplines, even though current interests and incentives have encouraged and promoted this relationship over the past ten years. A perceptual model of visual immersion offers a different perspective on the relationship of art and science, because visual immersive art necessarily engages the knowledge and methods of visual science rather than the knowledge and methods of virtual technology. With the aim of addressing this gap in the literature and developing an objective/perceptual model of immersion, and defining and distinguishing the unique concepts of immersion described in chapter 2, the research adopted a collaborative methodology engaging visual immersive art and visual science.

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Chapter 4: Methodology

Introduction

> *"It is probably quite generally known that in the history of human thinking the most fruitful developments frequently take place at those points where two different lines of thought meet. These lines may have their roots in quite different parts of human culture: hence if they actually meet, then one may hope that new and interesting developments may follow."*
>
> Werner Heisenberg

Visual artist and researcher Beryl Graham of the Glasgow School of Art compares research methods in the creative disciplines to the methods of engineering and experimental science:

> *"Art-practice PhDs involve the making of artwork by the researcher, as a major part of the research process, and may be strongly related to other PhDs involving practice, such as engineering, or experimental science."* (Graham 2006: 6)

Research theses in the experimental sciences and engineering disciplines usually describe details of the practical experiments undertaken, for example, 'the experiment measured the responses of 20 subjects in both indoor and outdoor conditions….', and may include images of the experimental set up, and/or visual representations of data in the form of graphs, charts, or diagrams. This aspect of scientific and engineering research is what Graham likens to a visual arts thesis:

> *"Writing a thesis demands substantial writing skills, but for artists, engineers and scientists, it can also demand the coherent display of visual information."* (ibid)

A key difference between the methods of creative and scientific disciplines is that in the latter, experimental rules and procedures are already established, and appropriate methods are already laid out prior to a practical experiment taking place, whereas creative experimentation is much less methodical, evolving in unpredictable, often intuited patterns. Whereas established academic disciplines benefit from an accumulated body of knowledge, established rules of practice, and proven methodological models, in the visual arts, academic research is still in its infancy and no such guidelines or models are available to visual arts researchers. Furthermore, there is also some debate as to whether predefined methods would be appropriate for research in the visual arts, as Graham also notes:

> *"Art practice research methods are by no means so established and to commit to predefined methods contradicts the very nature of creative practice."* (5)

Unlike research methods in science and engineering, in the visual arts, articulating a specific research method is perhaps where the biggest difficulty lies. Beryl Graham notes in her practice-led thesis (1997),

> *"The production of the artwork did not set out to keep to a certain methodology, but the method was set by need. […] These [methods] are explored as they arose from notes in the production diaries, and ideas on method changed at different points."* (224)

Similarly, in this study, the research methodology was necessarily vague from the outset, evolving intuitively around two clear preliminary objectives. The first was to become familiar with current research topics and practices in the visual sciences. The second was to develop ways of combining creative and scientific methods in the production of visual immersive environments.

4.1 The Methods of Art and Science

We often hear reference to the aesthetic qualities of scientific images, and they are increasingly featured in art exhibitions such as SF MOMA's *microMODERN* (2003)[40], which was comprised solely of images produced by researchers in the medical and biological sciences. The field of scientific imaging is largely believed to be a point of confluence in art and science disciplines. However, there was no requirement for the scientists involved in *microMODERN* to have any knowledge of visual art, because visual images, regardless of their origin or purpose, belong to the realm of art and are perceived as art when placed in the context of art. This is because as a discipline, the visual arts have no rules for determining what art should or should not be, nor any methods for establishing whether a particular image is art or is not. Therefore, it is possible for scientific images to be perceived as art, and qualify as art, simply by being placed in an art context. In the realm of science however, there is a clear understanding of what constitutes science, and there are established methods to determine whether something is science or is not. Therefore, while allusion to the aesthetic value of scientific images goes unquestioned, artworks are rarely noted for their scientific value, even though artists explore scientific concepts in their work.

Many artists have little knowledge of science or scientific methods, and, although by no means exclusive to the visual arts, artists often confuse science with technology, or perceive the technological tools of science as constitutive of the scientific subject itself[41]. More often than not, the extent of an artist's

40. See http://www.sfmoma.com/micromodern.html [Accessed 05/09/07]
41. See chapter 1, section 1.7 for a definition of science and technology

engagement with science is the use of scientific images and research topics as raw material for creative expression, or the use of the technological tools of science for the production of artworks. This is no different than the scientist creating, as a product of scientific research, aesthetically pleasing images. Artists too have no particular obligation or need to understand the discipline of science, or to use it correctly and with respect. However, to place artworks in the context of science does not assure them scientific justification, nor guarantee that they will be perceived as scientific work. This is because for something to qualify as science it must meet the requirements of the discipline, and reflect an accumulated body of knowledge and established disciplinary rules that are unambiguous and implicitly understood by all members of a scientific community. An artwork must therefore convey scientific knowledge and comply with established scientific laws and principles if it is to qualify as science, or be perceived as scientific work.

Today, it is generally believed that the practice of art and the project of science are fundamentally opposed (Kuhn, 1962). Ever since C P Snow first coined the ‘two cultures’ phrase in 1959 (Snow, 1963), art and science have been progressively alienated in the ensuing ‘Culture Wars’[42] (Sokal and Brickmont, 2001). Although artists belong to neither faction, as an academic discipline, the visual arts have been systematically placed under the umbrella of the humanities, and are presumed to advocate a postmodern, even anti-scientific position. This, coupled with the fact that science involves established methods and rules of practice that are foreign to the creative disciplines, serves to make collaborative and interdisciplinary exchange even more

42. Also known in the US as the ‘*Science Wars*’. In his original lecture, Snow referred to a lack of communication between the empirical sciences and the *humanities,* rather than *art* and *science*.

problematic. This is not to say that the disciplinary boundaries of art and science cannot, or have not, been breached before. Typically, scientists are seen as wanting to predict and control, and artists as wanting to avoid being predictable or producing work that is controlled by the tools and methods they use. However, like artists, scientists also strive to transcend their tools; their aim is not to generate more data that fits existing models, just as artists do not aim to produce more of the same objects that have already been made by others. Contrary to popular perceptions, scientists seek out the exception to the rule, and in discovering anomalies that cannot be explained by existing theories they then have to think creatively in order to devise a new principle or theory that will explain it:

> *"Indeed, in any science, while the requisite objectivity forbids wishful thinking, prejudicial reading of evidence, rejection of unwanted results, avoidance of ominous lines of inquiry, it does not forbid use of feeling in exploration and discovery, the impetus of inspiration and curiosity, or the cues given by excitement over intriguing problems and promising hypotheses"* (Goodman: 251).

Artists follow a similar process, experimenting with various tools and techniques until the desired result is achieved. The methodological aim of this study was to identify and capitalise on confluent interests, aims, and methods in art and science, and this influenced initial contextual methods.

4.2 Contextual Methods

In chapter two, it was explained that immersive art is generally associated with VR technology and interactive virtual art environments. It was proposed that certain contemporary artworks, which employ neither interaction nor virtual technology, embody a type of visual immersion that is founded on the scientific laws and principles of vision. In chapter three, an overview of the literature on immersion in other disciplines revealed two schools of thought that revolve around objective/perceptual and subjective/psychological models. The literature also revealed that as a consequence of the strong association of immersion with interactive VR technology, the former model is not available in the context of visual art.

With the aim of developing such a model, contextual methods proceeded along two lines of investigation. The first involved a study of perceptual phenomena in the context of experiments in the vision sciences. The rationale behind this line of enquiry was twofold, the first being to test the hypothesis that visual science and visual immersive art share confluent aims and experimental methods, and the second being to gain a scientific understanding of the perceptual phenomena at work in immersive environments. To this end, a schedule of vision science conferences in the US, Canada, Europe, and the UK were attended over a two-year period, beginning with the 2002 European Conference on Visual Perception (ECVP) in Glasgow, Scotland. A second line of investigation involved a study of pre-technological concepts of immersion and historical immersive art environments, its purpose also being twofold. The first was to identify and define a pre-technological concept of visual immersion that, as proposed in chapter two, is embodied in historical immersive environments throughout history and in certain contemporary artworks, including my own. The second was to identify the perceptual factors of immersion common to all immersive environments, including contemporary visual and virtual immersive art, in order to establish and define the perceptual factors and basis of immersion *per se*.

4.3 Applied Methods

As practice-based research, applied methods revolved around creative practice, which necessarily evolved intuitively but was influenced and took direction from information concurrently gathered through contextual studies described above. Initial studies were conducted that involved the design of architectural enclosures to house multiple moving image projections. These works resolved some of the practical issues associated with large-scale projections, and provided experimental environments for gauging the immersive effect of visual images alone. Over the course of the research period, these enclosures were refined to accommodate various perceptual experiments, which were modelled on existing scientific experiments. A final work was created in collaboration with visual scientists, which was devised to demonstrate the proposed factors immersion identified over the course of the research, and to accommodate scientific experiments on perception.

4.4 Justification for the Methodology

> *"Intellectual cross-pressures generated by an interdisciplinary outlook liberate a person's thinking from the limiting assumptions of his own professional group, and stimulate fresh vision."* (Milgram, 1969: 103).

4.4.1 Art and science

With regard to a collaborative art and science methodology, the justification is threefold.

First, many art and science collaborations involve scientific fields such as physics, biology, medical science and nanotechnology. Vision scientists have explored perceptual phenomena in artworks ever since the disciplines inception over a hundred years ago (Howard, 2002a), however, few of the organised art and science collaborations to date have connected visual art with visual science, and few artists have ventured to understand the science of visual perception.

Second, visual artists have historically used visual and perceptual phenomena to achieve visual effect, and vision scientists have used the work of artists to explore the perceptual phenomena these works demonstrate. Confluent interests in, and the exploration of, perception and perceptual phenomena, have therefore taken place concurrently, but separately, in the divided communities of the two cultures.

Third, the exchanges between vision science and visual art have historically focussed on two-dimensional art forms. This methodology focuses on perceptual phenomena in three-dimensional artworks, thus broadening the scope for future scientific studies of art and art and science collaborations.

4.4.2 Immersion and immersive art

With regard to concepts and theories of immersion and immersive art, justification for the methodology is threefold:

First, immersive art is strongly associated with VR technology and interactive VE's, yet pre-technological immersive environments generate immersion using only the faculty of visual perception. Perceptual factors are what connect pre-technological and virtual immersive art environments, yet these factors have yet to be investigated and defined.

Second, current art theoretical debates consider immersion only in the context of interactive VE's, yet historical immersive environments are neither virtual nor interactive, therefore it cannot be claimed that immersion is a product of interaction or virtual technology. Embodying only visual and perceptual factors, contemporary visual immersive art reflects an objective/perceptual model of immersion *per se* that is founded on the scientific laws and principles of vision, therefore the visual sciences can potentially shed light on the perceptual factors at work in immersive environments, and contribute to a broader understanding of the creative medium of immersion.

Third, as was explained above, in visual arts research the methodology develops intuitively from an original idea or insight, and is further refined as practical and theoretical work develops. A collaborative art and science research methodology was founded on the conviction that visual immersion occurs at the interstices of visual art and visual science, where the boundaries of art and science are perhaps at their weakest.

4.5 Summary

For visual artists, visual illusions provide a useful tool for generating visual effect, and for visual scientists the same illusions offer clues as to how vision works by revealing how vision fails. Many scientists have studied the perceptual phenomena that artworks, such as the paintings of Bridget Riley and Victor Vasarely, generate. Similarly, scientific aspects of perception are employed by artists to achieve certain visual effect. Biological scientist Margaret Livingstone has argued that Mondrian's *Broadway Boogie Woogie* (1925) generates an effect "*…skilfully obtained by casting yellow borders in low luminance contrast on a white background."* (Livingstone, 1988:73). In a recent issue of the *Journal of Consciousness Studies,* Joseph Goguen makes a similar observation:

> *"Alternatively, artists might not only be exploiting the visual system positively, but also taking advantage of some of its 'shortcomings' in order to obtain some effect or other."* (Goguen, 2001: 10)

In Simulated and Virtual Realities: Elements of Perception (1995), Karen Carr proposes that:

> *"Virtual reality is a perceptual experience, achieved using technology. Anyone wishing to develop virtual reality should understand the human perceptual processes with which the technology seeks to interact and control."* (4)

Similarly, this research proposes that visual immersion is a perceptual condition, and artists wishing to create visual immersive environments should understand the human perceptual processes that give rise to this condition. In his review of Joseph Anderson's *The Reality of Illusion: An Ecological Approach to Cognitive Film Theory*, David Large (1996) claims:

> *"…there is at least one other side to be considered, namely the empirical, or reality based approach of Experimental and*

> *Cognitive Psychology. Researchers in these areas look not at the effect technology is having on reality and illusion but rather at the way in which technology can be used to tell us more about reality where illusion is taken to be part of that reality."* (172)

As Large points out, researchers in experimental and cognitive psychology look at the ways that technology can be used '*to tell us more about reality where illusion is taken to be part of that reality'.* Visual immersion is an illusion that is also part of reality, and visual immersive artists and visual scientists look at the ways that perceptual phenomena explore that part of reality.

According to currently available literature, concepts, theories, and debates on immersion in the context of visual art revolve exclusively around virtual models. This model is representative of a subjective/psychological school of thought that considers and emphasises technological aspects of human-computer interaction, and subjective, psychological aspects of experience in virtual worlds as key immersive factors. In other disciplines, this model is countered by an objective/perceptual school of thought that applies to more traditional, non-interactive medium and type of practice within each field. This model of immersion is based on objective factors of human perception, and employs neither interaction nor virtual technology. Unlike other disciplines, the visual arts do not offer such a model, even though a pre-technological, perceptual model of immersion is embodied in immersive environments throughout history, and perpetuated in the works of contemporary artists such as James Turrell, Olafur Eliasson, and Veronica Janssens that are founded on the scientific laws and principles of vision. Collectively, these works and others like them represent a model of immersion and a genre of immersive art practice that has yet to be defined.

Visual immersive art and visual science provide an arena for interdisciplinary research and collaborative practice that can potentially benefit both fields. In these areas, art and science implement the same tools of perception, albeit for different ends, in a process that is both scientific and creative. The collaborative art and science methodology developed over the course of this research was the result of an initial hypothesis that visual immersive art and visual share confluent aims and experimental methods. Finding ways to build on these confluences and to combine scientific and creative knowledge and resources in the production of artworks was both the methodological aim and a large part of the motivation for the research itself. The intent was to permit the research process to emerge naturally, through the process of creative practice. The practical work described in the following chapter both influenced, and was influenced by, the collaborative process that evolved.

Chapter 5: Practice

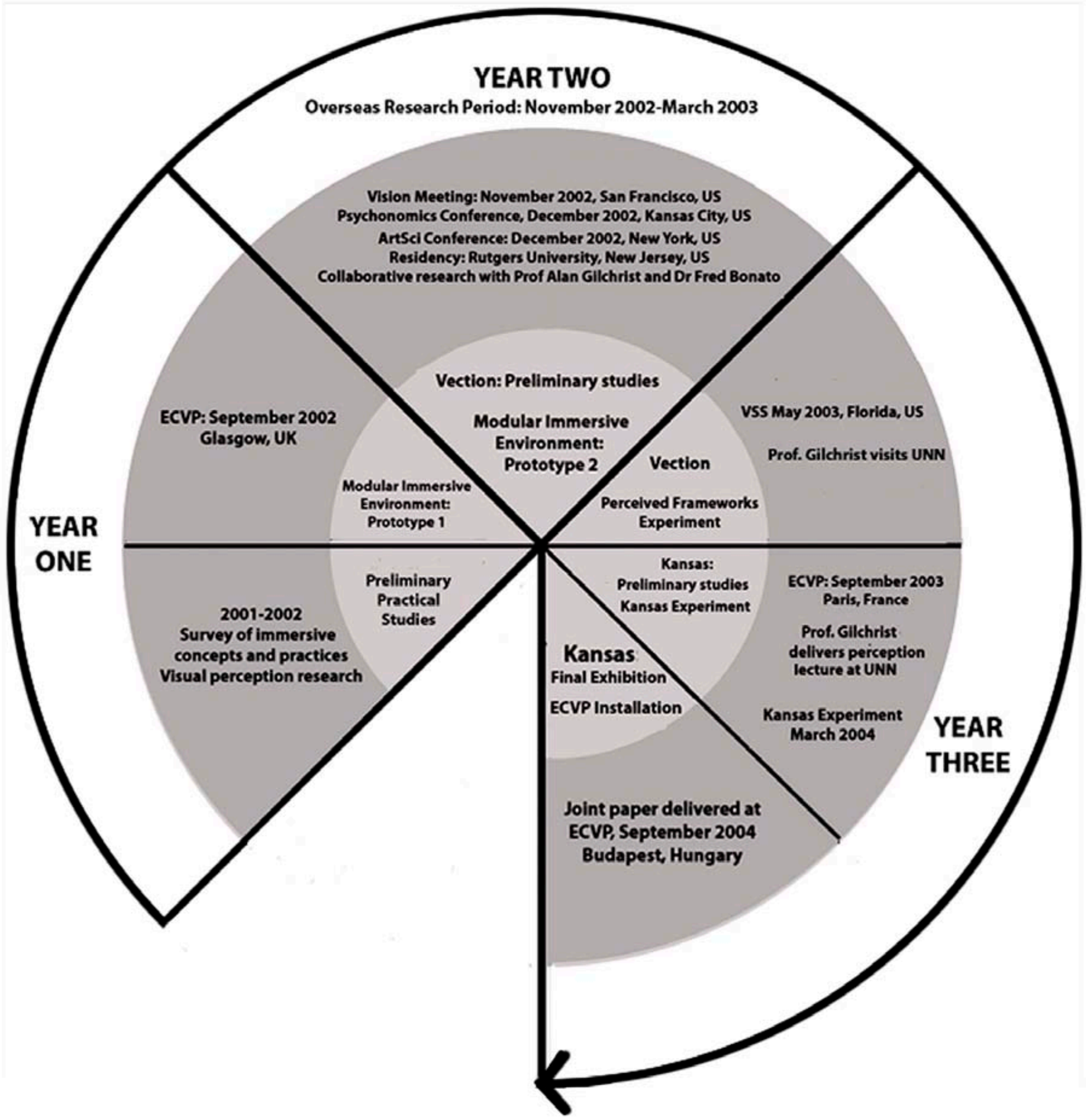


Fig. 24
Diagram showing research process and development of practical works

Introduction

Preliminary practical work developed alongside a concurrent study of research in the visual sciences; the influence of the latter being reflected in a series of experimental environments created over the research period. Three of these works, *Modular Immersive Environment* (MIE), *Vection*, and *Kansas*, are described in this chapter. The first, *MIE*, emerged from preliminary designs for experimental enclosures that could house multiple projected images, and was modified and reworked into various configurations throughout the course of the research. The second, *Vection*, takes its name and inspiration from a scientific apparatus used for experiments on self-motion perception. *Vection* developed from studies of self-motion and the research of vision scientist Dr Fred Bonato of St James College, NJ, US. *Vection* was a remodelled scientific apparatus installed in the context of visual art, which was later selected for the international art exhibition *Intersculpt* in 2004. The final work, *Kansas*, was developed in collaboration with vision scientists Dr Alan Gilchrist (Rutgers University, NJ, US) and Dr James Intriligator (University of Bangor, Wales), and involved the design and construction of a visual immersive art installation that also functioned as a scientific experimental apparatus.

A scientific and aesthetic assessment of this work draws on established psychophysical evaluation methods, using degrees of balance as a quantitative measure of immersion (the aesthetic experiment) and of perceived frameworks (the scientific experiment). Whereas *Vection* was taken from a scientific context and placed in the context of art, *Kansas* was originally devised and exhibited as an art installation, and subsequently placed in a scientific context as part of a joint paper delivered at the 2004 European Conference on Visual Perception (ECVP), in Budapest, Hungary. This chapter describes each installation and the process involved in their development.

5.1 Modular Immersive Environment (MIE)

Fig. 27
Studies for a modular immersive environment (2001-2002)

The objective of initial practical studies was to design and construct architectural enclosures and to explore the different ways they might accommodate fully surrounding images, the aim being to determine if, and how visual stimuli alone can generate the experience of immersion. The intent was to make portable immersive enclosures that could be erected and disassembled easily and quickly. This would ensure consistent experimental conditions, whilst various technical issues, including limited projector throw distances, materials, and installation space requirements, would only have to be addressed once. Thus, a portable experimental enclosure that could house fully surrounding moving images was a logical practical starting point.

5.1.1 MIE Prototype 1

Pre-fabricated products, including collapsible exhibition displays, tents, gazebos, awnings, small garden sheds and greenhouses, provided ideas and concepts for single occupant cubicles, umbrella shaped tensile structures, and ‘phone-box’ type booths, with some commercially available products being modified to fit requirements. Whilst these studies were ongoing, a full-scale prototype was constructed based on the proportions of the existing CAVE™ apparatus. The first environment (MIE1) was constructed from timber and cotton sheeting and comprised three walls and a ceiling, providing a total of four possible projection surfaces.

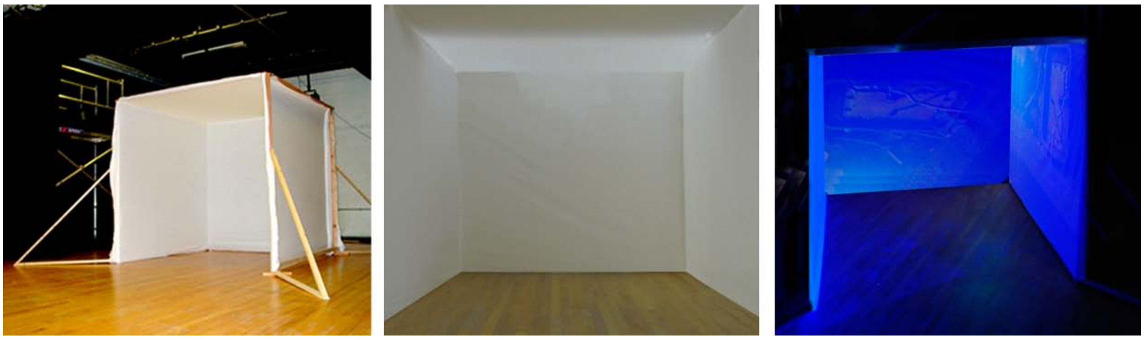


Fig. 28
MIE Prototype 1: (2002) Wood, cotton sheeting, steel cable

Two computer-generated image sequences were created using 3D Studio Max™ software, one showing linear motion (as if moving through a tunnel) and one rotational motion (as if inside a rolling ball). These were rendered as three separate but coordinated animations, which were then rear projected onto the walls and ceiling.

