Gaming and Photography:

Investigating the Elision of Illusion and the Actual

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Abstract

The application of aesthetics and techniques from photography into computer generated images leads audiences to read images of a virtual space similarly to images of a physical space. This phenomenon has allowed for a continuation in the cultural fascination with photorealism, and cases of audiences mistaking images from the virtual space as ‘real’.

This thesis looks in detail at how the boundaries between the virtual and physical space shift when approaching the virtual space of a video game from the perspective of a photographer, rather than a player. It looks in detail at how audiences interpret images of the virtual space of video games when displayed in a form reminiscent of art photography.

Photographs of the virtual and physical spaces were produced for online surveys and an exhibition to test audience perceptions of image origin. Participants were also asked to try and distinguish photorealism in the landscape form, urban form, and material form.

Technical analysis of audience responses, combined with textual analysis of the images themselves, helped in determining the types of content, as well as styles of photography that were used by the audience as indexes to reality in the virtual space. In some cases, the technical theory could explain the thought process of the participants, however in other cases there were dominant factors that more significantly impacted participant interpretations, despite what theory suggested. This highlighted the blur that is emerging between the physical and virtual spaces.

There were difficulties in designing tests that could identify and isolate the elements that influenced perceptions of photorealism, due to the complex, and sometimes unexpected, ways in which people made judgments about the images. A variety of factors and areas for future research arose from the tests, including using the medium of photography to document the ever-changing landscape of the virtual space.

01 Introduction

Video games offer an emerging form of space that has both similarities and differences to physical, real-world space. It is a new type of space that has been well documented by video game players with their focus on high scores, completions and glitches, but is now being explored by artists and photographers for different, more perceptual reasons.

As an artist, I am interested in capturing virtual space through photography and using it to create photographs as art and documents. As a researcher, I am interested in the ways in which people are interacting with video game spaces and how they interpret these virtual spaces when remediated and aligned with other forms of visual media.

To highlight some examples of this new interest in the virtual space, Eron Rauch is an artist who has printed a series of images from a virtual space entitled 'A Land To Die In' (Rauch, 2008). This series shows landscapes, glitches and corpses of in-game avatars. It challenges the validity of using the virtual space of games to create art, while also questioning who might own the art produced. Joseph DeLappe (2006-2011) uses the virtual space of the game 'America's Army' as a medium to create a memorial and a protest. He enters the virtual space with other players with the name 'dead-in-Iraq' and types the names of dead soldiers using the games text console that appears on all players' screens. This is done partly as a memorial to those who died and partly in protest to the atrocities of war. Since starting this thesis a more recent collaborative example has emerged. Users of the photographic social networking site 'Flickr' have set up a group where users have added their own images created in 'Grand Theft Auto 5' (GTA5) (Rockstar Games, 2013). The images mimic romantic landscape aesthetics of painting showing a similarity in the desire to represent the beauty in the virtual space by aligning it with an aesthetic approach used by painters to represent beauty in the physical space. Furthermore, the ability to have variable light in the virtual space has enabled people to make time-lapse videos within GTA5 capturing the

progression from sunrise to sunset. These examples use a grammar close to that of photography and cinema and show a growing desire to capture the spaces that people visit and also the expanding use of the virtual space beyond playing games.

Since the emergence of video games in the 1970's, technological advances have seen in-game graphics shift from very basic symbolic imagery to more complex photorealistic representations. The shift in the ability to render the virtual space with higher levels of verisimilitude has taken place as computing and screen display technologies have developed. The ability to create virtual spaces that increasingly mimic representations of our vision of the physical world has meant that video game spaces have begun to align with other forms of visual representation such as painting, photography, television and cinema. These forms relate through the shared use of Cartesian perspective; the application of mathematics to drawing to create naturalistic representations of the physical world. This is achieved through a combination of a two-dimensional (2D) plane and the use of the Cartesian coordinates, commonly known as the 'x', 'y' and 'z' axes, to create the illusion of perspective. This increased the ability of artists to render naturalistic representations, which has long evoked reactions in audiences whereby reality and depiction are confused. For as long as there has been a visual culture, the same kind of anecdotal stories about audiences being fooled by representations rendered naturalistically have emerged. Whether these stories are true or not, it is interesting to note that there is a recurring cultural fascination with the idea of being fooled in this way. There are many historical precedents for these reactions occurring in a variety of mediums, including painting, photography and cinema. This thesis aims to explore the continuation of this cultural phenomenon in the medium of the video game and the virtual space.