Fig. 29
MIE prototype 1: Animation studies (tunnel concept/linear motion)

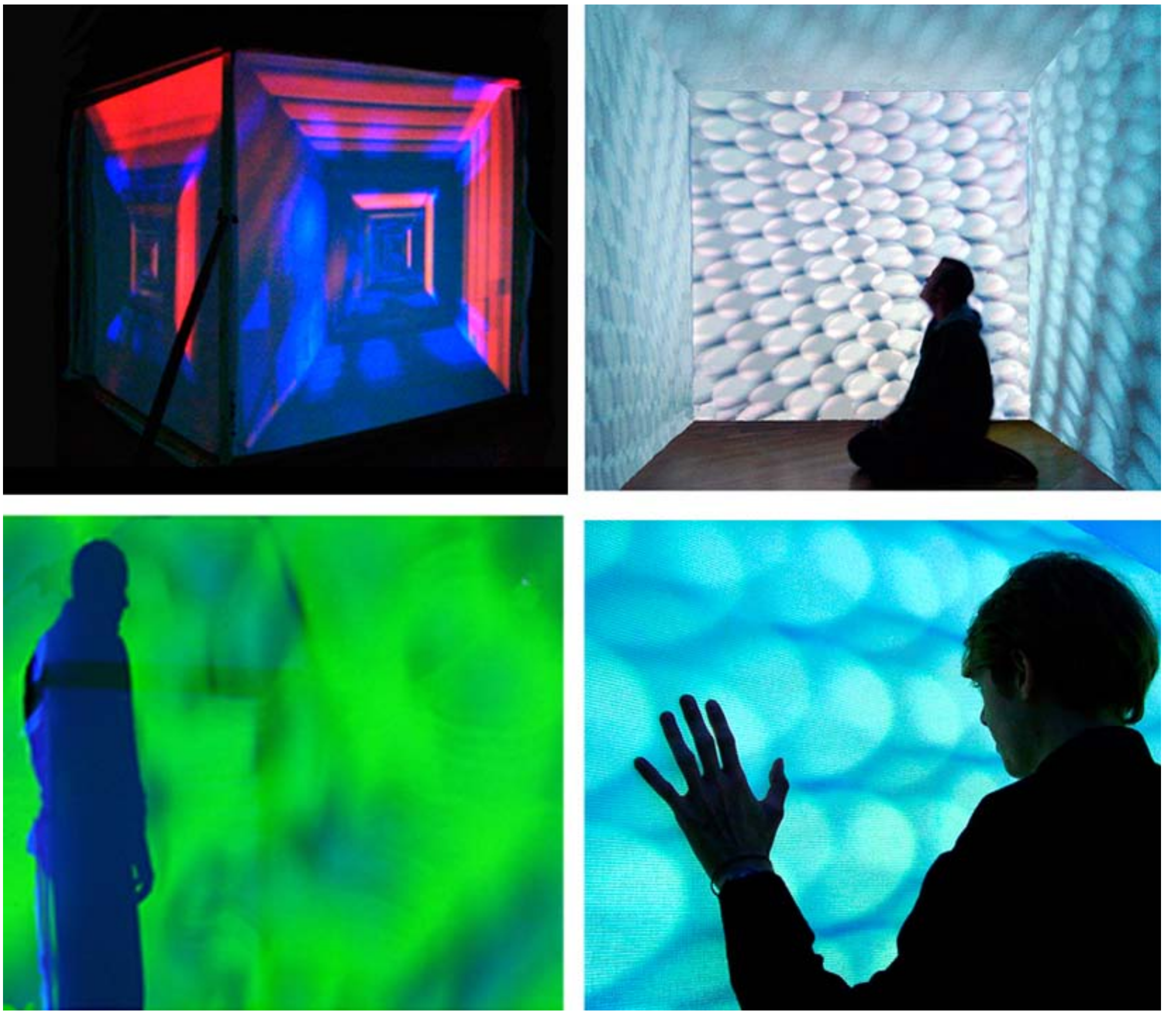


Fig. 30
MIE Prototype 1: Full-scale projection studies
Top left: Linear motion Top right: Rotational motion

Several technical problems were realised with prototype 1. The first involved making the image appear seamless, which meant that structural elements could not encroach into the path of the projection. The images at the corner seams could not be seen to bleed or overlap into the adjacent projection, therefore each image had to be isolated but remain aligned. Video synchronising equipment was also required to make multiple projections appear as one continuous image, and the projectors available at the time required a throw distance of at least five metres to achieve a diagonal image of 2.5 meters. To resolve this, mirrors had to be used to effectively double the image size in half the distance. The 'hotspot' from the projector lamp was visible through the cotton sheeting, which could only be resolved by using professional rear projection fabric, and finally, creating co-ordinated animations involved lengthy video editing processes. These issues were addressed in a second prototype, an aluminium-framed, soundproof, and lightproof modular structure.

5.1.2 MIE Prototype 2

Prototype 2, also a 2.5 metre cube, was made from lengths of 25 mm aluminium box section. Rear projection fabric[43] was stretched tight around the aluminium structure using turnbuckles, steel cable, and aluminium tubing to form a continuous projection surface with no visible corner seams. The unit housed three projectors, one for each wall, and a possible fourth could be ceiling mounted.

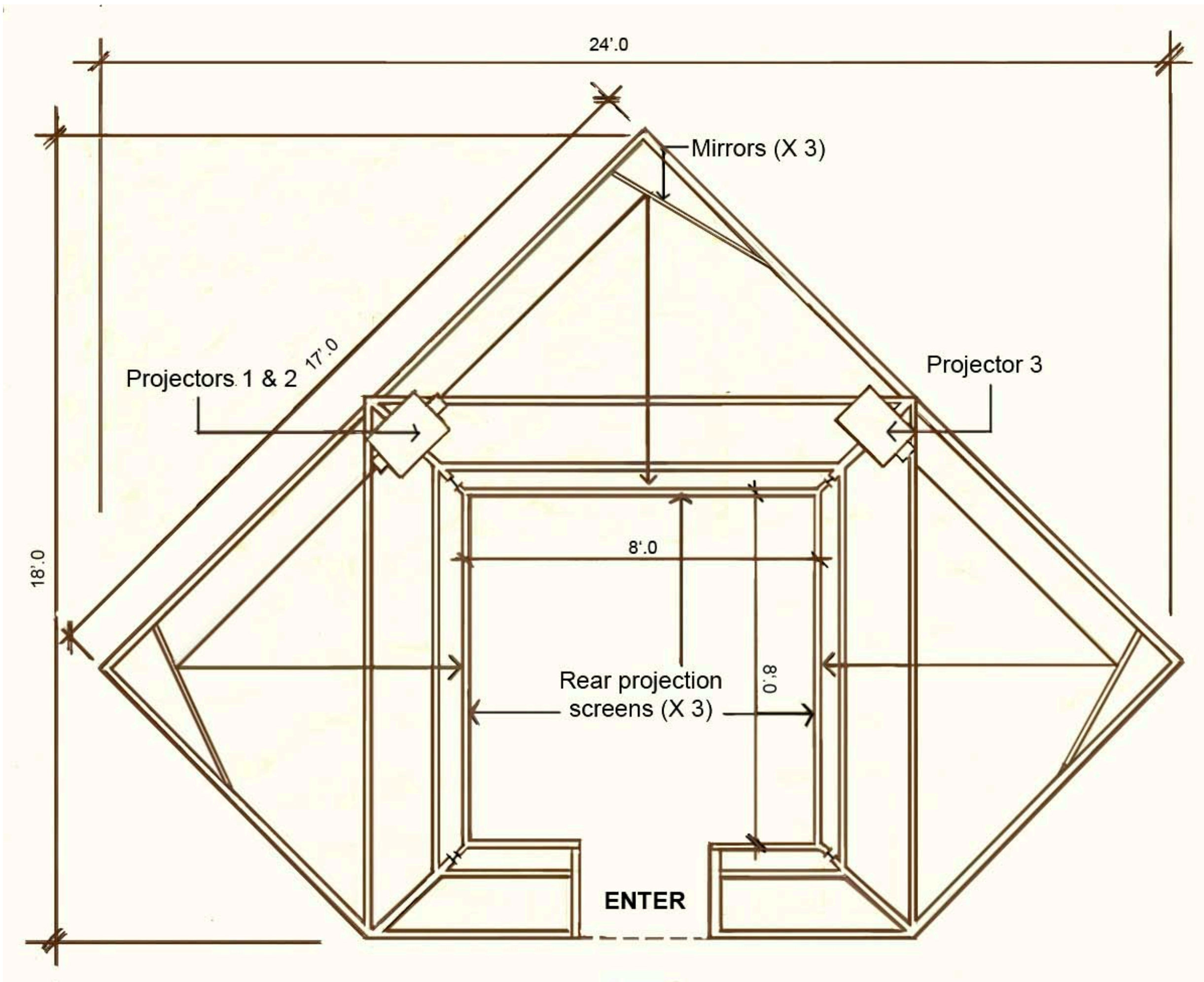


Fig. 30
MIE Prototype 2 Floor Plan: 1:125

43. For this prototype, DayLite ™ professional rear projection fabric was used.

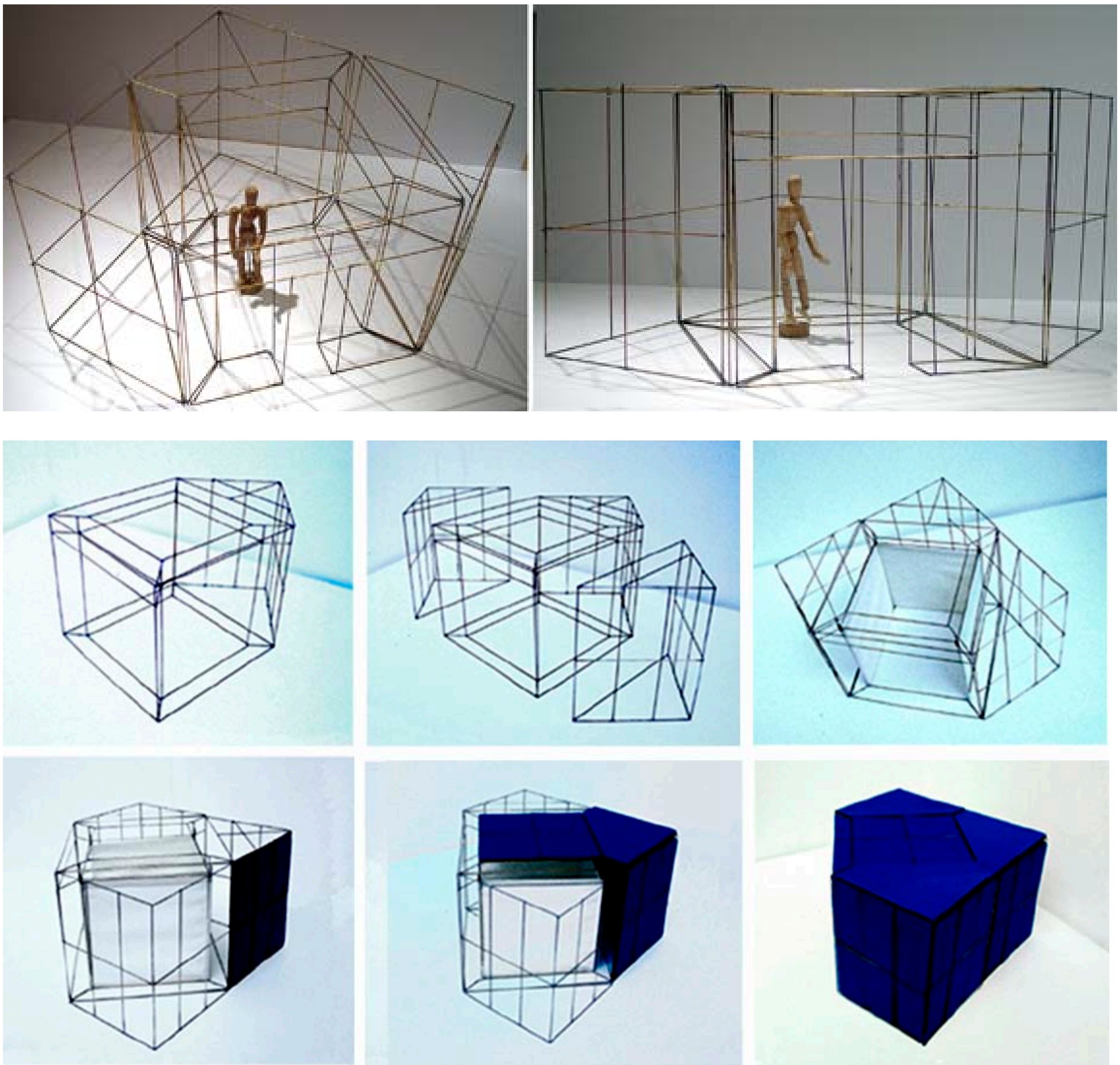


Fig. 32
MIE Prototype 2 Scale model: 1:125
Modular aluminium framework with sound and lightproof panels

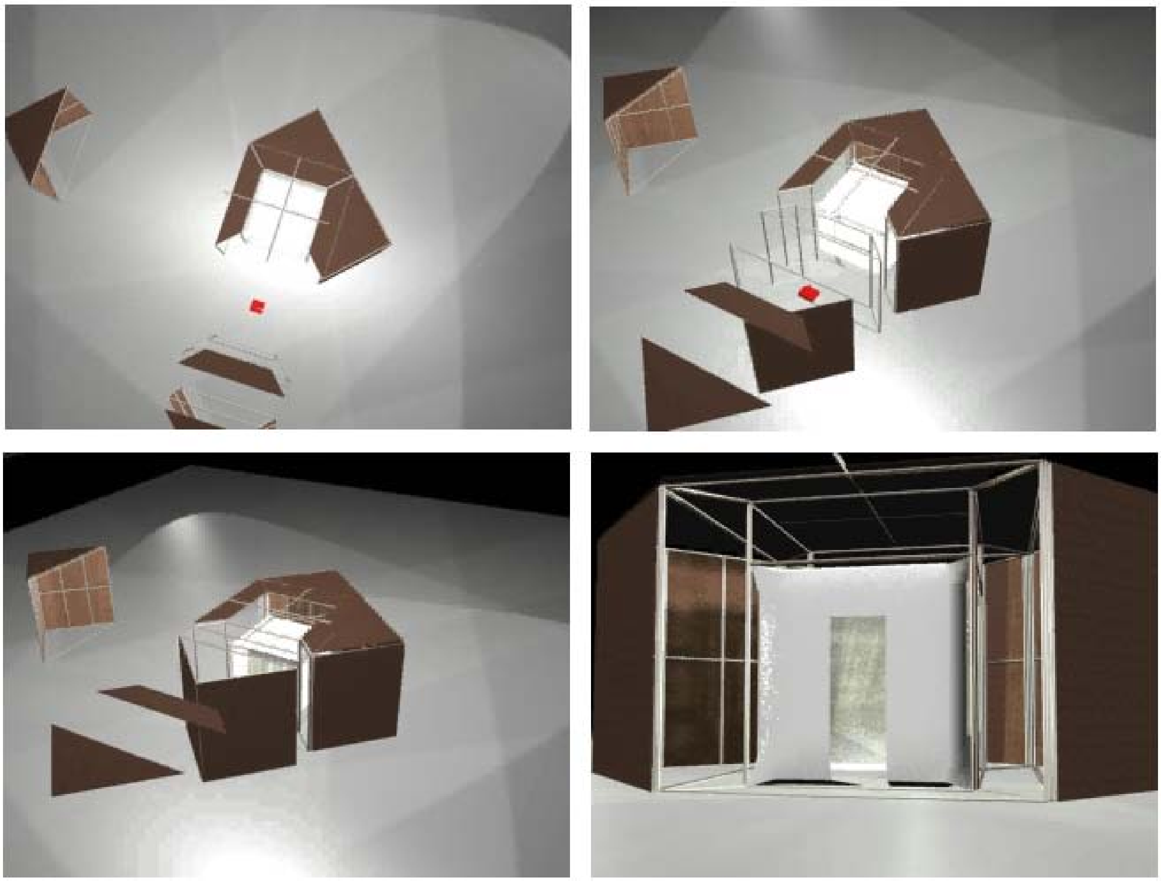


Fig. 33
MIE Prototype 2: Animation stills showing modular construction and assembly sequence

Fig. 34
MIE2: Full scale aluminium framework with three rear projection screens

This version of MIE was reconfigured for the video installation *Interlace* (2003) by Durham based artist Claire Davies, which was exhibited at the Globe Gallery, Newcastle, in June 2003. For *Interlace*, three video clips, three DVD players, and three digital projectors were connected to a single synchronising device[44] that made the three projections appear as one continuous image. In this work, the image content is actual footage (taken with a macro lens) of twine (or wool) being slowly wrapped around three adjacent 30cm square boards. With *Interlace,* the illusion of a fully surrounding and seamless image was successfully achieved, but this required exact synchronisation because at any given time only one strand of twine is in motion, and can be followed as it passes from one screen to the next.

44. A Dataton™ video synchroniser was leased for the duration of the exhibition.

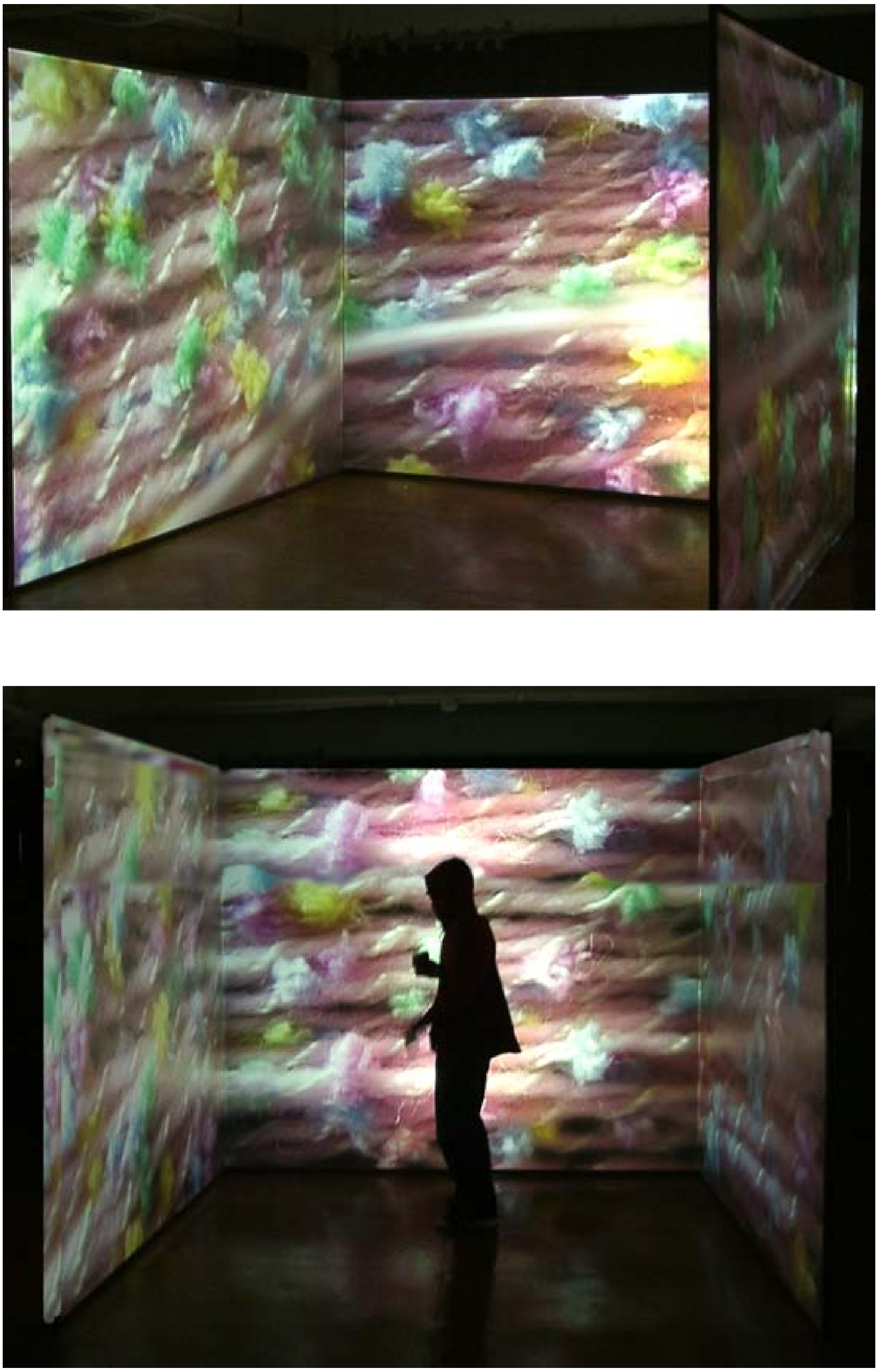


Fig. 34
Claire Davies: *Interlace* (2003) Multiple video installation

The FOV factor had been a key consideration in these studies, the aim being to generate some type of 'perceptual effect' using fully surrounding images, it was hoped that *MIE* and *Interlace* would generate some level of perceptual disorientation. Several people observed a series of images in *MIE* and in *Interlace*. In the former, there were reports of an initial sense of disorientation that lasted just a few seconds, however there were no reports of disorientation from observers with *Interlace*. It was concluded that the reason for this was that *Interlace* did not have image motion on all three screens at once; instead, there was a slowly moving focus point that observers would follow from one screen to the next. In effect, this was like watching three different videos, as observers were free to move around and focus on the screen showing motion at any given time.

Although the determining factors of immersion, and how or if immersion could be measured or gauged in these works was not yet clear, it was decided that for the majority of viewers, *MIE* and *Interlace* did not constitute an 'immersive experience'. *MIE* therefore proved to be a useful video exhibition apparatus for housing single and multiple image projections, but proved unsatisfactory as an immersive environment. In summary, although the experience of immersion in the MIE prototypes and in *Interlace* proved unsatisfactory, the desire for a level of disorientation proved useful in establishing a second critical immersive factor 'physiological effect'.

5.2 Critical Immersive Factors

5.2.1 FOV factor

We know that immersion depends to some degree on visual factors, and that one of these factors is a visual stimulus that fills the entire FOV (Slater, 1999; Grau, 2003)[45]. This immersive factor is best demonstrated using a ganzfeld apparatus[46], the effect of which can be demonstrated quite easily. A common method is to cut a ping-pong ball in half and place one half over each eye. The reason this works is that now the FOV has been greatly reduced, precisely to the size of the ball's hemispherical interior (about four centimetres in diameter). Thus, the tiny interior of half a ping-pong ball, as shown below, is able to completely fill a person's FOV.

Fig. 34
Encompassing the FOV using ping pong balls

This is the reason why the HMD is so effective. The small images inside the HMD are able to encompass the entire FOV because it has been greatly

45. See Chapter 1.7 for a definition of FOV.
46. The term 'ganzfeld' translates from German as 'whole field' and literally means 'whole field of view'. See Oettermann (1997).

reduced[47]. The traditional panorama and today's CAVE environments employ a different strategy; where the FOV is encompassed by a real world environment that is integrated with the illusory world. Although achieved using different methods, a fully surrounding visual stimulus encompassing the entire FOV, which is evidenced in immersive environments throughout history including virtual art forms, is the first critical immersive factor.

5.2.2 Physiological Effect

> *"Every aspect of a visual experience has its physiological counterpart in the nervous system."* (Arnheim, 1974:17)

Scientists Mel Slater and Fred Previc have investigated physiological effects in VE's and flight simulators, and explain that while a participant may be immersed in a VE, they are always aware that they physically remain in the real world environment. There are also real world clues such as gravitational forces, even though conditions in the illusory world may contradict them, to remind participants that they remain on real world ground (Slater, 1998; Previc, 2000)

Fig. 35
Left: Participant in Char Davies installation *Osmose* (1995) Right: VE participant (the author) at Brown University's *VisLab*, Rhode Island, US

The above left image shows a participant in Char Davies virtual art installation *Osmose* (1995). The right image shows the same HMD apparatus used at Brown University's *VisLab*, Rhode Island, US, for scientific studies of perception in VE's. The scene being presented to the participant on the right is that of an unstable landscape, which causes the participant to lose balance even though they are aware that they are standing on stable, real world ground. An example of this phenomenon is the experience one has when on board an aircraft that enters into a sharp bank. To maintain a perpendicular state in relation to the ground, the body naturally wants to compensate for the aircraft's change in attitude.

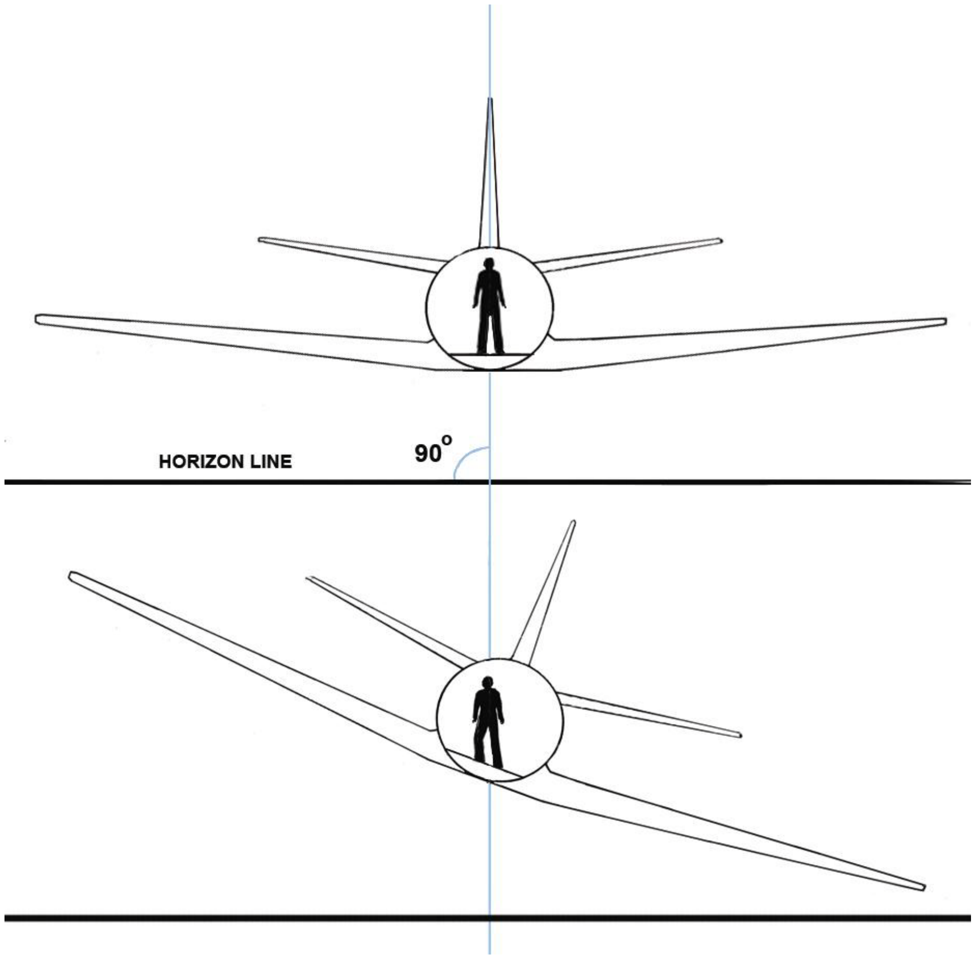


Fig. 36
Level (top) and inclined (right) actual flight conditions

The top image shows an aircraft in level flight. The person's centre of balance is comfortably maintained at 90 degrees from horizontal. In the lower image, the aircraft's state has changed, yet the person inside maintains the original position of 90 degrees from horizontal by physically compensating for the aircraft's change in attitude. This is because our position in the world is always gauged in relation to the position of the horizon, and the horizon is always presumed to be stable and level (Frigon and Delorme, 1992; Previc, 2000). The body's centre of balance provides a 'vertical axis' reference point, which, in normal conditions, is always 90 degrees from horizontal, and if it is not, we are compelled to compensate accordingly, because '*recognition of the* *vertical axis plays an essential role in the organisation of perceptual data'* (Bernhardt and Norman, 1998). The same sensation occurs in flight simulators, which are designed to replicate as closely as possible the conditions experienced in actual flight. The terrain and the horizon line, as they would appear from the cockpit of an actual aircraft, are projected onto the windshield of the simulator. From inside the simulator, the illusory terrain and the aircraft cockpit look and behave like their real world counterparts, and the simulated roll, yaw, or pitch of the aircraft, even though illusory, evoke the same perceptual and physiological responses evoked in actual flight (Frigon and Delorme, 1992).

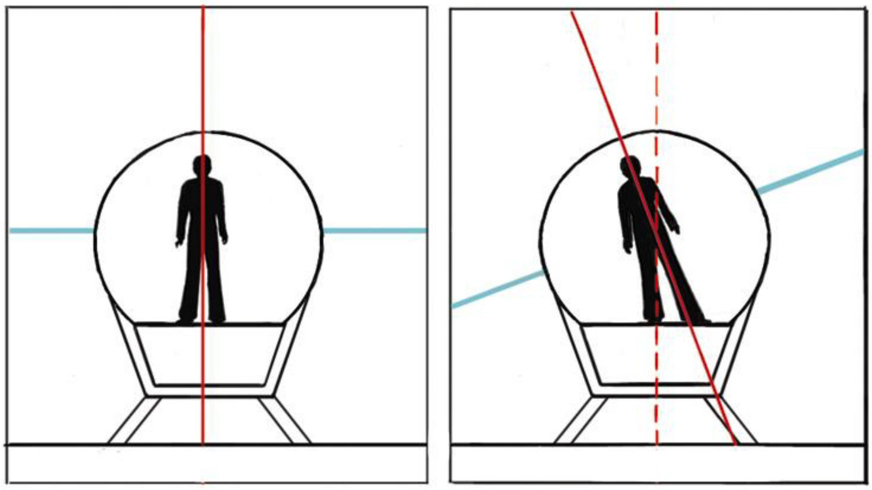


Fig. 37
Level (left) and inclined (right) flight conditions during flight simulation

The horizon line in the image on the right is an illusion, yet the person inside is compelled to respond as they would if it were the real horizon. Therefore, the individual has actually created a condition where his or her centre of balance is no longer perpendicular to the horizon. This phenomenon is a product of our reluctance to 'give up the stable world in favour of the stable individual' (Previc, 2000). In other words, the perception of a stable horizon is implicit; and any changes in attitude must be due to changes in our own rather than the horizon's position (Gibson, 1966; Howard, 1986).

In immersive art environments, as in all VE's and flight simulators, we can be made to anticipate events that are not forthcoming, and we are compelled to respond to forces that do not exist. If, for example, in the illusory world we are on a roller coaster, real world gravitational forces will not correspond with the forces we would be subjected to if on a real world roller coaster. When we are 'visually immersed' however, we are compelled to lean in accord with the motion of the roller coaster regardless; therefore we physiologically respond to the illusory rather than the actual environmental conditions. This happens when visual perceptions override real world physiological clues to the contrary, including gravity, because in these conditions vision is the dominant mode of perception (Previc, 2000). This phenomenon is a salient feature of VE's, flight simulators, and virtual art environments; however, it is also evidenced, and can be equally robust, in pre-technological environments such as the 19th century *Haunted Swing.*

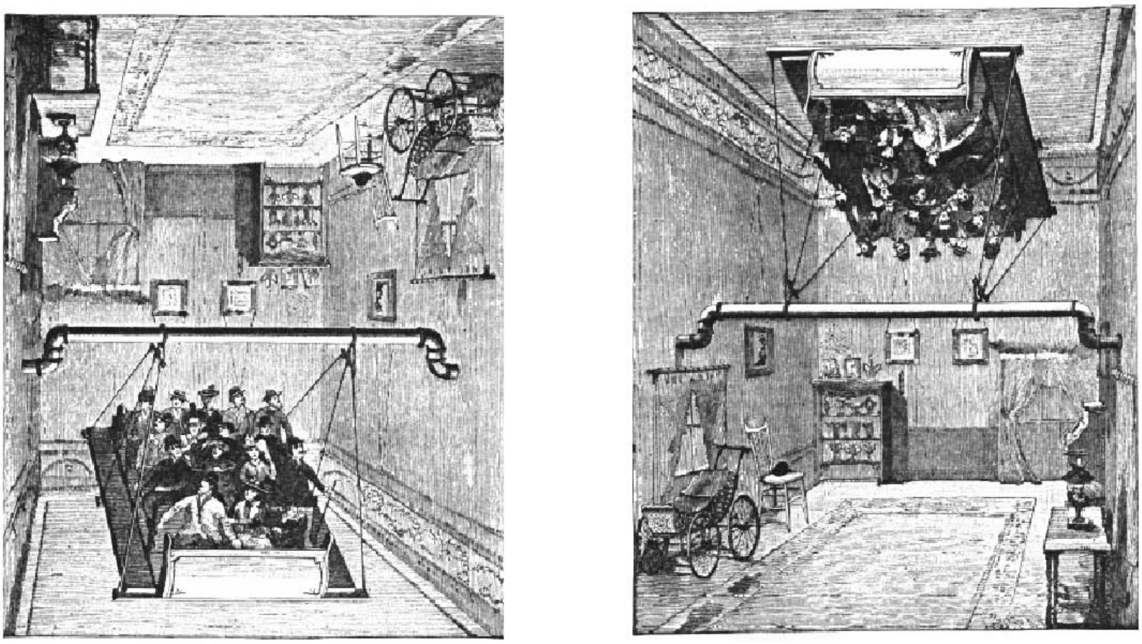


Figure 2. An illustration of a haunted swing from Hopkins (1898). The caption for the left picture is "True position of the swing". That for the right is "Illusion produced by a ride in the swing". The two illustrations are the same apart from their orientation.

Fig. 38
The *Haunted Swing* (c.1898)

Ever since its debut in 1898, the *Haunted Swing* has been a popular fairground feature. The above image accompanied an 1898 article in the journal *Psychological Review*:

> *"The swing proper was practically at rest, merely being joggled a trifle, while the room itself was put in motion, the furniture being fastened down to the floor, so that it could be turned completely over. The illusion was good, though the absence of centrifugal force, and the fact that the swing did not move with uniform acceleration as it descended, would indicate to a careful observer that he was not swinging freely. The curious and interesting feature however, was that even though the action was fully understood, as it was in my case, it was impossible to quench the sensations of `goneness within' with each apparent rush of the swing.* The minute the eyes were shut the sensation vanished instantly. *Many persons were actually made sick by the illusion. I have met a number of gentlemen who said they could scarcely walk out of the building from dizziness and nausea."* (Wood 1898: 277-278)

In the above description it clearly states that '*the minute the eyes were shut the* *sensation vanished instantly"* (my emphasis), thus the phenomenon of physiological response (nausea and dizziness) to illusory conditions (of being turned upside down) is a product of visual perception and strictly visual stimuli. Today, the same phenomenon is generated in OMNIMAX theatres, where visitors are advised to close the eyes momentarily to immediately alleviate symptoms should they be overcome by nausea or dizziness.

In summary, it can be said that historical and contemporary immersive environments share at least two fundamental and requisite immersive factors, which are a) a fully surrounding visual stimulus filling the entire FOV, that b) evokes a physiological response to illusory rather than actual conditions. Focusing on the two factors FOV and Physiological Effect as fundamental immersive criteria, certain known perceptual phenomena were explored that might augment or enhance the experience of immersion.

5.4 Perceptual Considerations

Certain perceptual phenomena are scientifically known to evoke various perceptual effects, and some of these were investigated for their potential to contribute to the sense of immersion based on the above criteria. These included conflicting visual clues, motion parallax, self-motion perception (vection), natural scenes versus digital imagery, visual occlusion, perceived frameworks, and visual anchoring.

5.4.1 Conflicting visual cues

The waterfall illusion, first documented in 1834[48], is one of many visual illusions that work on the basis of conflicting visual cues (Gibson, 1966; Gregory, 2003). This illusion is best demonstrated on a computer screen with an animated series of horizontal black and white stripes moving downward. If one fixates on the screen for a time and the motion is suddenly stopped, the stripes will appear to move upward. What is interesting is that we know, and can clearly see, that each stripe is not changing its position relative to the frame of the screen. The waterfall illusion is effective because we perceive lines that are both stationary and animated at the same time. In her installation *Phase=Time* (1999), artist Jennifer Steinkamp accidentally discovered the same 'apparent motion' illusion:

48. See Adams (1834)

> *"Projected liquid streams filled the screen from both sides forming a waterfall off the edge of the balcony. […] I came across an incredible optical illusion that occurred after the falling water was stopped by a viewer walking passed one of the sensors, the stopped image would appear to move mysteriously upward."* (Steinkamp, 1999)

Fig. 39
Jennifer Steinkamp: *Phase=Time* (1999)
Interactive video installation

Artists have historically used perceptual tools like conflicting visual cues to achieve various visual effect. Bridget Riley is renowned in both creative and scientific circles for her paintings, such as *Fall* (1963) and many others that generate similar kinds of perceptual phenomena.

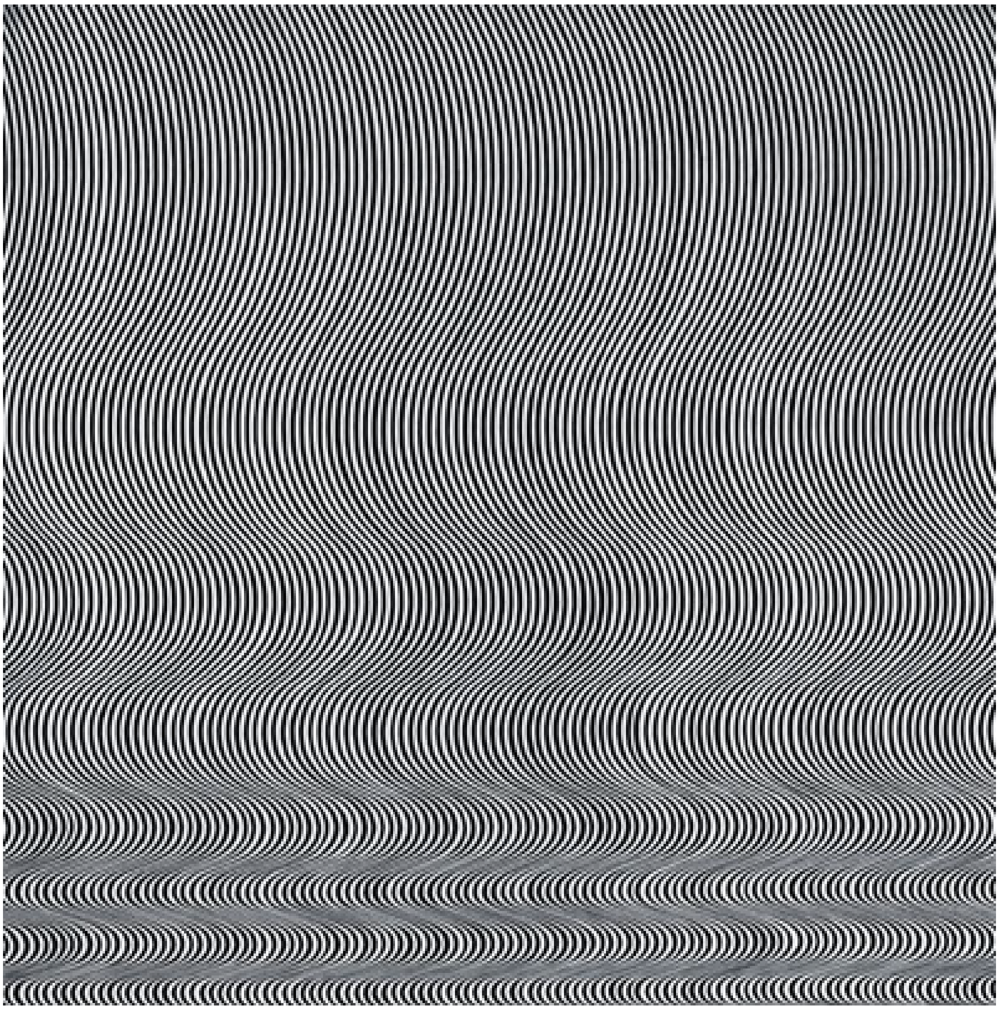


Fig. 40
Bridget Riley: *Fall* (1963) oil on canvas

When viewing this image, even though we know that the lines are stationary we perceive them to be in motion. What is interesting is that we always experience the same illusion every time we view the painting. Whereas artists seek to exploit such phenomena, vision scientists seek to explain it, an observation made by vision scientist James J Gibson in 1966:

> *"The problem of conflicting cues in space perception has been studied in a great many experiments, by many investigators, but always with the aim of trying to solve the puzzle of how one sense could validate another, or provide criteria for another. […]Usually this information is covariant, coincident, or correlated with the information got by another perceptual system, and it is therefore made redundant or equivalent. It can be made contradictory, however, by an experimenter, with various interesting consequences for perception."* (Gibson, 1966:298)

What Gibson means by one sense validating or providing criteria for another is that most often, conflicting visual cues are corrected or resolved either by the visual system itself or by other sensory information, however, under certain conditions perception does not, or cannot, correct it. The image below is especially effective because certain elements have been intentionally exaggerated, or as Gibson describes 'made contradictory', by vision scientist Akiyoshi Kitayoka to demonstrate the 'peripheral drift' illusion[49] (Kitayoka, 2001; 2007).

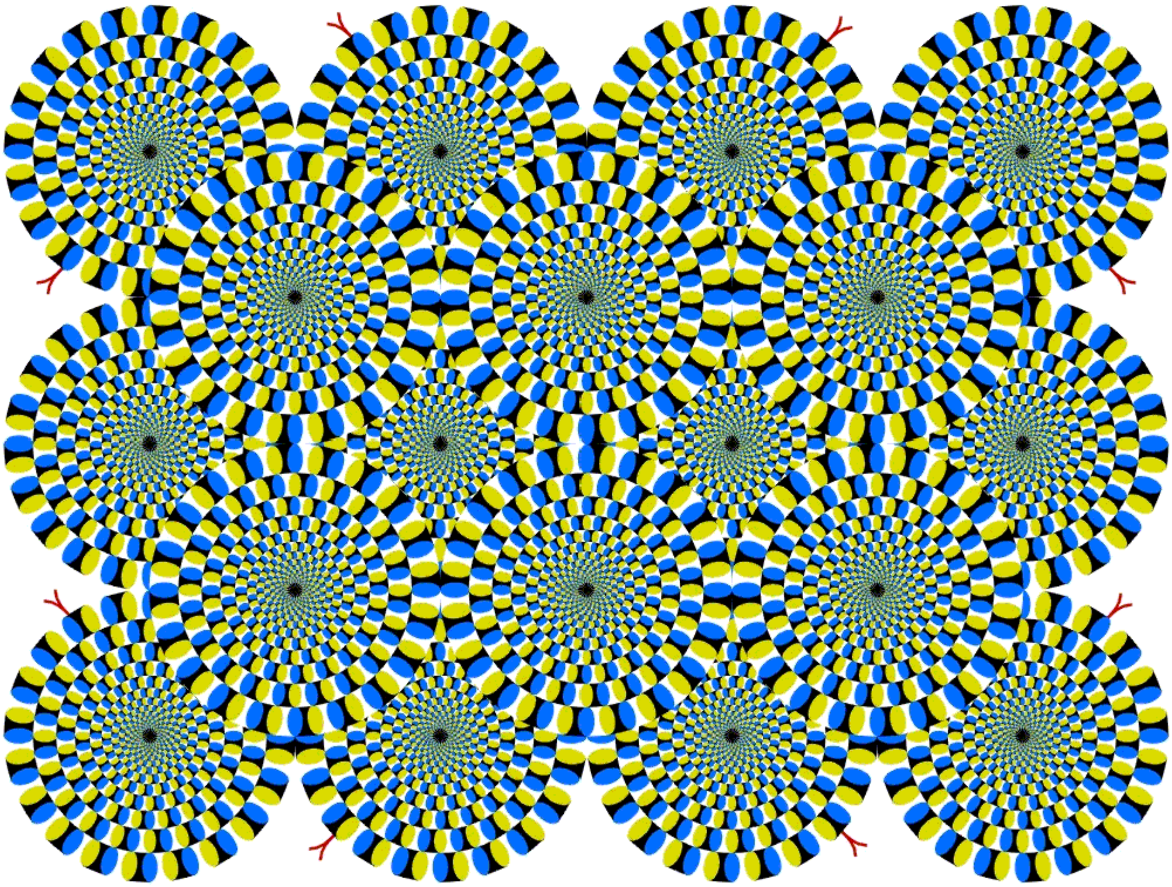


Fig. 41
Akiyoshi Kitaoka: *Rotating Snakes* (peripheral drift illusion)
Move your gaze around the image and you will notice that circles in the periphery will appear to rotate.

49. See http://www.ritsumei.ac.jp/~akitaoka/index-e.html [Accessed 28/10/07] see also Kitaoka et al (2001)

We know that the above images are stationary because they are two-dimensional static representations on paper; however, even though we are fully aware of our 'perceptual error', we perceive motion nonetheless. The illusion is evoked every time because our visual system *makes no attempt to correct the error*, and we cannot correct it even if we consciously try.

5.4.2 Self-motion perception (vection)

> *"Conflicting situations in which visual cues contradict vestibular and other proprioceptive cues show, in the case of linear vection a dominance of vision which supports the idea of an essential although not independent role of vision in self motion perception."* (Berthoz, Pavard, and Young; 1975:489)

When Gibson refers to perceptual processes that are '*covariant, coincident, or correlated with the information got by another perceptual system'',* he is referring to the perceptual system's ability to 'cross reference' sensory information in order to correct or confirm what is perceived. Scientists have studied how this works by observing how perceptual error is corrected by other modes of perception such as the vestibular system (Howard, 2002a)[50]. A more familiar example of this is the illusion of self-motion when inside a stationary vehicle (a train or car). We soon realise that in fact, it is the adjacent vehicle that has begun to move. The illusion lasts only a few seconds because the (visually induced) misperception is cross-referenced with information from the vestibular system, which indicates that we are indeed stationary. In other words, the inner ear tells the visual system that we are stationary, our visual system quickly corrects the perceptual error, and at that moment we are

50. The vestibular system is a small apparatus in the inner ear that is sensitive to accelerations. It is a hidden sense organ, and its presence is usually noticed under extreme circumstances, like after a ride on a roller coaster. The reason it goes unnoticed under normal conditions is because it does what it is supposed to do; which is to help us maintain our equilibrium by informing us about our self-motion. See Howard (2002a).

immediately made aware that the adjacent vehicle rather than one we occupy is in motion. In normal everyday conditions, we maintain a correct sense of self-motion because we cross-reference information received from both the visual and vestibular system (Stanney, 1997; Bonato, 2000; Previc, 2000). When the visual system fails to do this, we experience veridical (or continuous) self-motion perception, or 'vection'[51].

Vision scientist Fred Bonato of Kings College, N.J, US, studies self-motion perception and vection. To measure these phenomena, Bonato has constructed an 'optokinetic drum'; a small cylindrical enclosure with a built in seat and a chin rest for a single subject. When inside the drum, the visible area of the cylinders surface is limited by the location of the chin rest.

Fig. 42
Optokinetic drum (interior view)
Laboratory of Dr Fred Bonato, Kings College, New Jersey, US

The visual stimulus still fills the entire FOV, but this involves a significantly smaller area compared to that of a room like *MIE* or CAVE™. The optokinetic drum effectively reduces the FOV by placing the observer as close as possible to the visual stimulus. Similarly, to distance the observer is to increase the

51. It has also been proposed that vection contributes to the sense of presence in VE's. See McGreevy (1992).

FOV, and the area that the visual stimulus must cover to encompass it. The required screen size in IMAX movie theatres demonstrates how large this must be to achieve an immersive effect. OMNIMAX cinemas, like traditional panorama rotundas, address the FOV problem by curving the surface of the screen within a geodesic dome type architectural structure.

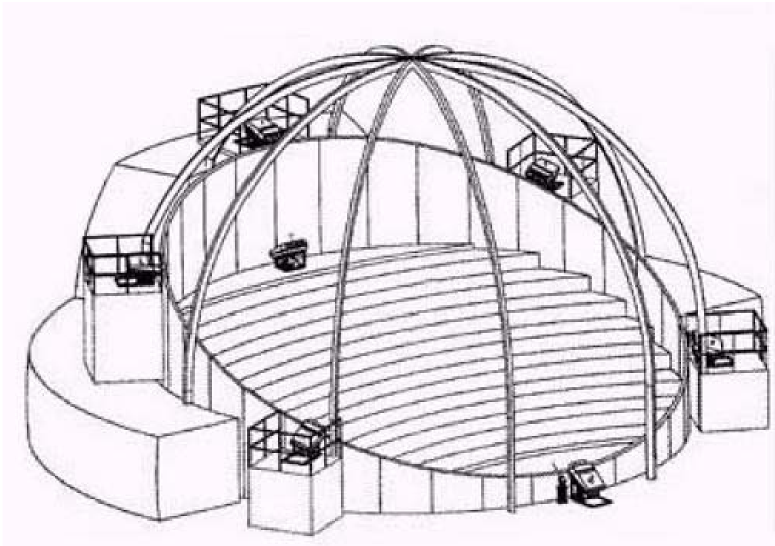


Fig. 43
Diagram of typical construction technique used in OMNIMAX cinemas

The curved screen is especially effective for achieving vertical FOV requirements[52]; however, the FOV is never entirely encompassed because all viewers are seated some distance from the screen, and the theatre's architectural structure is always visible, even if very little, in the periphery. This is not the case with the optokinetic drum, as the observer is close enough to the 'screen' of the drums interior that the vertical and horizontal FOV are encompassed by a very small surface area. Like an HMD, the drum reduces the area of stimulus required to fill the FOV by reducing the enclosure's scale, and by restricting observer's head movements with a chin rest.

52. See chapter 1, section 1.7 for vertical and horizontal FOV requirements

Fig. 44
Exterior view of the optokinetic drum with Dr Fred Bonato and Prof. Alan Gilchrist
Kings College, New Jersey, US (2002)

The optokinetic drum is suspended from a skeleton structure housing a motor that rotates the drum in a clockwise or counter clockwise direction. This generates ‘circular vection’, or, a continuous sensation of physical rotation in space (Bonato, 2002). For the observer, the onset of vection is almost immediate:

> *“Within 30 seconds, most observers experience circular vection in the direction opposite to that of the drum’s true rotation.”* (Bonato and Bubka, 2006: 4)**.**

Unlike the illusion of self-motion on a train, vection in the optokinetic drum is maintained for the entire duration of time spent inside. As a subject, I found that as much as I tried to correct the perceptual error, I still perceived the drum to be stationary and myself to be rotating in the direction counter to the rotation of the drum. This illusion cannot be wilfully corrected, and, like the *Haunted Swing*, the panorama, and the OMNIMAX theatre, this can have certain perceptual and physiological consequences. In the optokinetic drum, the vestibular system fails to correct incorrect visual information, the result being a persistent (or ‘veridical’) illusion of self-motion, or ‘vection’. If subjected to vection for a given time, observers inevitably succumb to motion sickness (Bonato and Bubka, 2006)[53]. Bonato’s vection experiment presents conditions that, as Gibson describes, are *‘generated by an experimenter with various interesting consequences for perception.’* The optokinetic drum generates the same kind of perceptual error as the two-dimensional images of Kitayoka, Riley, and Steinkamp, but in three-dimensional form in that we know that what we are perceiving is not real but our visual system makes no attempt to correct it, and we cannot correct it even if we consciously try. This phenomenon was explored in the experimental immersive environment *Vection*; slightly modified version of the optokinetic drum apparatus.

53. A similar condition, simulator sickness (or SS), occurs in VE’s and flight simulators and has been extensively studied in the visual sciences.

5.4 Vection

Fig. 45
Vection: Preliminary studies (2003)

As an experimental immersive art environment, *Vection* replicated Bonato's original scientific apparatus, the only difference being the use of a moving image rather than a moving apparatus. The main practical concern with this configuration was spherical distortion. Projecting an image onto a curved surface can be a considerable problem, as can be seen in the far right image above. According to scientific research, the human visual system perceives motion with more acuity in the peripheral visual range, but is less sensitive to detail (Wolpert, 1990).

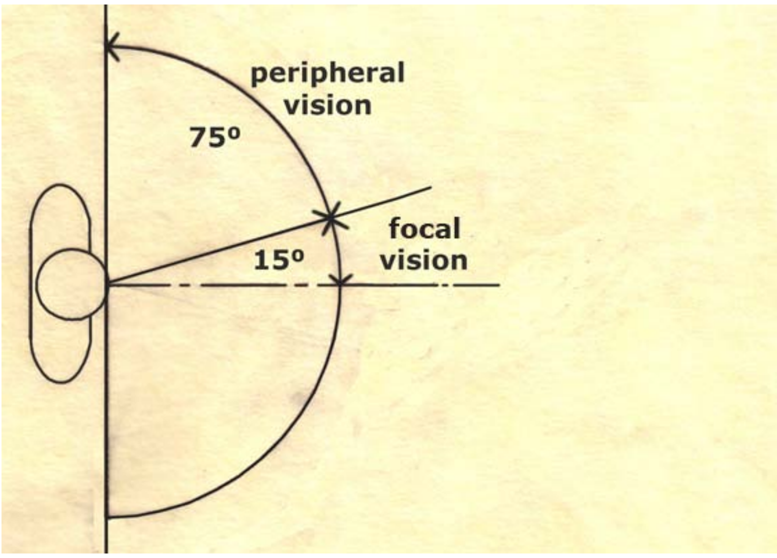


Fig. 46
Peripheral and foveal (focal) visual range

There is also evidence that motion perceived in the periphery plays a larger part in vection than motion in the focal range:

> *"… reports indicated that stimulation of peripheral areas of the retina was more effective in eliciting perception of self-motion than simulation of more central areas."* (Brandt, Dichgans and Koenig 1973:489)
>
> *"…vection is strongly correlated with body movement, and vection and body sway are more dependent on stimulation of the peripheral visual field."* (Kawakita et al, 2000: 321)

In *Vection*, head movement is restricted by a chin rest; therefore, it is theoretically possible to make the observer's area of focussed vision fall within the image area where distortion levels are unnoticeable. In other words, if the focused area of the image and the observer's focussed visual range are aligned, the distortion in the periphery would be undetected, thus the observer would perceive a continuous moving image and the illusion of self motion would not be compromised.

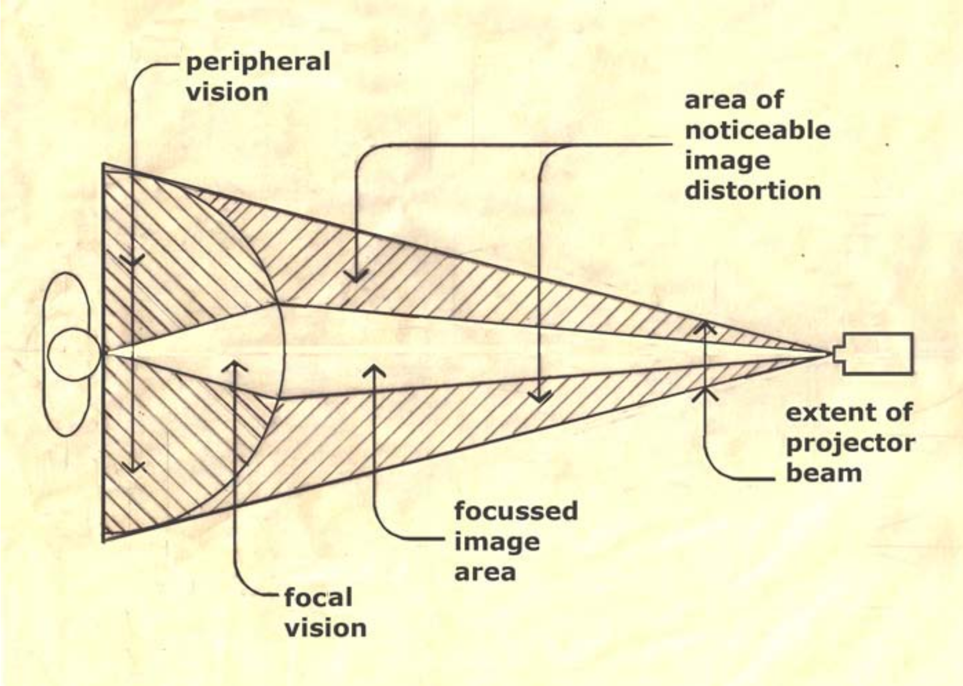


Fig. 47
Peripheral and focal visual range aligned with distorted and focussed image areas

What this means is that a single projected image should be effective even with extreme levels of spherical distortion in the periphery, as in this area vision is more sensitive to motion. According to Margaret Hagen (1978) motion is so important that the content of the images in this area can even be arbitrary:

> *"…estimates of size and distance are more accurate in conditions where the peripheral vision has at least some visual stimulus, even if the stimulus has no direct relationship with the information in the fovea."* (Hagen 1978:327)

What Margaret Hagen's research suggests is that the focused image may be perceived as more 'realistic' as long as stimuli are also present in the periphery, regardless of whether the peripheral stimuli is perceived as associated or aligned with the focused image. In these conditions, the seated observer should perceive a fully surrounding, undistorted, and continuous moving image.

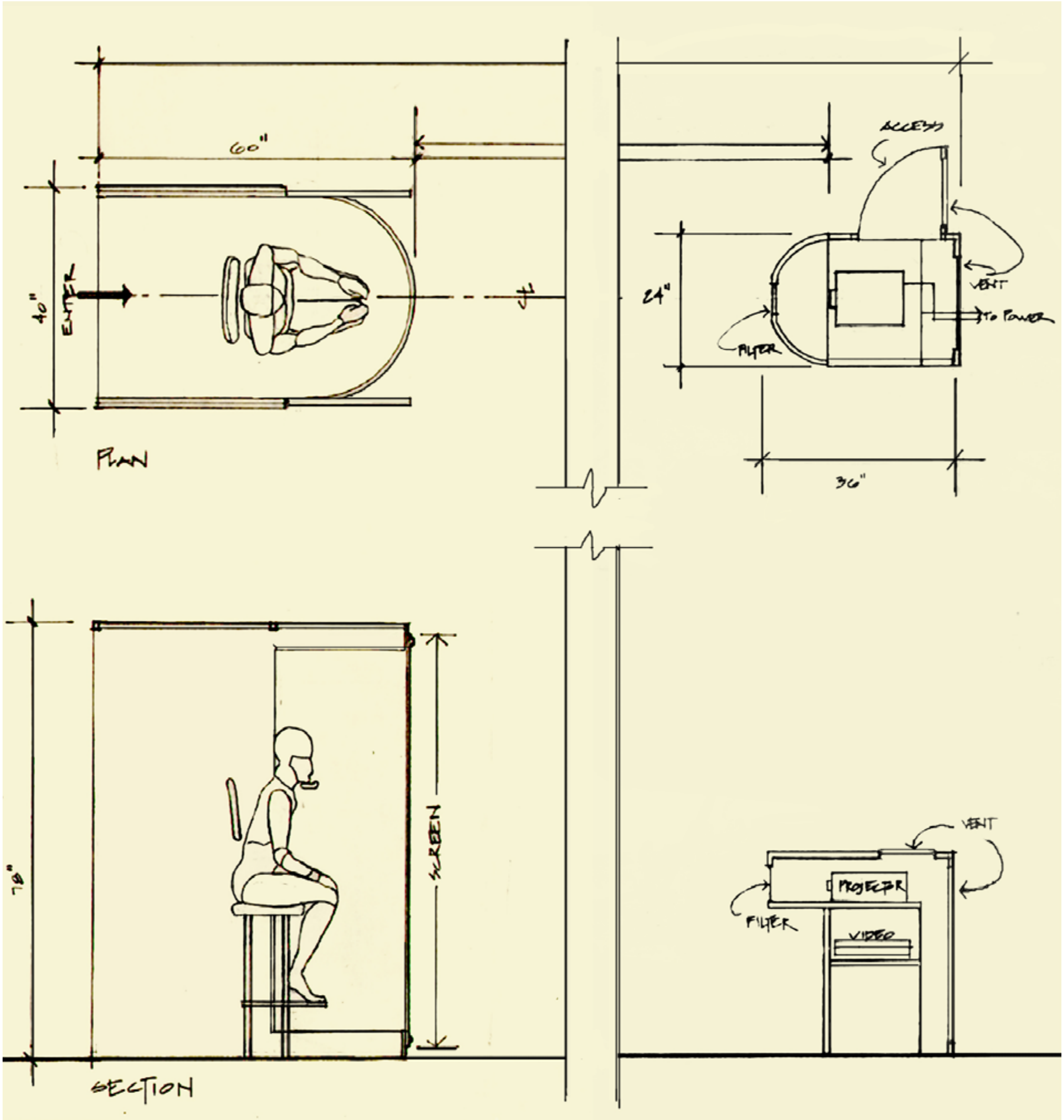


Fig. 48
Vection (2003) Floor Plan/Section

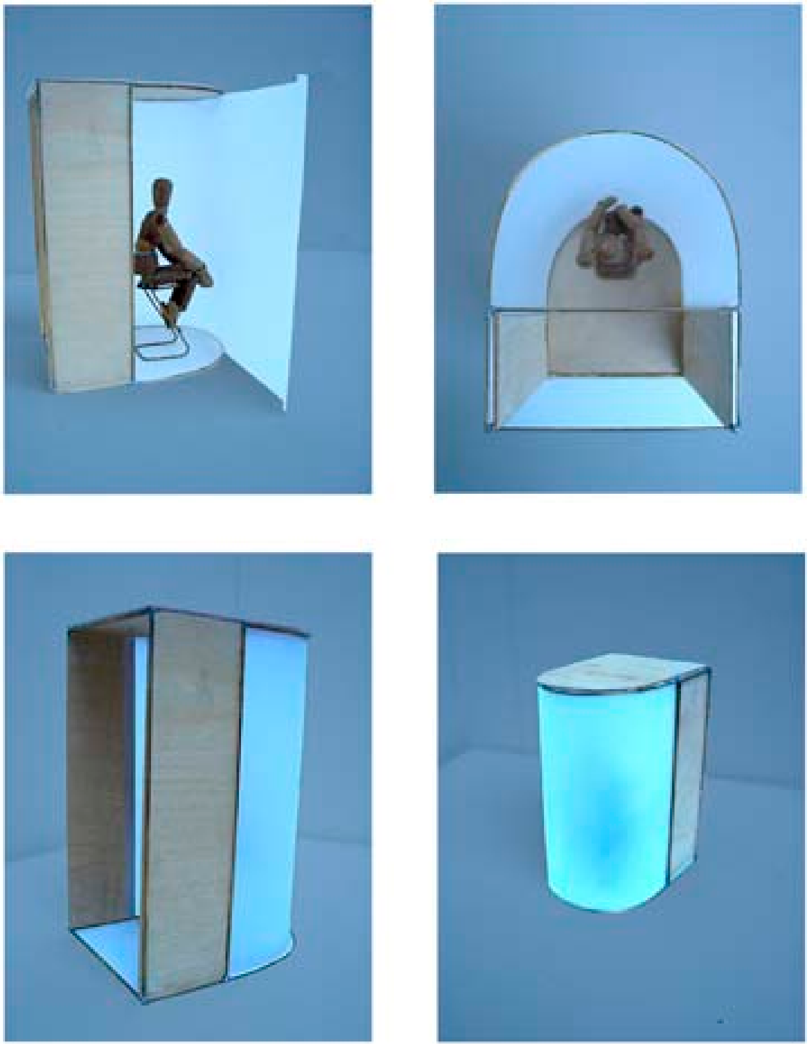


Fig. 49: *Vection*: Scale Model 1:125

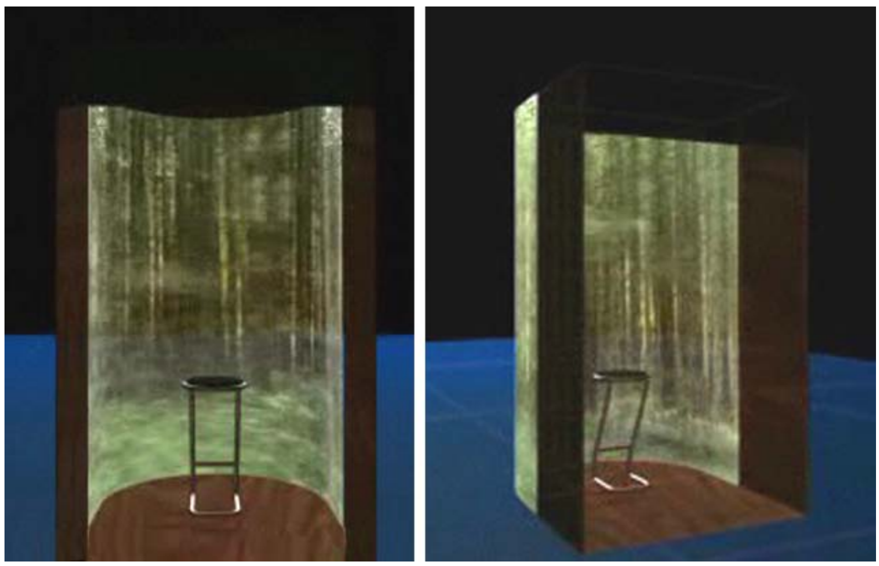


Fig. 50: *Vection*: Preliminary animations

Fig. 51
Vection (2003) Full-scale prototype

Various computer-generated images, including a digital rendering of the original black and white stripes in Bonato's optokinetic drum, were tested in *Vection* and assessed for immersive effect, which brought several problems to light:

- the requirement for a chin rest
- the requirement for explicit instructions on how to use the chin rest
- noticeable image pixelation
- the screen door effect

The first two problems were anticipated, the third problem was more noticeable than expected, but the fourth was unexpected and it was the most problematic. The pixelation problem was reduced by using higher resolution images, high quality rear projection screens, and a DLP rather than LCD projector[54]. The DLP projector also reduced, although not sufficiently, the screen door effect. The screen door effect is a property of the projector lens (rather than the video image itself) that appears as a stationary fine wire grid over the entire image, and this cannot be easily corrected[55].

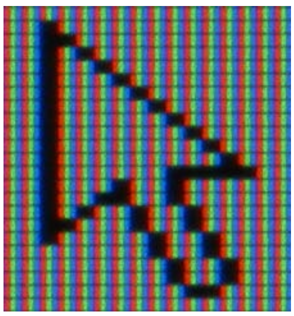


Fig. 52: The 'screen door effect'

54. DLP projectors have noticeably less screen door effect than LCD projectors.
55. The lines of the screen door grid are approximately 0.5 pixels wide, and are thus much less noticeable from a distance.

5.4.1 Perceived frameworks and visual anchoring

Vision scientist Dr Alan Gilchrist (Rutgers University, NJ, US) explained that in *Vection,* the stationary grid of the screen door effect prohibited the perception of self-motion because it, rather than the image, was the largest ‘perceived framework’, and the largest framework always provides the ‘visual anchor’. According to Gilchrist (personal communication, April, 2003), the visual anchor plays a critical role in the perception of self-motion, because when the visual anchor is stationary, an observer perceives him/herself to be stationary, and when in motion, an observer will perceive him/herself to be in motion also. Thus, it is only when the visual anchor is in motion that observers will perceive self-motion. The problem with *Vection* was that observer’s anchored to the screen door grid, which is stationary, thus they perceived themselves to be stationary also. In *Vection*, the perception of self-motion was inhibited because the stationary grid of the screen door would always provide the visual anchor.

Using a variation of the optokinetic drum, an experiment was devised to test Gilchrist’s hypothesis of whether we anchor to the largest retinal framework or the largest perceived framework. In this experiment, lengths of solid white material are spaced at equal distances around the circumference of a circular enclosure, with the gaps and the strips being equal in size and spacing. The enclosure is in a darkened room, so the solid white strips and the gaps between them appear contiguous, and are perceived as one solid surface of alternating black and white stripes, just like the alternating stripes in Bonato’s original vection experiment. Because this condition is perceptually equivalent to the conditions inside a solid optokinetic drum, when rotated, an observer should experience vection in the same manner.

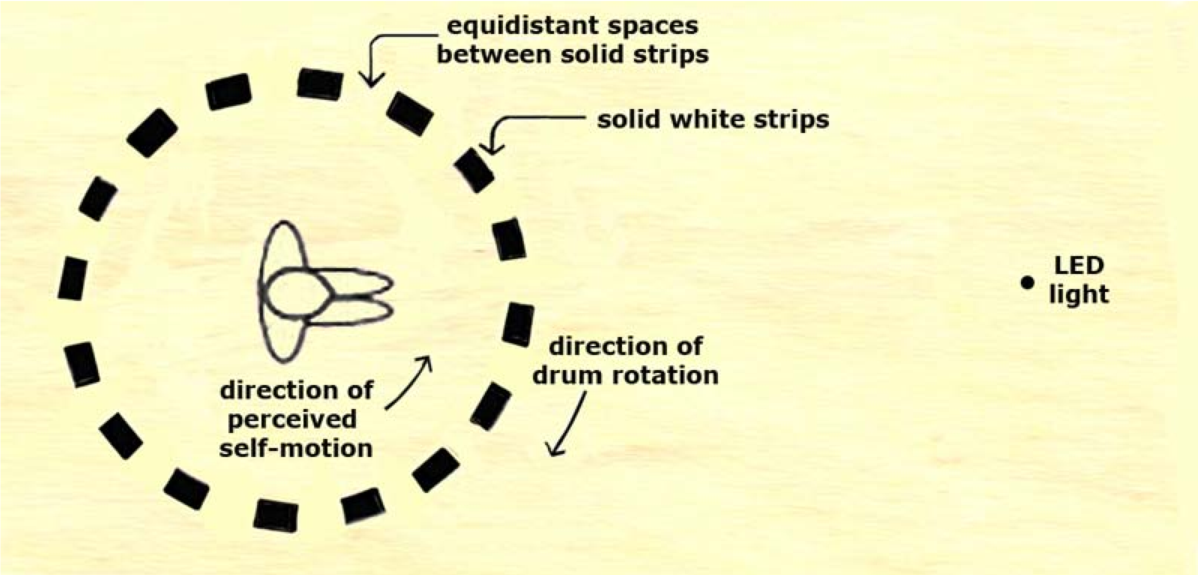


Fig. 53
Diagram of perceived frameworks experiment

Placed directly in front of the device, but some distance away, there is a small LED light. When illuminated, the light is visible, but only through the black (open) spaces as they pass directly in front of the observer. The light tells the observer that there is a much larger space beyond the interior surface of the enclosure. The larger space is now the largest framework, which becomes the new visual anchor. Because the larger space is now providing the visual anchor, and the visual anchor is stationary, vection ceases. When the light is switched off, the drum's interior once again becomes the largest framework and the observer's visual anchor, thus vection returns.

The reason vection, or self-motion perception, is an appropriate means for measuring immersion is because it indicative of a loss of control, whereas the viewer is unable to prevent physiological responses to conditions that that they are aware don't exist. In other words, the environment has successfully managed to ‘trick’ the viewer into physiologically responding to it as if it were real, even if the viewer consciously tries to prevent it. This has been the archetypal feature of all immersive environments throughout history, such as the naval panorama that made Queen Charlotte feel seasick. With regard to the design and construction of immersive art environments, the perceived frameworks experiment led to a subsequent and significant hypothesis.

5.4.2 Interim hypothesis

If, in the above experiment, the LED were replaced with visual images, the scale of the images required to generate vection would be significantly reduced. In theory, the images could even be as small as the LED as long as they were the visual anchor. If the conditions of the LED light and the optokinetic drum were reversed; the drum being stationary and the light being in motion, most of the retinal image would be comprised of a solid, stationary enclosure, yet the much smaller moving image source would be perceived as a much larger area beyond the enclosure. The implication of this is that the LED light could be replaced, for example, by a small LCD screen; therefore, very small images in a cubicle type enclosure could generate immersion and overcome many of the problems encountered regarding image pixelation, screen door effect and image scale. This suggests that *MIE* and *Interlace* could have been more effective without full screen image projections.

In theory, a cubicle or room (such as *MIE*) with three solid walls, each with a single small aperture, could effectively generate immersion. The room’s interior surface will still be the largest *retinal* framework as it will take up the larger part of an observer’s visual field. However, what is visible through the small apertures will be perceived as a larger space beyond the enclosure, becoming a larger *perceived* framework and the visual anchor. In the perceived frameworks experiment, the enclosure is in motion and the larger space is stationary. In this configuration, the enclosure is stationary and moving images are visible through the apertures. Since the largest perceived framework and the visual anchor are now in motion, the observer will perceive self-motion. What is significant is that the moving imagery can be any number of possible environments or conditions. Furthermore, if an effective immersive environment were created based on this and Gilchrist's original frameworks hypothesis, it should be possible to create an immersive art environment that could generate scientific data, therefore testing both hypotheses with a single environment serving as both a scientific apparatus and an immersive art installation. In developing this experiment, other perceptual phenomena were explored that might augment the experience of self-motion, which would evoke a greater physiological response, therefore enhancing the experience of immersion. These included natural scenes versus digital patterns, visual occlusion, and motion parallax.

5.4.3 Natural Scenes versus Digital Imagery

Scientific research has shown that self-motion perception is greater when an observer is presented with natural, recognisable scenes rather than computer generated patterns:

> *"Previous studies have typically used abstract stimuli to induce vection. Here we show that the illusion can be enhanced if a natural scene is used instead…"* (Rieke, 2006: 17)

According to Fred Previc's research on perception in flight simulators and VE's, a perceptually believable virtual world will ideally include 'landmark-rich' and ‘realistic environments’, which he claims are as effective as ‘corresponding views onto the real world’ (Previc, 1995). According to these and other studies (Duh 2002; Warren 2000, Wertheim and Bless, 1997), images of natural scenes are more ‘immersive’ in that they are more effective for generating the illusion of self-motion than digitally rendered patterns This would imply that the image content visible through the apertures should ideally be of an actual environment, such as video footage taken while moving through an articulated landscape.

5.4.4 Visual Occlusion

> *Gestaltists believe that individuals group stimuli in their own perception. […] The basic law of Gestalt theory, the law of Pragnanz, "implies that if a perceptual field is disorganized when an organism first experiences it, the organism imposes order on the field in a predictable way. […] There are five other laws related to the law of Pragnanz: (1) Similarity: similar items tend to grouped, (2) Proximity: items are grouped according to the nearness of their respective parts, (3) Closure: completed items are grouped together; (4) Good Continuation: an example would be that straight lines appear to continue as straight lines, and curves as curves; (5) Membership Character: a single part of a whole is defined by the context in which it appears.* (Blosser, 1973:44).

Using small apertures rather than full screen projections eliminated several of the problems realised in *MIE* and *Vection,* such as projector throw distance, image resolution issues, corner shadow, and synchronisation problems. Another significant benefit to having smaller images separated by comparatively large surface areas is the potential for ‘visual occlusion’, which, according to scientific studies, is ‘critical to motion perception’ (McDermott, 1999). If part of an object or feature is visible in one aperture and another part is visible in the next aperture, it will be perceived as continuous (Gombrich, 1987; Gibson, 1966; Gregory, 1997). The phenomenon of visual occlusion is best demonstrated by the Poggendorf illusion.

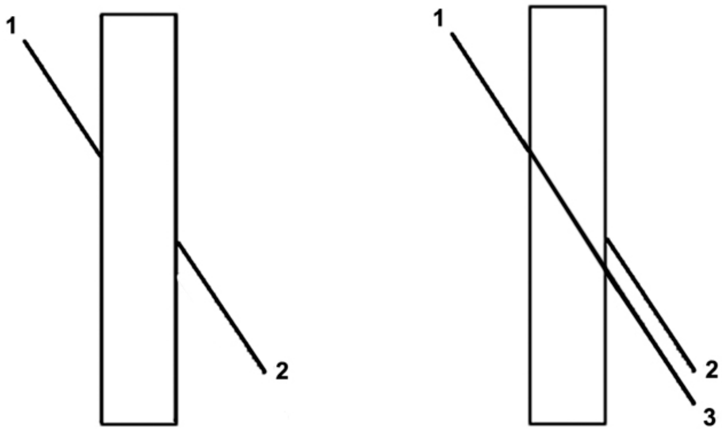


Fig. 54
Poggendorf Illusion

In the above image, we perceive a continuous line (marked 1 and 2 at each end point) that is occluded by a rectangular object. However, if a continuous line is drawn from end point one, effectively removing the occluding object, we can see that it terminates at new end point 3.

The reason for this, according to Gestalt theories, is that the visual system tends to group similar objects in a visual scene (Blosser, 1974; Gregory, 1997). When the lines are occluded, the visual system subconsciously connects them even when in reality that connection does not exist. Theoretically, the same phenomena will occur with moving images that are occluded by the enclosure's interior surface. This phenomenon could be incorporated into video footage by including objects or features that span the distance between the apertures, such as a continuous line of hedgerows or fencing. This type of feature would also accommodate 'motion parallax'.

5.4.5 Motion Parallax

Motion parallax describes differences in the perceived velocity of near and far objects, which tells us that we, and not the landscape, are in motion (Howard, 2002a). As all objects are equidistant when viewed from above, the landscape viewed through an aircraft window lacks the element of motion parallax, whereas a visually complex landscape viewed from an eye-level perspective increases motion parallax. As we travel through the environment on a train for example, the fences or hedgerows at the track's edge appear very close, other features such as nearby trees or hilltops are further away, distant hilltops further away again, and mountain ranges even further still. The speed at which each of these elements appears to travel is directly related to their proximity to us (Howard 2002a; Gibson 1966). The fence posts appear to be whizzing past us at a blur, the nearby trees travel somewhat slower, yet they appear to be travelling faster than the hilltops behind them, and the hilltops appear to be travelling slower than the trees but faster than the distant mountain ranges, which appear stationary in relation to the nearby fence posts. The greater the range of elements and distances between them, a mountainous, undulating terrain compared to an open flat plain for example, the greater the element of motion parallax.

5.5 Kansas

5.5.1 Preliminary concepts

Ways of exploiting the above perceptual conditions in an immersive environment were explored in collaboration with scientists Alan Gilchrist and James Intriligator (University of Bangor, Wales). The aim was to create an immersive art environment, as defined by established immersive factors of FOV and Physiological Effect, to incorporate as many of the above perceptual conditions as possible in the visual stimuli, and to devise it in such a way that it could provide viable scientific data. While exploring various new configurations using the framework of MIE, the structure took on the recognisable form of a room in a house and the apertures its windows.

Fig. 55 *Kansas*: Scale model: 1:125

Fig. 56 *Kansas*: Preliminary studies

5.5.2 Video footage

Initial video footage was taken in an area of the Yorkshire countryside that presented many desirable perceptual conditions, including winding narrow roads, near and distant trees, stretches of fence posts, roadside hedges, and distant hills. Three video cameras were required, one each for the front, right, and left windows, which were mounted onto a modified camera tripod and secured to the roof of a vehicle.

Fig. 57
Vehicle mounted tripod with three digital video cameras with wide-angle lenses


Fig. 58
Still images of footage showing perceived velocity of near and far objects (motion parallax).

Fig. 59
Still image of video footage using three wide-angle lenses at 75º

Wide-angle lenses were used to encompass as much of the FOV as possible, and to alleviate camera shake. Footage was also taken through a city centre and its surrounding residential areas.

Fig. 60
Still image of city footage using three standard camera lenses at 90º

To generate circular vection, and to accommodate a possible floor projection[56], another configuration used three and four cameras from a floor standing tripod that rotated through 360º.

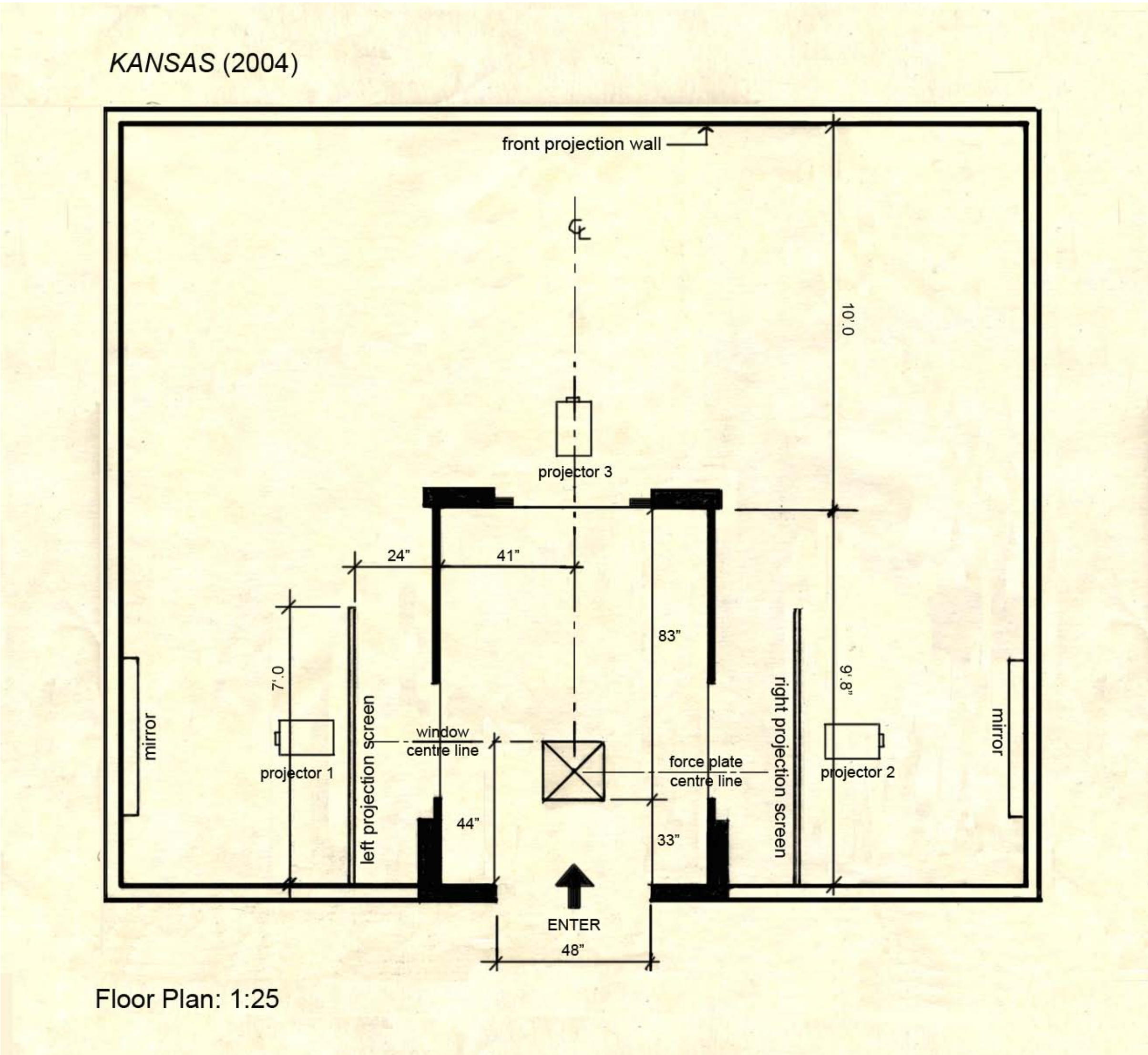
Fig. 6: Three and four camera configurations with floor standing tripods

56. The floor projection was not essential from an aesthetic perspective, but was considered for the purposes of the scientific experiment.

5.5.3 Kansas: The experiment

> *"Apparatus: Kansas, an installation consisting of an 8 x 10 foot room containing three windows. Moving video images recorded by 3 video cameras mounted atop a moving car and facing in three directions, were projected onto 3 screens located 2 (front window) and 2 ft. (side windows) behind the three windows. This stimulus was designed to create the impression that the observer was inside a moving room."* (Nolan, Intriligator, and Gilchrist, 2004: 2)

For the experiment, *Kansas* was constructed on site in an art gallery at Northumbria University, where the art exhibition remained open to the general public for two weeks.



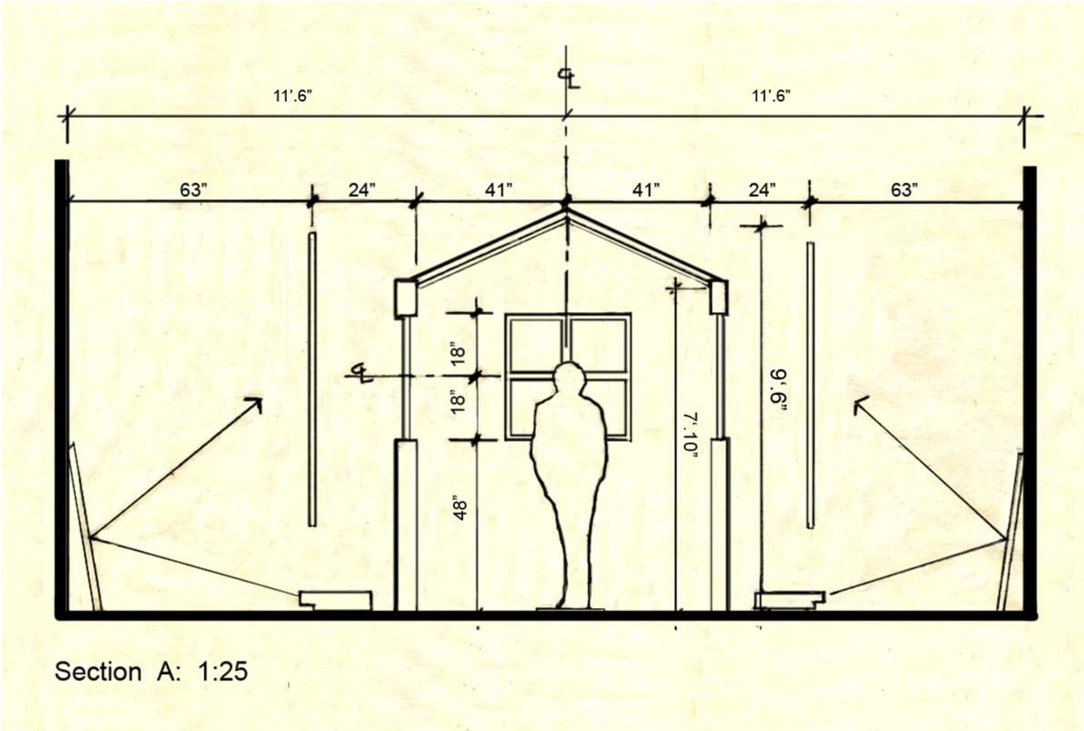


Fig. 62: *Kansas*: Floor Plan/Section (2004)

The *Kansas* experiment is different than Dr Bonato's vection experiments in that the enclosure moves along with the observer, rather than the observer experiencing his or her own self-motion in a stationary environment. When inside *Kansas*, the interior space makes up the largest part of the retinal framework, but the outdoor environment in the video footage is visible through the apertures, and is indicative of a larger framework beyond the interior:

> *"Apparatus: Kansas, an installation consisting of an 8 x 10 foot room containing three windows. Moving video images recorded by 3 video cameras mounted atop a moving car, and facing in three directions, were projected onto 3 screens located 5 ft. (middle window) and 2 ft. (side windows) behind the three windows. This stimulus was designed to create the impression that the observer was inside a moving room." (*Nolan, Intriligator, and Gilchrist, 2004: 4)

The experiment was conducted during the two-week exhibition. Volunteer subjects, the only visitors informed of the experiment details, were asked to stand with their feet together on a force plate facing the front window. The force plate was used because it promised to provide an accurate account of even very small levels of balance loss. Considering the need to acquire accurate measures of each subject's balance, both as a measure of immersion for the reasons explained above and as scientific data, the force plate offered more reliable and immediate results than quantitative methods (such as subject reports) could provide.

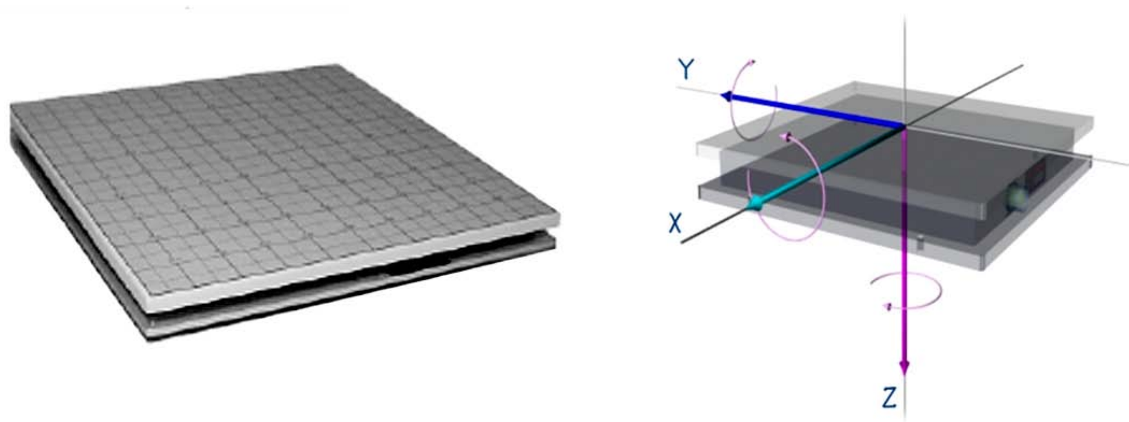


Fig. 63
AccuSway™ force plate

Fig. 64
Subject and force plate inside *Kansas*

The force plate[57] recorded the degrees of balance for each subject, showing where and at what point in the image sequence that balance was most affected:

> *"The observer stood facing the middle window, standing on an 18 by 18 inch force plate that recorded the moving centre of force. Balance was assessed by the size of an ellipse enclosing 75% of the locations of the centre of force during a three-minute exposure. Observers: 30 Art and design students at Northumbria University."* (Nolan, Intriligator, and Gilchrist, 2004: 4)

The extent of balance loss was measured by the distance that a subject's weight shifted from a centre of pressure (COP) reference point as they tried to maintain balance. This information was fed to a computer and the results were

57. See Appendix for Balance Clinic™ force plate specifications

recorded in spaghetti diagram format[58]. The extreme points, marked as red dots in the below right image, are the points that fall the farthest beyond an elliptical boundary around the COP. These are the points in the video where self-motion perception was strongest. The image on the left is a record of the subject's balance taken for the same length of time without the video playing.

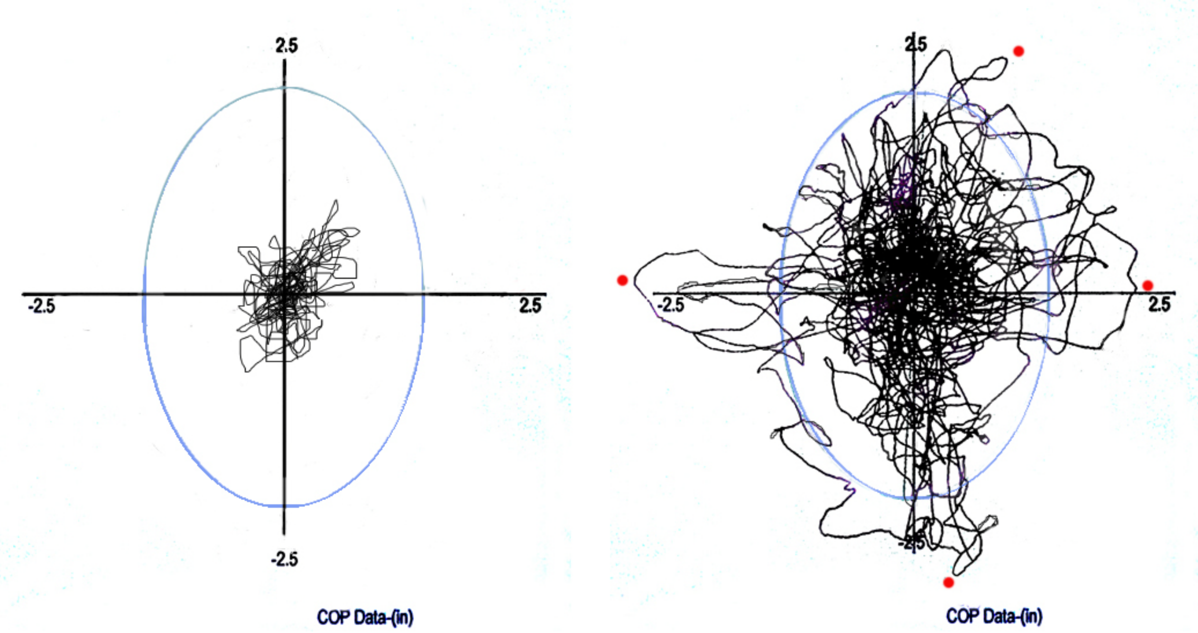


Fig. 65
Left: three minutes without stimulus, right: three minutes with stimulus
Typical balance patterns recorded in large aperture condition.

In order to provide a measure of difference, the installation was designed to accommodate two conditions using different aperture sizes:

> *"Parametric component: Windows of two sizes were created, 12 by 12, and 36 by 36 inches. If only perceived framework size is important, window size should make little or no difference. If retinal area plays some role, window size should matter."* (Nolan, Intriligator, and Gilchrist, 2004: 4)[59]

As an aesthetic experiment, this also revealed the effective difference of smaller and larger moving images.

58. Software was provided by the force plate manufacturer, the spaghetti diagram was one of several formats available. See Appendix for graphs and data recorded for each subject.
59. This and the following quotes from the same source are taken from a paper delivered at the 2004 ECVP, which is explained later in the chapter.

Fig. 66
Kansas: installation view with large aperture configuration

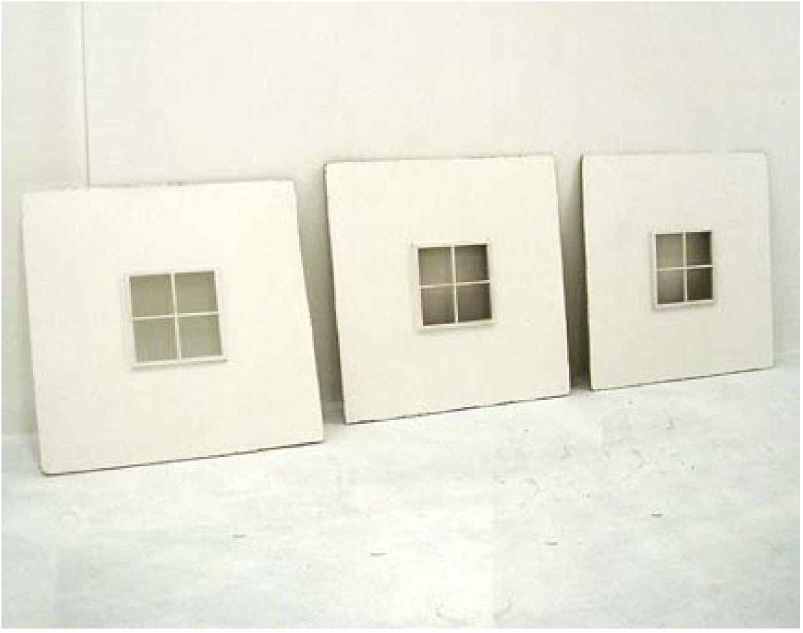


Fig. 67
Interchangeable small aperture inserts
(The outside frame is equal in size to the opening for the larger apertures shown in Fig. 66)

Fig. 68
Kansas Experiment: Installation view showing small and large aperture configurations.

As a scientific experiment, degrees of balance established whether subjects anchored to the largest perceived or the largest retinal framework:

> *"The stationary room (inner framework) fills most of the observer's visual field. But the environment perceived to lie outside the room (outer framework) constitutes the largest perceived framework. If retinal area governs, perceived self-motion should be minimal and observers should remain balanced. If perceived area governs, strong self-motion should occur with loss of balance."* (Nolan, Intriligator, and Gilchrist, 2004)

In *Kansas*, if observers had anchored to the largest *retinal* framework (the enclosure's interior), they would have maintained balance, however, a consistent loss of balance was recorded for all subjects, therefore subjects anchored to the largest *perceived* framework, which was the moving image:

> *"All observers experienced self motion (vection), despite being surrounded by a stationary room, showing the importance of the largest perceived framework. […] This suggests that perceived area is more important than retinal area."* (Nolan, Intriligator, and Gilchrist, 2004)

As an aesthetic experiment, the results provided a quantitative measure of immersion in that they provided a measure of the work's 'physiological effect'.

They also shed light on the effect of smaller and larger moving images. Although both configurations proved to be effective, there was a difference in the extent of balance loss between the two.

Although scientific data was generated during the exhibition, *Kansas* was installed in an art context, and was perceived as an art installation by exhibition visitors[60], thus *Kansas* functioned as both an art installation and a scientific apparatus at the same time. Whereas *Vection* was taken from a scientific context and placed in the context of art, the intent was to now reverse this process and place *Kansas* in a scientific context. Since the results of the experiment provided viable scientific data, a joint paper describing the work was submitted to the 2004 ECVP (European Conference on Visual Perception), in Budapest, Hungary[61]. As part of the paper, *Kansas* was re-installed at the conference venue as a working demonstration of the perceived frameworks experiment and the art and science collaboration that it entailed.

60. With the exception of volunteer subjects
61. The abstract of the paper, also titled '*Kansas*', was published in the annual ECVP supplement of *Perception* Vol. 23:153

5.5.4 European Conference on Visual Perception (ECVP)

To exhibit *Kansas* at the ECVP venue meant transporting the installation by air. To do this the original aluminium structure of MIE2 was reconfigured in such a way that it stayed within airline regulations, while maintaining the original scale and proportion.

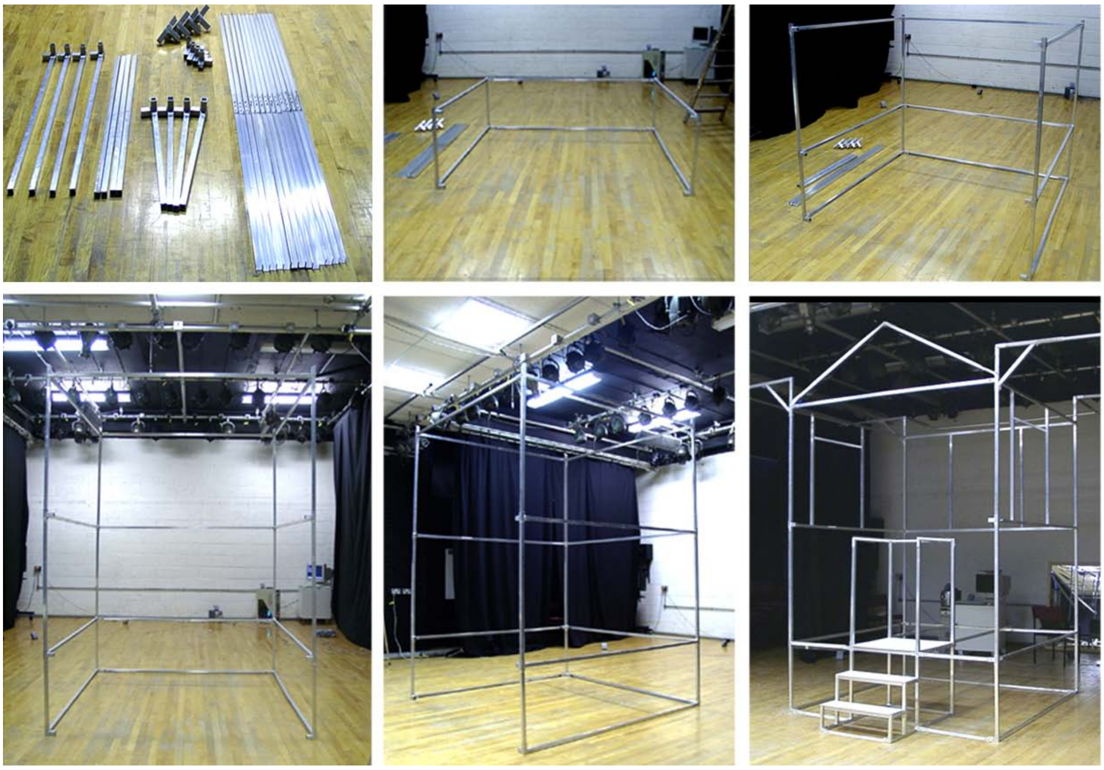


Fig. 69: *Kansas*: Modular framework configuration for ECVP 2004

Fig. 70: The portable version was able to fit into two standard golf bags (far right)

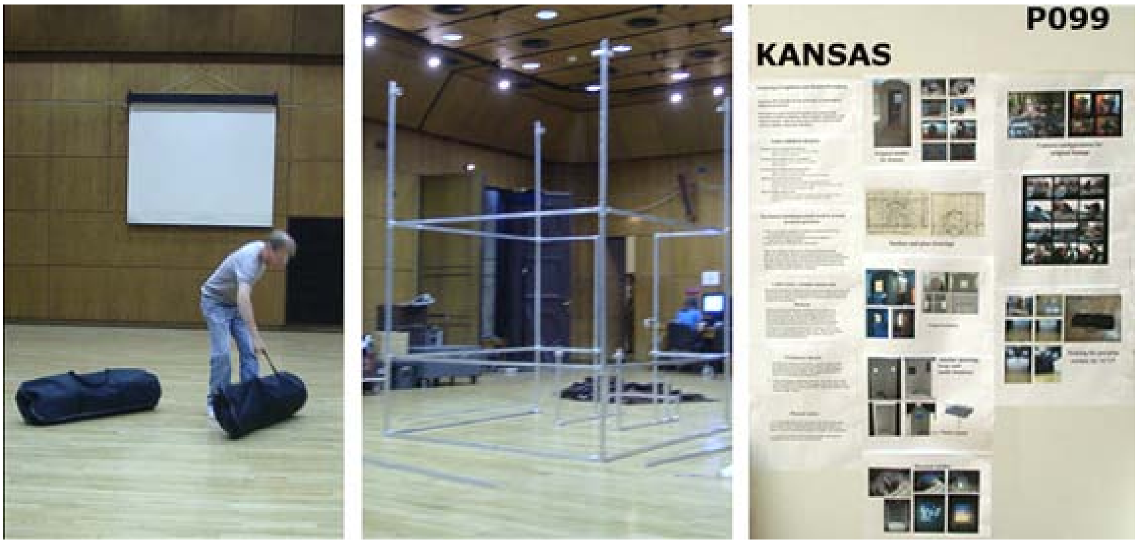


Fig. 71: ECVP set up and poster, Budapest, Hungary

"We present an exhibit called Kansas, which is both an art installation and a visual perception apparatus. The observer steps into a small room containing a number of windows. Computer-generated flow fields are projected onto screens located beyond each window and create the visual impression that the observer is moving through space. However, because the room itself appears stationary in relation to the observer, only one solution is possible for the visual system – both the observer <u>*and*</u> *the room are moving through space together. In essence, the observer feels the motion (via vection) and the room "goes along for the ride." As an art installation, Kansas demonstrates that immersion is a product of visual stimulation that can be achieved without complex virtual reality/interactive technology. As a vision experiment, Kansas is being used to investigate the rules of anchoring in the motion domain. As an art/science collaboration, the exhibit suggests the individual benefits of installation artists and visual scientists working together."* (Nolan, Intriligator, and Gilchrist, 2004)

Fig. 72: *Kansas*: ECVP 2004, Budapest, Hungary.

At ECVP, *Kansas* demonstrated both the perceptual frameworks concept and the concept of visual immersion, establishing that when placed in the applicable context *Kansas* functioned equally as an object of science and as an object of art. This observation and the overall research findings are discussed in the following chapter.

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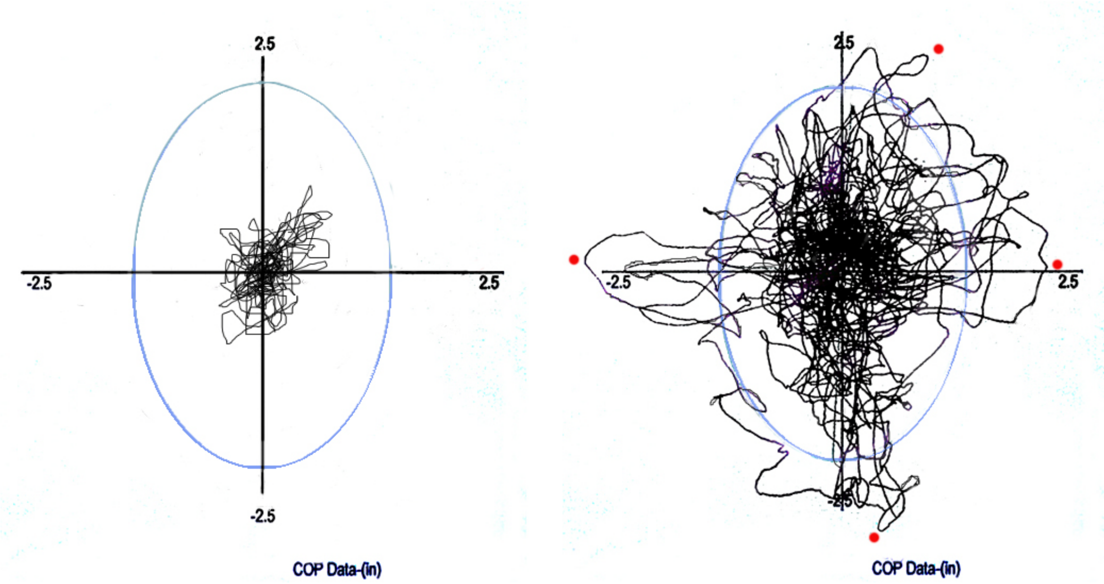
Chapter 6: Analysis and Discussion

6.1 *Kansas*: An Analysis

The data gathered for each subject in the *Kansas* experiment are extensive[62], and include individual factors such as age, race, height, and video gaming experience[63]. Most of this information was not required for the purposes of the aesthetic or the scientific experiment. For the latter it was necessary to analyse only the degree to which each subject shifted from a ‘centre of pressure’ (COP) reference point as they tried to maintain balance. Data was gathered in both the large and small aperture configurations in order to provide a measure of difference between two different frameworks conditions[64]. As an aesthetic experiment, the data confirmed that when inside *Kansas*, all observers experienced a degree of ‘physiological effect’ in the form of imbalance. The graphic printouts also showed where levels of imbalance were the most extreme.

62. See Appendix B for an example of a typical data file.
63.The results indicated that subjects with video gaming experience were more stable, as were shorter and younger subjects.
64. Data analysis was conducted by James Intriligator in accordance with the force plate software and the manufacturer’s instructions. See Appendix A for the AMTI force plate specifications.



Spaghetti graphs showing degrees of balance in the same subject during three-minute exposures in two conditions, without visual stimuli (left) and with visual stimuli (right). Red dots in the right image indicate extreme points of imbalance as gauged by the distance that the subject's weight shifted from the COP.

As was expected, these points correspond with the most noticeable motion in the video sequence, where rapid or sudden accelerations, decelerations, and sharp turns occurred. Although secondary, this is a relevant observation with regard to this study as it provides evidence that immersion can be achieved using visual stimuli alone. The data clearly indicates a strong correlation between the extreme points of motion in the video sequence and the extreme points of imbalance recorded for each subject, proving that the 'immersive effect' (of balance loss) experienced by all observers was not just a consequence of the visual information alone, but also directly correlated with it.

We know that immersion in *Kansas* is the product of visual stimuli alone that encompasses the entire FOV, which is comprised of the enclosure's visible interior surface area and the 'outside' environment visible through the apertures. Therefore, the first immersive factor 'FOV' is implicit. We also know that the outside environment was perceived to be in motion, and that this generated an illusion of self-motion, which in turn evoked subconscious, physiological responses to the condition of self-motion. Therefore, all observers responded to the illusory conditions (of the video environment) rather the actual conditions (inside the enclosure), confirming the second immersive factor of 'physiological effect'.

The overall results of the *Kansas* experiment confirmed the following:

a) The requisite factors for immersion per se are perceptual.

Kansas generated immersion using only the two fundamental immersive factors of 'FOV' and 'Physiological Effect', both of which are perceptual rather than virtual or interactive factors.

b) The processes at work in visual and pre-technological immersive environments are subconscious, objective, and perceptual in nature.

Each subject in the Kansas experiment was asked look straight ahead and to stand in the feet closed and centred position on the force plate for the duration of the video. In pre-test runs without visual stimuli, all subjects showed normal to less than normal deviations from the COP. With visual stimuli, all subjects showed significant deviations from the COP for 85% of the total duration, with extreme deviations for 13% and normal to less than normal deviations for 2% of the total exposure time. The only difference between pre-test and actual experimental conditions was the presence of visual stimuli. All subjects were asked to try to maintain their balance and to remember that they remained on stable ground, but subjects spontaneously shifted their weight from the COP even though they tried not to. Some subjects were asked to close their eyes for 5-second intervals during the video sequence. The results showed that no imbalance was experienced during these 5-second periods; therefore, the physiological response (of imbalance) was strictly a visually induced phenomenon determined by sub-conscious, perceptual processes.

c) Levels of immersion are determined by and directly correlated with the visual stimuli presented.

Extreme points of imbalance were recorded at those points in the video sequence showing the most rapid acceleration, deceleration, sharp turns and steep hills or inclines. The ‘immersive effect’ as indicated by levels of balance loss was therefore proportional to levels of motion in the visual imagery.

d) Levels of immersion can be influenced by the nature and content of the visual stimuli presented.

Certain elements of image content affected levels of imbalance more than others, such as motion parallax and real rather than digitally generated scenes. Therefore, in an immersive environment, visual stimuli alone can be manipulated so as to evoke a greater or lesser sense of immersion.

e) immersion can be achieved using minimal visual stimuli as long as that stimuli serves as the visual anchor.

Although levels of imbalance were slightly less, the small aperture condition also generated immersion as subjects still anchored to the larger outside framework beyond the aperture. In this condition, the stationary surface area inside *Kansas* made up 90% of the subjects FOV, and the apertures only 10%. It can therefore be concluded that a fully surrounding visual stimulus is not necessary for generating immersion when the visual stimuli presented (regardless of size) serves as the visual anchor.

What these results imply is that there are many ways to generate immersion using only visual imagery, and that the content, context, and scale of visual imagery alone can be manipulated in order to achieve greater or lesser levels of immersion. All of these results where realised in a visual immersive environment that embodied only the requisite perceptual factors of immersion *per se* defined in this study, which are described below.

6.2 Requisite Immersive Factors

The perceptual factors ‘FOV’ and ‘Physiological Effect’ defined in chapter five were the only factors at work in *Kansas*. Without these factors, a sense of immersion was not achievable, which explains why these factors can be identified in all immersive environments throughout history, from the simplest panorama to the most complex VE.

6.2.1 FOV

In virtual art environments, the FOV factor is achieved with the aid of technological devices, either an HMD or CAVE apparatus. The former narrows the FOV so that it can be fully encompassed by small virtual images projected onto the HMD’s monitors. The latter involves confining the FOV within an architectural enclosure that is integrated with the virtual world images. Thus, virtual art environments achieve the first immersive factor with the aid of VR technology. In the real world, the FOV is naturally encompassed by the expansive and fully surrounding real world environment. Similarly, in visual immersive environments, the FOV is naturally encompassed by the fully surrounding real world of the installation space, as in Eliasson’s *The Mediated Motion* (2001-), Turrell’s *1st Moment* (2003), and Janssens mist filled room (*Untitled*, 2001). Therefore, just as in the real world, in visual immersive art environments the FOV factor is implicit.

6.2.2 Physiological Effect

Virtual worlds are illusory, yet we physiologically respond to the conditions in a virtual world as if they were real. The VE at Brown University's *VisLab* presented an unstable environment, which evoked the physiological response of instability even though participants physically remained on stable real world ground. Therefore, virtual art environments meet the second immersive requirement in that they evoke visual perceptions of, and subsequent physiological responses to, illusory virtual world rather than actual real world conditions. In the real world, physiological responses to illusory conditions occur when we experience perceptual phenomena such as vection or vertigo, both of which are a product of perceptual error. Visual immersive environments also evoke this kind of perceptual error. In *Kansas,* observers perceived motion in the environment, and, even though fully aware that the actual environment they occupied was stationary, they physiologically responded to the illusory conditions (of being in motion) rather than the actual conditions (of being stationary). Just an in VE's and flight simulators, visual immersive environments evoke subconscious physiological responses to illusory rather than actual conditions, thus meeting the second requisite factor of 'physiological effect'.

All immersive art environments necessarily embody these requisite perceptual factors, but they are achieved in very different ways. Another perceptual factor that visual and virtual immersive art environments share is the phenomenon of 'perceptual error'. However, like the requisite factors above, the types of perceptual error each engenders are markedly different.

6.3 Immersion as Perceptual Error

> *"Illusions are failures of perception, delusions are failures of conception. So illusions are errors of the perceived here and now; but delusions are errors of understanding that may be very general, even to madness."* (Gregory, 2003a: 257)

Vision scientist Richard Gregory classifies two types of perceptual error as 'illusions' and 'delusions' (Gregory, 2003a). The latter describes the perception of objects, conditions, or events in the world that appear to us as real, and that we believe to be real, such as a dessert oasis, when in fact they are not. We are unaware of our perceptual error because we believe that the oasis is real and that our perceptions are correct. This falls under Gregory's classification 'perceptual error as delusion'. The former describes the perception of objects, conditions, or events in the world that appear to us as real, but we are aware that they are not. An example of this is the perceived motion in Bridget Riley's paintings, we are aware of our perceptual error, but we cannot correct it even if we consciously try. This falls under Gregory's classification 'perceptual error as illusion'.

6.3.1 Virtual Immersion: Perceptual error as delusion

> *"Total immersion, that state of virtual being that is the holy grail of the VR industry, can be characterised as a total lack of psychic distance between the immersant's body-image and the immersive environment…"* (Heim, 1998:18)

The aim of virtual immersion is to achieve a level of 'believability' that generates an experience of presence in a virtual world, and this involves reducing a participant's awareness of, or diverting their attention from, the fact that they remain physically present in the real world. As was explained in chapter 5, participants in a VE are always aware that they remain present in the real world, but if the virtual world is perceptually accurate, or more '*real in effect*', and thus more believable, a participant will experience the perceptual *delusion* that he/she is 'more present' in the virtual world than the real world (Heim, 1998; Slater, 1999, Steuer, 1992). The virtual 'Holodeck' of the TV series *Star Trek* paints a fictional picture of this ideal immersive environment, in which all of the human senses are replicated with such accuracy that participants readily perceive and experience the illusory world as the real world. Just as we perceive and believe an oasis to be real, we will perceive and believe the ideal virtual environment as real: because "*VR is an event or entity that is real in effect but not in fact.*" (Heim, 1998:111). If objects and events are perceived and experienced in a virtual world in precisely the same manner that we perceive and experience the real world, immersion arises as a result of *correct* perceptions of the *illusory* world. Thus, the concept of virtual immersion reflects Gregory's concept of perceptual error as delusion, in that the aim is to (ideally) generate the delusion that the virtual world (like the oasis) is real, when in fact it is not.

6.3.2 Visual Immersion: Perceptual error as illusion

Visual immersion works quite differently. Rather than conceal the real environment, in visual immersive environments the real world is plainly visible. Visual immersion taps into subconscious, involuntary perceptual processes, evoking the type of perceptual error of which we are fully aware, but cannot consciously correct. Visual immersion works much like a three-dimensional adaptation of the apparent motion illusion in the images of Kitayoka and Riley.

Even though we are aware of our perceptual error, our visual system makes no attempt to correct it, and we cannot wilfully correct it even if we try. What is intriguing about immersion in this context is that we are made aware of our inability to control our own perceptions, and we are obliged to acknowledge our own perceptual shortcomings. Visual immersion reflects Gregory's category of perceptual error as illusion in that it generates *perceptions of reality that are an illusion*, whereas virtual immersion evokes *the perception of an illusion as reality*. Therefore, we can say that whereas virtual immersion arises from *correctly* perceiving *illusory conditions* in a *virtual world*, visual immersion arises from *incorrectly* perceiving *actual conditions* in the *real world.*

Gregory further defines 'error as delusion' as 'error of conception' and 'error as illusion' as 'error of perception', and, according to the science of vision (Gregory 2003a) and the philosophy of Robert Irwin (Irwin, 1972a), '*perception precedes conception*'. This is a principle distinguishing feature of visual and virtual immersive art, the former focussing on *subconscious perceptual processes* that precede the *conscious conceptual experiences* of the latter. Perceptual error therefore plays a key role in both visual and virtual immersive art environments. However, the types of perceptual error they engender belong to very different classifications of perceptual phenomena of '*subconscious perceptual illusions*' and '*conscious conceptual delusions*' respectively. Thus, perceptual factors can be seen to both fundamentally connect and ultimately distinguish two very different concepts of immersion that are manifest in two very different immersive art genres. Another distinguishing aspect of visual and virtual immersive art lies in the knowledge and skills applied in their creation. Visual immersive art and vision science experiments both involve unmediated acts of observation and the generation of perceptual phenomenon in the real world. Virtual immersive art and the design and development of VR technology both involve technologically mediated physical interactions and the replication of real world imagery in the virtual world. From this perspective, interdisciplinary methods can also be seen to both connect and distinguish virtual and visual immersive art.

6.4 Technological and Scientific Models of Immersion

6.4.1 A technologically informed virtual model

Virtual immersive art depends on the interactive VR technologies that facilitate its production, and virtual artists have been credited with some of the most significant advances in VR technology. Even the concept of 'Virtual Reality' is largely attributable to the collaborative efforts of artists and engineers in the 1960's and 70's. Virtual artists are necessarily technically competent, with most having previous professional backgrounds or experience in computer technology related fields. Today's virtual artists continue to contribute to the development of their technological medium, working closely with VR technologists who share the same technological aims and methods in the development of VE's.

Virtual immersion entails conditions of 'visual saturation', or, the accurate replication in the virtual world of the rich amounts of visual information, behaviours, and interactions we experience in the real world. Therefore, technologically determined factors including image resolution, graphic update and computer processor speeds, and the levels of human-computer interaction are considered key immersive factors. Descriptions of the experience of virtual immersion focuses on subjective factors, including the user's level of engagement with and sense of presence in a virtual art world. All of these factors are unique to virtual immersion, and the technologically informed virtual model that has come to dominate current theories, definitions, and perceptions of immersive art as a whole.

6.4.2 A scientifically informed perceptual model

In pre-technological and contemporary visual immersive environments, immersion is a product of subconscious perceptual processes that function according to the scientific laws and principles of vision. In the vision sciences, perceptual mechanisms are studied in isolation from other perceptual information that may influence the mechanism, process, or phenomenon under investigation (Howard and Rogers, 2000; Benschop, 2006). Visual immersive artists use a similar method to generate immersion in visually diminished environments. In these environments and in scientific perceptual experiments the same types of perceptual error are generated that can evoke a sense of disorientation, visual illusion, or self-motion perception. Using minimal and strictly visual stimuli, these environments present the conditions required for the aesthetic experience of visual immersion, and for scientific studies of perception. This study has focused on the qualities of immersion *per se* embodied in these and historical environments, which reflect a scientifically informed perceptual model that sharply contrasts with current virtual models.

6.5 Summary of Research Findings

The research findings pertain to two independent but interwoven research threads concerning the type of creative methodology employed and the type of creative work produced over the course of this investigation. These findings are individually summarised below.

6.5.1 Immersion and immersive art

With regard to the concept of immersion in the context of visual art practice, there are three key research findings that can be summarised as follows:

1. There are at least two critical factors necessary for immersion, and the success of all immersive art environments, from the simplest panorama to the most complex VE, depends on their meeting these fundamentally perceptual criteria.

Through the development of practical works it was determined that in order to generate a sense of immersion the two fundamental immersive factors 'FOV' and 'Physiological Effect' must be met, and the research has shown that these factors can be identified in all immersive environments throughout history.

2. Immersion in its fundamental visual form is necessarily present in all immersive environments and it is a product of visual stimuli and perceptual processes alone; therefore, it can be said that immersion per se is a fundamentally perceptual phenomenon.

In chapter two, contemporary immersive art practices and historical concepts of immersion were presented, and it was shown that the factors common to both contemporary and historical immersive environments are strictly visual and perceptual in nature. In section 5.2, these factors were further explored and defined as 'FOV' and 'Physiological Effect'. In section 5.3, perceptual phenomena were explored that might contribute to or augment the sense of immersion based on these factors. Section 5.4 and 5.5 outlined the process and development of the installations *Vection* and *Kansas*, both of which emerged through the process of incorporating certain visual and perceptual phenomena that were assessed for the levels of ‘immersive effect’ they could generate. Based on the concept of ‘visual immersion’ or immersion *per se,* as it has been defined, *Vection* and *Kansas* are successful immersive environments. However, *Kansas* proved to be more effective in achieving the second immersive factor of ‘Physiological Effect’, which was attributable to the further exploration and incorporation new perceptual phenomena that were only realised during the development and assessment of *Vection*.

3. Visual and virtual immersive art environments reflect objective/perceptual and subjective/psychological models of immersion respectively. Therefore, as a creative medium, immersion comprises visual and virtual sub categories that describe two technologically, methodologically, and aesthetically unique genres of immersive art practice.

In summary, the research findings with regard to concepts of immersion and immersive art practice revolve around the fact that the fundamental concept of immersion *per se* necessarily encompasses contemporary immersive art forms as well as a long history of pre-technological immersive traditions. It has been argued that these historical traditions are perpetuated in a certain type of contemporary art practice, including my own, that has yet to be recognised and categorised as an immersive art genre. *Vection* and *Kansas* helped clarify and define immersion in its fundamental visual form, which is embodied in the work of contemporary artists including James Turrell, Anne Veronica Janssens, and Olafur Eliasson.

It is interesting to note that although many comparisons and parallel descriptions have been made about the work of the above artists and many others that could not be included in the scope of the thesis, a genre or category to collectively describe them has until now remained elusive (Bal, 1999; Brayer, 1996). It was explained in chapter one that my work has always been difficult to categorise or align with a specific genre of art practice, thus I consider this finding significant not only because a new category of immersive art that connects these works has been articulated, but also because it bears directly on my own creative practice. I am now able to situate my own work within a contemporary genre of visual immersive art that has been acknowledged and defined as a result of this research.

6.5.2 Questions of art and science

With regard to the current art-science movement and the practice of art and science collaboration, there are three key research findings that are explained below.

1. Visual immersive artists and visual scientists share confluent aims and experimental methods.

Connections between the work of virtual artists and the work of VR technologists are patently clear; and it could even be argued that the success of virtual artists Char Davies and Maurice Benayoun is attributable to their knowledge and technological skill with VR hardware and software applications. Equally, it could be argued that James Turrell's success is attributable to his knowledge of visual science. Whereas virtual artists and VR technologists share confluent aims and methods in the development and creation of VE's, visual immersive artists and visual scientists share confluent aims and methods in the exploration and generation of perceptual phenomena. The work of James Turrell and Alan Gilchrist, Olafur Eliasson and Boris Oicherman, and the immersive installations and scientific experiments that developed as a result of this investigation stand as testimony to the confluence of visual immersive art and visual science practice.

2. The knowledge and methods of science can be successfully applied to creative practice, and creative practice can contribute to the process of scientific research.

Artists Char Davies and James Turrell have both achieved a level of interdisciplinary knowledge and understanding about virtual technology and visual science respectively that they have successfully transferred to their creative practice, and this is perhaps one reason why their work has gained international recognition. The work undertaken in this study has demonstrated that the knowledge and methods of science can be conducive and successfully applied to creative practice, and that creative practice can contribute to the process of scientific research. The research set out to prove the former; the latter was a fortuitous extension of the research that was unexpected, and, like the positive reception and support received from the scientific community, could not have been anticipated. Again, these findings bear directly on my own creative work, which has explored new avenues and taken new directions as a result of the interdisciplinary knowledge and collaborative experiences gained.

3. Art can become science, and science, art.

It was explained in chapter three that visual arts research is a new academic discipline, and as such no established knowledge base, disciplinary rules, or methodological guidelines are available to visual arts researchers. What constitutes new knowledge in the field, and how or if art practice can contribute to such knowledge remains unclear. However, some progress has been made in this area. In his article *Modelling Experiential Knowledge and Research*; Simon Biggs (2006) of Hertford University explains that *objects of art* differ from *objects of arts research. A*n object of arts research is a receptacle for knowledge, the value of which can only be identified through its transformation into communicable knowledge. The same applies to objects of science; it is the means for *value extraction* that determines whether an object is science or art. From this perspective, a single object can be both science and art, and at the same time, if that object embodies value that is extracted and communicated within both fields. *Kansas* functions as both a scientific experimental apparatus and an immersive art installation. As an object of art, *Kansas* was perceived as art when exhibited in a visual art context, and, as an object of science, *Kansas* was perceived as science when exhibited in a scientific context. *Kansas* embodies new knowledge pertinent to creative concepts of immersion and to scientific concepts of perception, which was communicated to the scientific community by means of scientific demonstration and publication, and to the creative community by means of art exhibition and this thesis. Therefore, as a single object embodying extractable and communicable scientific and creative knowledge, it can be argued that *Kansas* is an object of art and an object of science at the same time.

The paintings of Bridget Riley and Victor Vaserely are amongst many two-dimensional artworks that have contributed to the process of scientific research (Cutting, 2002; Frankel, 2005; Zanker, 2006). This study has found that the reverse is also true; scientific research can contribute to the process of creative practice. The point of departure in this investigation has been the focus on three-dimensional rather than two-dimensional artworks, and the recognition of genuine confluences in creative and scientific methods and practices. As a result of these confluences, the collaborative work undertaken proved useful within both domains, which provides evidence that the methods of art and science can be mutually conducive, and that collaborative work can be concurrently and equally productive. The implications of the overall research findings, outcomes, and conclusions are outlined in the following chapter.

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Chapter 7: Conclusions

Introduction

In the visual arts, as in many disciplines, immersion continues to carry various meanings, definitions, and interpretations, all of which have developed a strong association with VR technology and interactive VE's. In the field VR technology and virtual art practice, interactive VE's are a presumed precondition for immersion, and as such, a technologically informed virtual model has come to dominate art theoretical discourses and visual art practice. Although authors including Oliver Grau (2003), Joseph Nechvatal (1999), and Laurie McRobert (2006) and others acknowledge pre-technological immersive environments, the concept of immersion that these and certain contemporary art environments embody has yet to be investigated and defined. Interactive virtual art environments are necessarily immersive; however, immersive art is not necessarily interactive or virtual. The implication of this is that concepts, theories and definitions of immersion are being shaped by a newly emerging body of literature that focuses strictly on virtual immersion and interactive virtual art, therefore current understandings of immersion are developing around an incomplete account of immersive art practice.

The fundamental factors required for immersion will necessarily be present in all immersive environments; therefore, immersion *per se* cannot be a product of interaction or virtual technology, both of which are exclusive to virtual art. This raises questions as to what criteria determine whether an artwork is immersive or is not, and what immersive factors do historical and contemporary immersive art environments share. This research has argued that the fundamental and requisite factors of immersion *per se* are neither interactive nor virtual but perceptual in nature, thus it can be said that immersion is a fundamentally perceptual phenomenon.

7.1 Original Research Goals

Claims and Hypotheses

Central to the thesis is the claim that a new model of immersion is needed if we are to develop a broader understanding and a more comprehensive account of historical and contemporary immersive art practice. The research commenced from the hypothesis that immersion *per se* is a product of perceptual rather than virtual factors. The research methodology developed around a second hypothesis; that in the generation of perceptual phenomena, immersive art and visual science share confluent aims and experimental methods, therefore, the knowledge and methods of visual science are pertinent to an investigation of immersion.

Aims and Objectives

Initial objectives were to identify and investigate common immersive factors, and to develop a new model of immersion *per se* based on these factors. The practical objective was to apply this model in the development of new immersive art environments that reflect a pre-technological concept and model of *visual* immersion that encompasses all immersive art forms. The goal of practical and theoretical work was to define and distinguish different concepts of immersion and different genres of immersive art, the aim being to develop a broader and more comprehensive account of historical and contemporary immersive art practice. Initial methodological objectives were to become familiar with current research topics in the field of vision science, to gain a basic scientific understanding of perception, and to identify and develop liaisons with scientists in research areas pertinent to this study. The aim was to combine scientific and creative concepts and methods in collaborative investigations of immersion and perception. The purpose of this methodological approach was threefold: first, it would test the hypothesis that immersive art and visual science share confluent aims and methods. Second, scientific knowledge of vision would shed new light on the role that perceptual phenomena play in the generation of immersion. Third, if collaborative work proved to be of both aesthetic and scientific value, a successful methodological model will have been realised.

7.2 Research Outcomes

The research outcomes present evidence that bears on current assumptions in two areas of visual art practice. The first concerns the concept of immersion, and challenges current perceptions and the presumed preconditions for immersion. The second concerns the relationship of art and science, and challenges the presumed dichotomy of creative and scientific disciplines.

With regard to the former, the research identified and investigated the fundamental immersive factors present in all immersive environments, the outcome of which was the development of a new perceptual model of immersion and new visual immersive art environments that reflect this model and the scientific laws and principles to which it conforms. With this model, it was possible to define a pre-technological concept of visual immersion, and to categorise a genre of contemporary art practice that perpetuates a long history of pre-technological immersive traditions.

With regard to the latter, it was hypothesised that in the generation of perceptual phenomena, visual immersive art and visual science share confluent aims and experimental methods. Based on this hypothesis, a collaborative art and science methodology was adopted, the outcome of which was a body of experimental immersive environments created in collaboration with visual scientists. Using strictly visual stimuli, these environments demonstrated the requisite factors of immersion *per se* as defined in the thesis, while concurrently providing data that shed light on scientific questions about perception. In embodying both aesthetic and scientific value, the work confirmed two research hypotheses: that the concept and requisite factors of immersion *per se* are perceptual in nature, and, that in the generation of perceptual phenomena, visual immersive art and visual science share confluent aims and experimental methods.

An unanticipated further outcome was the submission of a joint scientific paper detailing the work to the 2004 *European Conference on Visual Perception* (ECVP) in Budapest, Hungary. In support of the paper, *Kansas* was reconfigured and reinstalled as a scientific demonstration at the conference venue. The ECVP paper was a fortuitous extension of the research that is pertinent to both the creative concepts and models of immersion developed in the thesis, and to larger questions of when, and if, art can become science, and science, art.

7.3 Research Conclusions

Based on the above outcomes, four key research conclusions can be summarised as follows:

1. *Immersion per se is a fundamentally perceptual phenomenon.*

The research identified and defined the fundamental factors common to all immersive environments as ‘FOV’ and ‘Physiological Effect’. It was shown that these are requisite immersive factors that can be generated using strictly visual stimuli and perceptual phenomena alone.

2. *As a contemporary creative medium, immersion comprises perceptual and virtual models and respective genres of visual and virtual immersive art.*

The research has shown that a comprehensive description of historical and contemporary immersive art practice requires both perceptual and virtual models of immersion. The former is embodied in a long history of pre-technological immersive environments and in a contemporary genre of visual immersive art that until now was not recognised as such.

3. *The methods and aims of virtual immersive art are closely aligned with VR technology, and the methods and aims of visual immersive art are closely aligned with visual science.*

Whereas the parallel aims and methods of virtual art and virtual technology are patently clear, this research revealed equally strong parallels in the aims and methods of visual immersive art and visual science.

4. *In the context of visual immersive art and visual science, art can become science, and science, art.*

Parallel interests, aims, and methods in visual immersive art and visual science provided a platform for collaborative work, and in exploiting these parallels, the research developed practical works that embodied both scientific and aesthetic value. When placed in the context of visual art, the work was perceived as art within the art community, and when placed in the context of science, the work was perceived as science within the scientific community. Therefore, the work is both an object of science and an object of art at the same time, providing evidence of one instance when art can become science and science art.

7.4 Research Contributions

7.4.1 Immersion and immersive art

It has been argued that current concepts of immersion and immersive art are based on an incomplete account of immersive art practice, and that the creative medium of immersion is comprised of virtual and visual creative sub-genres, reflecting virtual and perceptual models of immersion respectively. These models mirror subjective/psychological and objective/perceptual schools of thought on immersion within other fields, including literature, film, science, and technology. The perceptual model developed in this study reflects the latter school of thought, which, until now, has not been available within the field of visual art. The research has shown that this model describes a fundamental concept of immersion *per se* that is determined by visual and perceptual processes alone.

Although fundamentally and categorically connected, visual and virtual immersive art environments are technologically, methodologically, and aesthetically unique. Reflecting a technologically informed virtual model, the latter emphasises subjective aspects of immersion determined by psychological and emotional engagement with a virtual world. Reflecting a scientifically informed perceptual model, the former emphasises objective aspects of immersion determined by sub-conscious perceptual processes in the actual world. Thus, as a creative medium, the research reveals that immersion is comprised of visual and virtual sub-genres, which reflect scientifically informed perceptual and technologically informed virtual models respectively. The art environments of James Turrell, Olafur Eliasson, and Anne

Veronica Janssens collectively illustrate a perceptual model and the concept of visual immersion developed and defined in the thesis. These works, and the work produced as part of this study, sharply contrasts with current concepts of immersive virtual art. The research has distinguished, categorised, and collectively located these works and a long history of pre-technological immersive traditions within a new genre of visual immersive art.

Until now, debates on immersion in the visual arts have revolved around only one model of immersion and only one type of immersive art practice. A key research contribution therefore lies in distinguishing and defining different models of immersion and categorising different genres of immersive art practice. The research has developed new concepts and defined a new model that encompasses all immersive art forms, acknowledging a long history of immersive traditions and a type of contemporary art practice that, until now, had not been collectively recognised as an immersive art genre. The research therefore contributes new knowledge in that it has developed a broader and more comprehensive account of immersive art practice, extending both current understandings of immersion and its scope as a creative medium.

7.4.2 Art and science

> *"Despite a fascinating history and the vibrancy of current practices internationally, there is a paucity of scholarly literature on interdisciplinary collaboration involving artists"* (Shanken: 278)

Art and science collaboration is a prominent and popular practice in the visual arts, and the proliferation of art and science opportunities have brought with them a pressing need for new methods and collaborative strategies, something recently noted by art historian Edward Shanken:

> *"Given the increasing dedication of cultural resources to engaging artists and designers in science and technology research, there is great need for scholarship that analyzes case studies, identifies best practices and working methods, and proposes methods for evaluating both the hybrid products of these endeavours and the contributions of the individuals engaged in them."* (279)

This research has brought genuine and significant methodological and practical parallels to light in areas of art and science that provide a strong and as yet unexplored platform for collaborative exchange. In light of current debates and questions raised by the art-science movement, the research contributes to the field by providing one case study and one methodological example of art and science collaboration, and by making one possible collaborative strategy available for future researchers interested in art and science or interdisciplinary research in general.

7.5 Research Implications

The methodology employed and some of the claims and propositions put forward in the thesis will likely encounter scepticism from members of the arts community who consider scientific methods to be anathema to the very nature of creative practice. Less than positive reports from completed organised art and science collaborations would support this argument (Anderson, 2001; Ede, 2000; Cohen, 2001). However, many of these projects lack research and planning with regard to the pairing of particular artists and types of art practice with particular scientists and areas of scientific research[65]. It is my contention that the potential benefits of combining creative and scientific methods, and interdisciplinary research in general, are undervalued and under explored in contemporary visual art practice. This is possibly because, in the UK, an artist's higher education is comprised largely of 'self-directed' studies, offering little to no exposure to the methods and practices of disciplines outside the field of art.

A fact widely acknowledged in scientific circles, and noted by authors including David Bohm and F. David Peat (1987), Alva Noe (2000), Howard Eysenck (1995), Moti Nissani (1995b) Patrick Cavanaugh (2005), Vera John-Steiner (2000) and many others, is that some of the greatest contributions to knowledge have come from creative thinkers with a scientific bent, and scientific thinkers with a creative bent. What such individuals possess is the ability to discover new ways to apply the knowledge and methods gained in

65. There are some examples of successful collaborations. See Arends (2002) for a description of the completed collaborations funded by the Wellcome Trust. Of the twenty or so projects described, there are at least two in which participants have equally gained from the project. This is because they ultimately share some common thread that was the basis of the collaborative work undertaken.

one field to the benefit of the other. In most cases, these individuals have some basic knowledge, interest, or skill that spans a creative and a scientific discipline. In the context of current art-science initiatives however, there are limitations as to how and when this can work. Reflecting on the experiences gained over the course of this research, I would conclude that successful exchange between art and science depends on the presence of three critical components. The first is an identifiable common interest, topic, or idea to which both parties can contribute fresh ideas and that both wish to see from new perspectives. The second is basic background knowledge of key theoretical positions, key questions posed, and the key terminology employed within the scientific field involved. The third and perhaps most important is a clear understanding of and respect for the scientific method and all that it implies. Using immersive art practice as a vehicle and applying these guidelines, the research has shown that this is a plausible and potentially successful methodological approach.

7.6 Future Directions

Over the course of this research, several potential avenues of investigation were revealed that could not be fully explored. One such avenue revolves around the distinct divisions in immersive art practice that can be traced to the 1960's invention of VR technology. Further research into the events and consequences of this historical moment may shed light on how and why the concept of immersion became enmeshed with concepts of interaction. Around the same time of VR's inception, a new theory of vision was proposed by James J Gibson (1966); concurrent events that were to have significant consequences for both visual art and visual science. There is scope for further research into the parallels between Gestalt and Gibsonian approaches to perception, and the methods of visual and virtual immersive art respectively. This study has focussed on the former; what could not be covered here are the equally remarkable parallels between Gibson's 'ecological' theory of vision (1966), and theories of virtual immersion (Laurel, 1991; Davies, 2004). In vision science, Gestalt and Gibsonian perspectives represent two sharply contrasting but equally valid models of perception, which parallel sharply contrasting but equally valid models of immersion in the visual arts.

Gibsonian approaches in vision science include the work of Bill Warren and others at Brown University's *VisLab* who use VE's for experiments on perception and navigation[66]. In these studies, perception is considered an emergent property of our movements and interactions within the environment, and thus cannot be studied in isolation from it (Gibson, 1966, 1968). Ecological

66. See <http://www.brown.edu/psychology/warren.html> [Accessed 10/10/07].

theories of perception reflect the creative concepts of 'emergent meaning' (Nechvatal, 1999; Seaman, 1999) and 'embodied engagement' (McRobert, 2006; Davies, 2004) in virtual art practice. I believe, as does scientist Bill Warren[67], that the latter is a valuable and as yet untapped research area for virtual artists and vision scientists.

The science of perception is particularly pertinent to immersive art, but also to visual art practice in general, offering a vast resource of knowledge and methods that have yet to be fully explored and exploited by artists. Similarly, the science of visual perception has much to gain from taking scientific studies of artworks beyond the two-dimensional realm. During the course of this research there has been exponential growth in the number of art and science opportunities available, and a majority of the visual scientists I met and worked with expressed a long-standing interest in visual art that was evidenced in the way my own research was received and encouraged. Yet, these scientists, and the field of vision science in general, are largely unaware of the number of opportunities now available for art and science related research. This is partly because many highly publicised and highly funded collaborations have involved areas of scientific research, that, in my opinion, are much less sympathetic with, and less conducive to the methods and interests of creative disciplines. It is also due in part to creative practitioners having little knowledge of the diversity of scientific research areas pertinent to visual art practice. It is hoped that this research will encourage artists to become familiar with areas of science that can feed into and help develop their particular creative practice. This way, new and independent collaborative opportunities will naturally

67. Personal communication, March 2003, Brown University, Rhode Island, US.

emerge, and vision science in particular will be recognised for its potential as an arena for collaborative work.

My own practice continues along the same line of enquiry, and further work with vision scientists who have expressed interest in collaborative research is already underway. Coupled with the work of the visual immersive artists described in the thesis and many others working in a similar vein, the research findings, with regard to both the concept of visual immersion and art and science collaboration, promise to be further substantiated in the future.

7.7 Recent Developments

Since this study began, the interest in art and science collaboration has continued, albeit in various guises and contexts. Foremost amongst the organisations interested in art-science ventures is the National Endowment for Science, Technology, and the Arts (NESTA). NESTA has emphasised the importance of interdisciplinary training and collaborative research as a catalyst for innovation. A number of higher education institutions have been awarded NESTA grants to pursue alternative methods of education. *The Leonardo Effect* is a recent NESTA pilot project undertaken at St Mary's University College, Belfast, which sought to bridge the art-science divide in primary school environments by giving equal weighting to both subjects[68]. The project has proven a great success, with students learning '…*more in a week than we might have expected in a term and in a deeper way…*" (McLarty:1). Similar projects have since been launched across the UK. NESTA's CONNECT programme and Crucible project also encourage research communities to see their roles in a wider context, and to collaborate with other disciplines. Over the past five years, the benefits of interdisciplinary research have become widely recognised and are increasingly acknowledged as a viable approach to both academic and creative practice. *The Leonardo Effect* project is particularly exciting. The type of highly funded art and science collaborations such as the Wellcome Trust's has declined over the last few years, and I believe this is because most were not successful. I believe that current interests in interdisciplinary approaches to education, particularly at primary school level,

68. See *The Leonardo Effect: a research report*, available online at http://hdl.handle.net/2428/15217 (Accessed October 28 2008)

will prove much more beneficial in the long term, as this promises to make future engagements between art and science a conventional and more constructive practice.

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<http://www.nesta.org[Accessed 25/10/08]

List of Conferences Attended

2002

Association of Art Historians (AAH), April 5-7, Liverpool, UK
European Conference on Visual Perception (ECVP), Aug. 25-29, Glasgow, UK
(www.ecvp.org)

Fall Vision Meeting (FVM), Oct. 24-27, San Francisco, CA, US
www.osavisionmeeting.org)

Psychonomics Society, Nov. 21-24, Kansas City, MO, US
(www.psychonomic.org)

ArtSci 2002: International Symposium on Collaboration, Art and Science Collaborations Incorporated (ASCI), Dec. 6-8, New York, NY, US
(www.asci.org)

2003

Vision Sciences Society (VSS), May 9-14, Sarasota, FL, US
(www.visionsciences.org)

European Conference on Visual Perception (ECVP), Sept. 1-5, Paris, France

Reith Lectures:The Emerging Mind, Lecture 3: The Artful Brain, Apr. 23, Birmingham, UK. (www.bbc.co.uk/radio4/reith2003/lecture3.shtml)

2004

European Conference on Visual Perception (ECVP), Aug. 22-26, Budapest, Hungary
Paper delivered: Kansas. Authors: L M Nolan (School of Arts and Social Sciences, Northumbria University, UK), James Intriligator (Dept. of Psychology, University of Bangor, UK) Alan Gilchrist (Dept. of Psychology, Rutgers University, US)
See: Nolan, L, Intriligator, J., Gilchrist, A, (2004) 'Kansas' Perception, Vol. 33, page153
Available online at: www.ecvp.org/2004/ (Accessed October 28 2008)

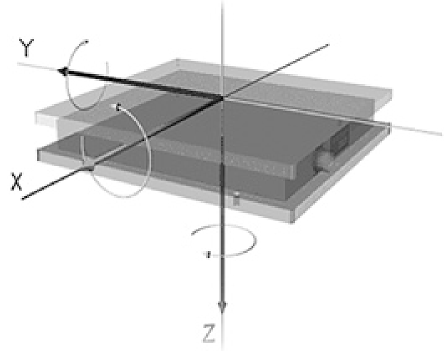
2005

Experiment-Experimentalism, Mar. 11-12, Manchester, UK
(www.surrealismcentre.ac.uk)

European Conference on Visual Perception (ECVP), Aug. 22-26, A Coruna, Spain

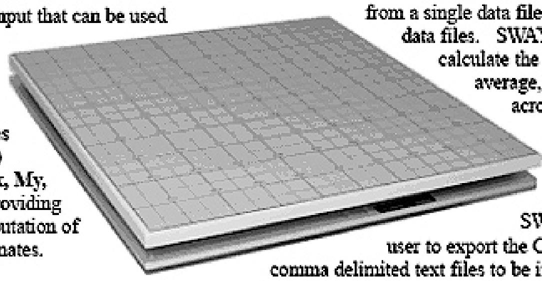
AccuSway PLUS

For Balance and Postural Sway Measurement



DESCRIPTION
AMTI's AccuSway PLUS system is a complete solution for quantifying and evaluating human balance. AccuSway PLUS was developed and built to be economical, portable, and easy to use.

The AccuSway PLUS:
- provides a large 50 x 50 cm support surface
- can be used with a desktop or laptop computer
- plugs directly into the R232 port of the computer
- contains complete built-in electronics
- has an external trigger input that can be used to synchronize data
- weighs only 11.4 Kg
- is only 4.4 cm high



The AccuSway PLUS **measures the three forces (Fx, Fy, Fz) and the three moments (Mx, My, Mz)*** involved in balance, providing outputs that allow easy computation of the center-of-pressure coordinates.
(*U.S. Patent #5,339,699)

A grid on the surface of the platform provides base-of-support coordinates which can be combined with the balance data, allowing the center-of-pressure (COP) to be plotted relative to the subject's position

SOFTWARE
AMTI's SWAYWIN95 postural sway measurement software acquires, analyzes, and plots data from the AccuSway PLUS platform at a rate of 50 sets per second. SWAYWIN95 performs a comprehensive analysis of the sway data and presents many summarizing parameters. One particularly useful parameter, the area of a 95% confidence ellipse, may be used to track time related sway in balance due to the effects of drugs or therapy. Other results include the length of the path of the COP and the average velocity of the COP. Other parameters calculated by SWAYWIN95 are listed on the right.

ISO 9001 CERTIFIED
AMTI

SWAYWIN95 offers various plots of the sway data, including:
- color or black& white plots
- batch processing of plots
- the COP path on the force plate.
- actual boundaries of the 95% confidence ellipse.
- elliptical area vs. time plots during the test.
- Fast Fourier Transform (FFT) which shows a spectral analysis of the data.

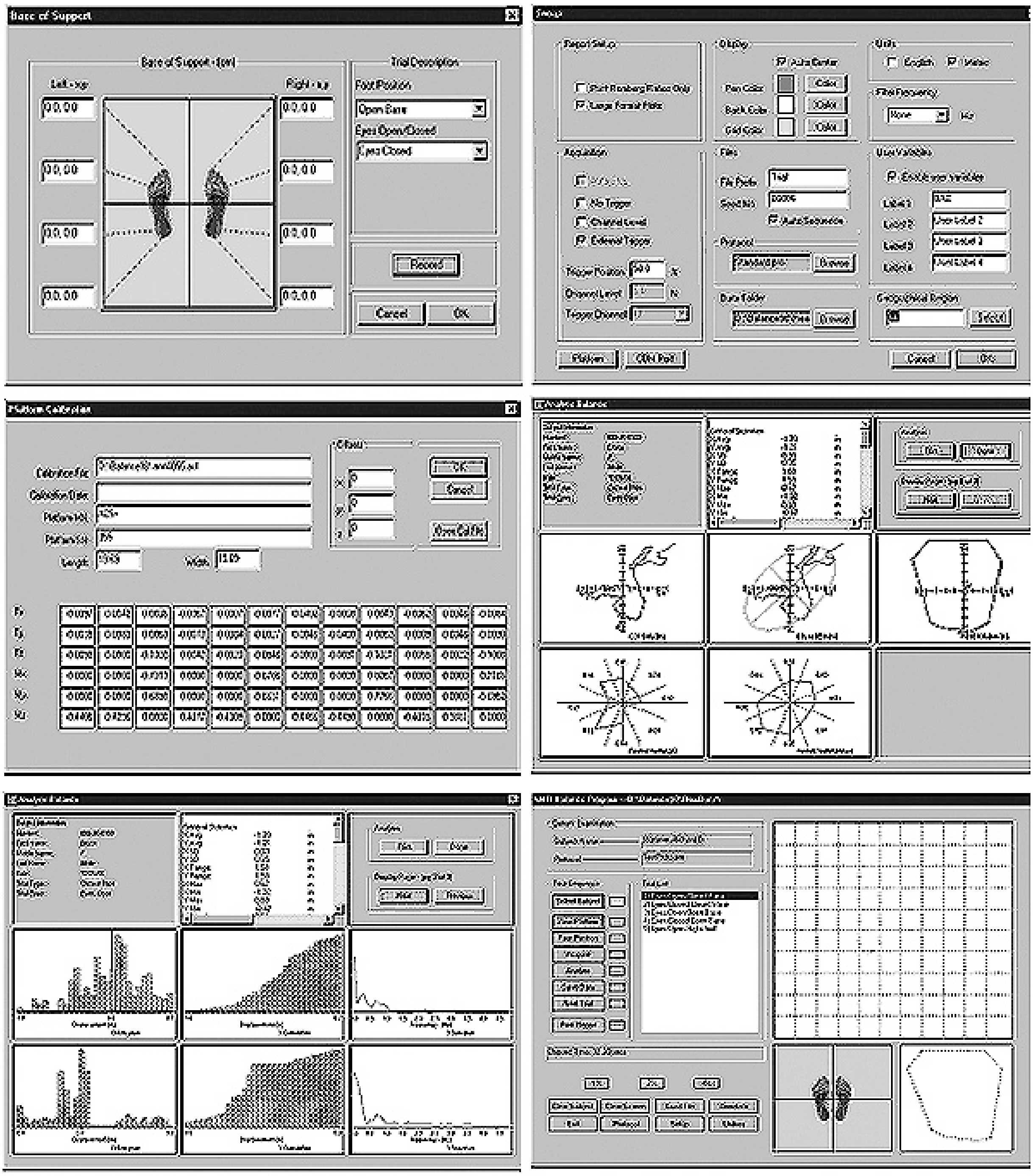
SWAYWIN95 calculates statistical parameters using data from a single data file or from multiple sets of data files. SWAYWIN95's ability to calculate the minimum, maximum, average, and standard deviation across a set of data files allows the easy compilation of a baseline for any study.

SWAYWIN95 allows the user to export the COP and analysis data to comma delimited text files to be imported into spreadsheets like Excel, LOTUS, etc., for further analysis.

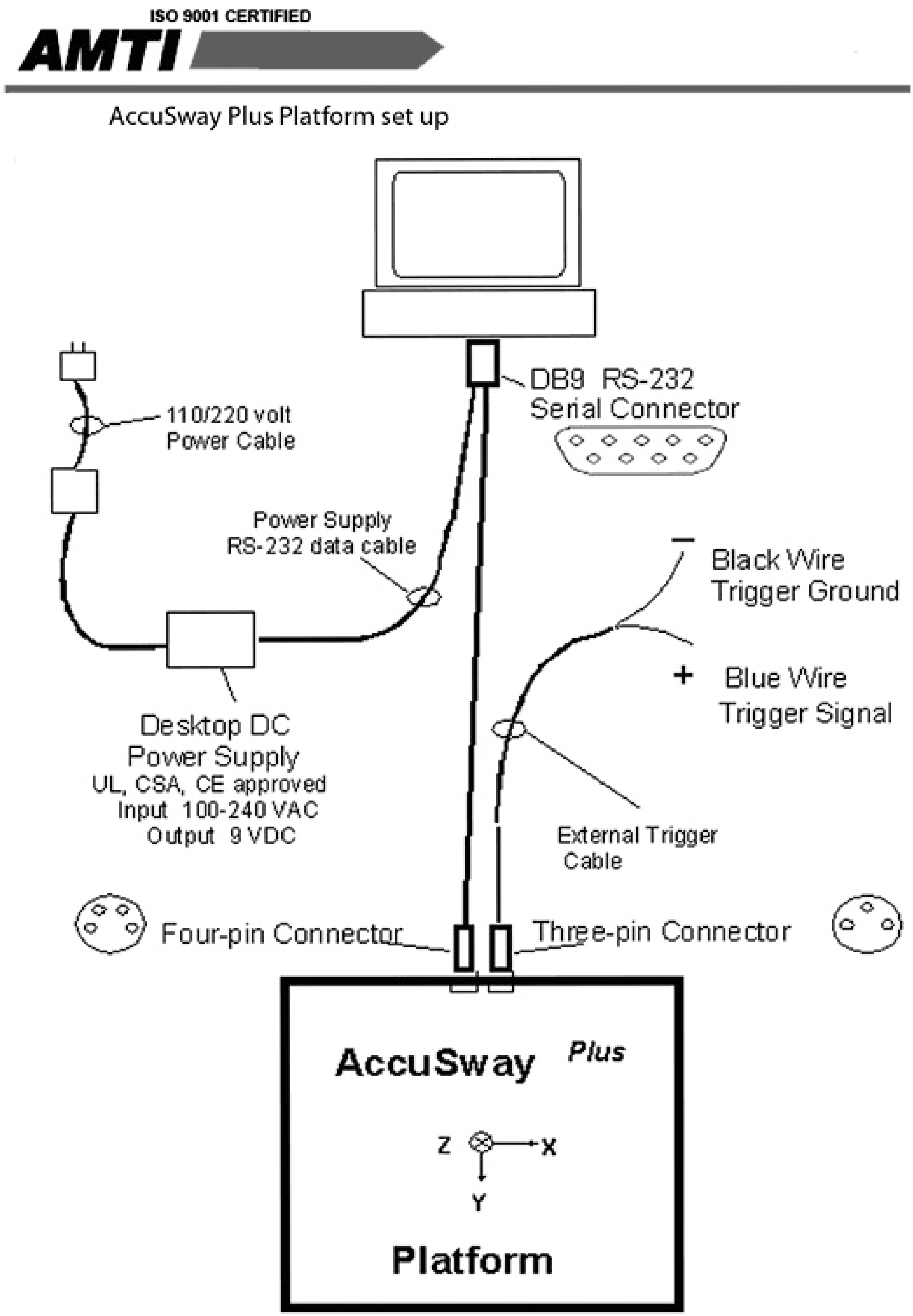
Parameters Calculated by SWAYWIN95

dT	Sampling interval
N	Number of data sets
Xo,Yo	Mean position of COP
Xs,Ys	Standard deviations of the coordinates of the COP
Xm,Ym	Mean deviations of the coordinates of the COP
Rm	Mean displacement of X,Y from Xo,Yo
Rs	Standard deviation of the displacement of X,Y from Xo,Yo
Cc	Correlation coefficient of X and Y
Is	Standard deviation of displacement along the axis of maximum standard deviation
IIs	Standard deviation of displacement along the axis of minimum standard deviation
Theta	Rotation required to bring the X-axis to the Is axis
L	Length of path of the COP
VEL	Average speed of COP along it's path
Ao	Area included within the path of the COP
A95	Area of the 95% confidence ellipse
ABOS	Area of the base-of-support

AMTI

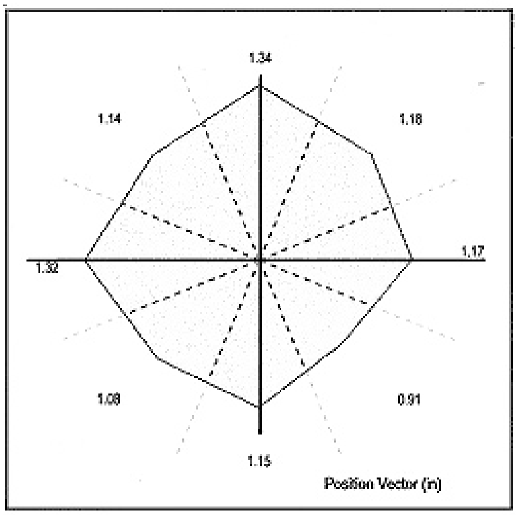


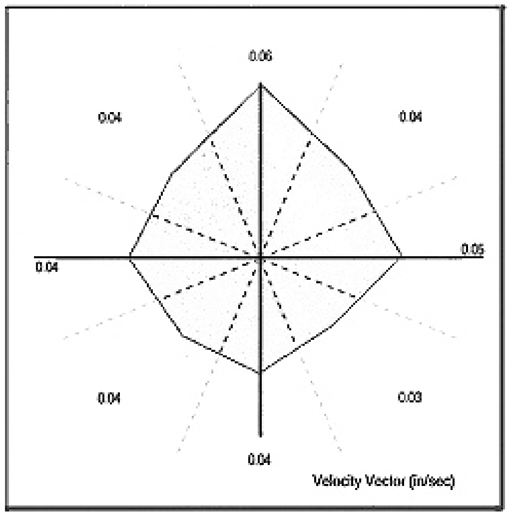
AMTI User Manual Balance Clinic: Version 1.1

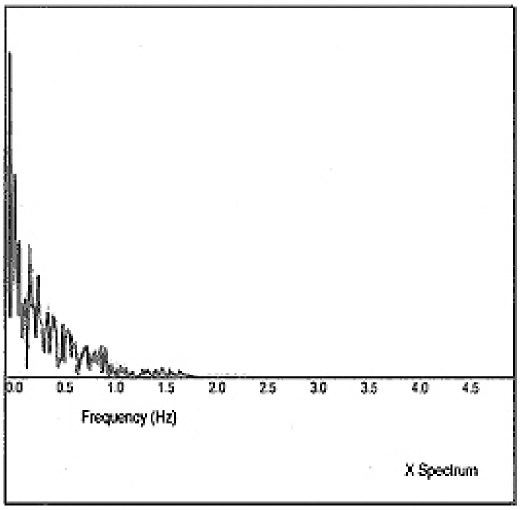

ISO 9001 CERTIFIED
AMTI
AccuSway Plus Platform set up
DB9 RS-232
Serial Connector
110/220 volt
Power Cable
Power Supply
RS-232 data cable
Black Wire
Trigger Ground
Blue Wire
Trigger Signal
Desktop DC
Power Supply
UL, CSA, CE approved
Input 100-240 VAC
Output 9 VDC
External Trigger
Cable
Four-pin Connector
Three-pin Connector
AccuSway Plus
Z
X
Y
Platform

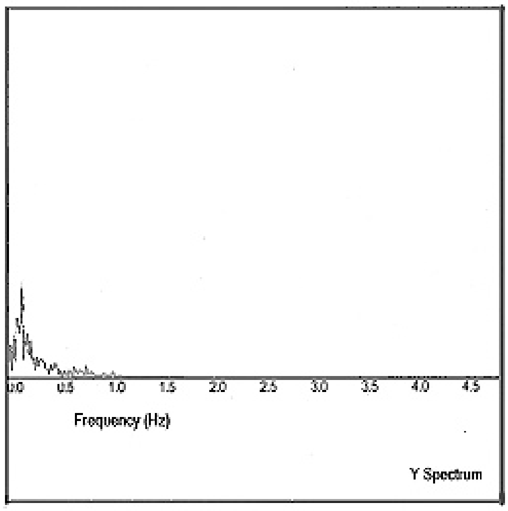
Balance Test

Trial Name: KANSAS
Subject Information
Number: 33
First Name: [redacted]
Last Name: [redacted]
Date: 24/05/04
Trial Type: Large Aperture
Eyes: Open Feet: Together









Balance Test

Trial Name: KANSAS
Subject Information
Number: 33
First Name: [redacted]
Last Name: [redacted]
Date: 24/05/04
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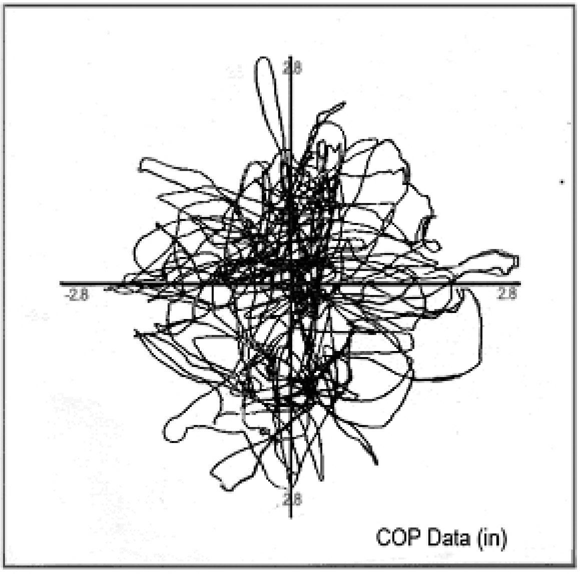

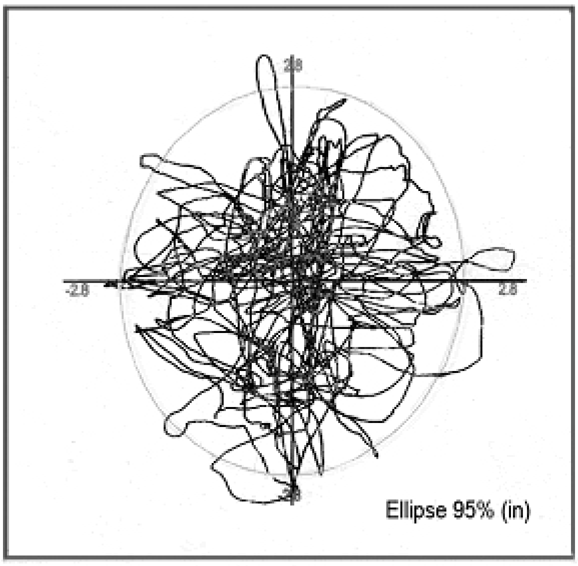

May 15th 2004

An account of an art/science collaboration

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In April 2004, I spent a week in Newcastle, UK, at Northumbria University to participate in an art/science collaboration with Lucille Nolan and others in the department of fine art. Based on earlier discussions about visual perception, Lucille had created an installation that created the illusion that one is standing inside a small room that seems to be moving through the streets of Newcastle. We used the installation to conduct an experiment in visual perception, testing a total of 88 subjects. Each subject stood inside the 7 ft by 9 ft room facing one window straight ahead and with two side windows, one on each side. Video footage was projected onto screen located at some distance behind each window. The footage was taken by mounting three video cameras, facing three directions, on a special tripod atop an automobile that was driven around the city. The subject felt as if he or she was moving with the room. This arrangement is scientifically interesting because it bears on the question of how the visual system determines what is moving and what is stationary (the anchor). The interior of the room fills most of the subject's visual field, but the scene perceived to lie outside the room is perceived to occupy a larger 3D space. If the scene that fills the largest part of the visual field serves as the anchor, the subject should not experience self-motion. If the largest perceived framework serves as the anchor, both the room and the subject should appear to move. This is what happened. Indeed several subjects actually fell over. We ran two conditions of the experiment, using windows of two sizes. The larger windows were three times as high and wide as the smaller windows. Subjects stood on a force plate, which is a computer operated transduction device that continuously records the centre of force (the need to correct for balance) of the subject. Our subjects showed less stability in the large windows condition. This proved that the largest perceived framework serves as the anchor. The installation was unique in the sense that the subject and the immediate environment were both perceived as being in motion rather than the subject experiencing self-motion within a stationary environment, which is usually the condition created for such visual experiments. The success of this pilot project has stimulated many ideas for future experiments and art installations.

Anchoring in Lightness and Motion Perception

Question: How parallel are the principles of anchoring in lightness and motion?

Both lightness and motion perception are based on the encoding of relative stimulus values (relative luminance and relative motion). Thus in each case a rule is required that converts relative values into absolute.

Some common themes:

Percept relative to frames of reference

-Lightness (Koffka, 1935; Gilchrist et al, 1999)
-Motion (Duncker, Wallach)

Frameworks strengthened by articulation

-Lightness (Katz, 1935; Gilchrist et al, 1999)
-Motion (Bonato,)

Frameworks strengthened by larger area

-Lightness (Li and Gilchrist, 1999)
-Motion: Largest framework appears stationary (Duncker)

Retinal area versus perceived area

-Lightness Framework strength depends on perceived area, not retinal area (Cataliotti & Gilchrist, 1995; Bonato & Gilchrist, 1994)
-Motion: ? (Howard and Heckmann, 1989)

Role of multiple frameworks:

-Lightness: Percept is a weighted average of values computed in local and global frameworks (Kardos, 1934; Gilchrist et al, 1999)
-Motion ?

The Kansas installation lends itself to several research questions:

1. What is the relative strength of retinal area and perceived area in induced self-motion (vection)?
2. Does self motion show a compromise between separate frameworks, as lightness does?
3. Does retinal area influence this compromise?

Logic: The stationary room (inner framework) fills most of the observer's visual field. But the environment perceived to lie outside the room (outer framework) constitutes the largest perceived framework. If retinal area governs, perceived self-motion should be minimal and observers should remain balanced. If perceived area governs, strong self-motion should occur with loss of balance.

A pilot study: variable window size

Parametric component: Windows of two sizes were created, 12 by 12, and 36 by 36 inches. If only perceived framework size is important, window size should make little or no difference. If retinal area plays some role, window size should matter.

Methods

Apparatus: Kansas, an installation consisting of an 8 x 10 foot room containing three windows. Moving video images recorded by 3 video cameras mounted atop a moving car, and facing in three directions, were projected onto 3 screens located 5 ft. (middle window) and 2 ft. (side windows) behind the three windows. This stimulus was designed to create the impression that the observer was inside a moving room.

The observer stood facing the middle window, standing on a 18 by 18 in. force plate that recorded the moving center of force. Balance was assessed by the size of an ellipse enclosing 75% of the locations of the center of force during a three-minute exposure.
Observers: 30 Art and design students at Northumbria University.

Preliminary Results

1. All observers experienced self motion (vection), despite being surrounded by a stationary room, showing the importance of the largest perceived framework and corroborating findings of Howard and Heckmann (1989). This suggests that perceived area is more important than retinal area.

2. Vection was greater with larger windows. Two observers in this condition actually fell down. This suggests that both frameworks have an influence on vection and that the retinal area influences the relative weight of these.

Planned studies

1. In a comparison study, the 3 screens on which the moving images are projected will be mounted inside the room, several inches in front of each window. This will create the same flow fields on the observer's retina, but not the experience of a larger, outer framework.

2. A window on the floor will be added to test the effectiveness of stimulation in the lower part of the visual field.

Kansas

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We present an exhibit called Kansas, which is both an art installation and a visual perception apparatus. The observer steps into a small room containing a number of windows. Computer-generated flow fields are projected onto screens located beyond each window and create the visual impression that the observer is moving through space. However, because the room itself appears stationary in relation to the observer, only one solution is possible for the visual system – both the observer <u>and</u> the room are moving through space together. In essence, the observer feels the motion (via vection) and the room "goes along for the ride."

As an art installation, *Kansas* demonstrates that a sense of immersion depends on the nature of the visual stimulation, and that immersive art forms can be achieved without complex virtual reality/interactive technology. As a vision experiment, Kansas is being used to investigate the rules of anchoring in the motion domain. It is known that the largest framework appears stationary and serves as the anchor for relative motion. But "largest" can be defined in retinal or perceived terms. The interior of the room fills most of the observer's visual field, but the flow fields (seen through the windows) create the experience of a larger framework outside the room. We find that this phenomenal framework functions as the anchor. As an art/science collaboration, the exhibit suggests the individual benefits of installation artists and visual scientists working together.