An example of this type of reaction to painting is found in Giorgio

Vasari's "Lives of the Artists" (1991). Leonardo Da Vinci was commissioned by Ser Piero to paint a buckler (a small shield). He wanted to paint something "that might be able to terrify all who should come upon it, producing the same effect as once did the head of Medusa" (Vasari, p.287). In his studio, Leonardo painted a horrifying creature inspired from a variety of small dead animals. The creature "[belched] forth venom from its open throat, fire from its eyes, and smoke from its nostrils". When revealing the finished painting Ser Piero reacted startled, not realizing that the creature was painted.

[Leonardo] adjusted the buckler in a good light on the easel, and put to the window, in order to make a soft light, and then he bade him come in to see it. Ser Piero, at the first glance, taken by surprise, gave a sudden start, not thinking that that was the buckler, nor merely painted the form that he saw upon it, and, falling back a step, Leonardo checked him, saying, "This work serves the end for which it was made; take it, then, and carry it away, since this is the effect that it was meant to produce." (Vasari, p.287).

There is a long history of painters striving to render their paintings so naturalistically as to evoke these reactions. In painting, the depictions are rendered by hand and require highly skilled artists to be able to render an image that could fool an audience. With the invention of the camera this rendering process became mechanized, allowing the rendering of naturalistic images by people who were unskilled in the art of painting. The ability of the camera to render naturalistic representations much faster than a painter became a catalyst for painters to shift their aesthetic approach away from naturalistic renders and explore other forms of expression within their medium. The mediums of photography and cinema took over the role of producing naturalistic renders and subsequently stories began to emerge of

audiences being fooled into perceiving depiction as reality. One such reaction found in the medium of cinema is documented in Stephen Bottomore's "The Panicking Audience?: early cinema and the 'train effect'" (1999). Bottomore discusses the film by the Lumiere Brothers of a train traveling toward the camera as it arrived at a station, noting how it produced "an anxious or panicky reaction" (1999, p.177) in the audience.

Suddenly a train appeared. Women cried out with terror. Men threw themselves to one side to avoid being run over. It was panic. And triumph. George Reyes, 'Chez les Lumiere'. (Bottomore, p.177).

Bottomore points out in his article that this particular anecdote was not true, and that a possible motive for this story may have been as publicity for the film. [p. 181]. The trueness of the story is not important, what matters is the story was still told, thus continuing the cultural fascination with naturalistically rendered representations in a new medium.

Due to the mechanical nature of production, photographs can be viewed as indexes to their referents; as proof that the subject was in fact in front of the lens. An example highlighting photography's indexicality is the "Cottingley Fairies". In this example, paper cutouts of fairies were depicted in a set of photographs from 1917; these fairies were viewed as real. Arthur Doyle discusses accounts relating to the Cottingley Fairies photographs in his book "The Coming of the Fairies" (1921). The film transparencies were deemed to be unaltered by professionals who analysed them, so there was little dispute that the fairies were there in front of the camera; the dispute was whether they were real or paper cutouts (Doyle, 1921, p.33).

It may be added that in the course of exhibiting these photographs (in the interests of the Theosophical

bodies with which Mr. Gardner is connected), it has sometimes occurred that the plates have been enormously magnified upon the screen. In one instance, at Wakefield, the powerful lantern used threw an exceptionally large picture on a huge sheet. The operator, a very intelligent man who had taken a sceptical attitude, was entirely converted to the truth of the photographs, for, as he pointed out, such an enlargement would show the least trace of a scissors irregularity or of any artificial detail, and would make it absurd to suppose that a dummy figure could remain undetected. The lines were always beautifully fine and unbroken. (Doyle, 1921, p.92).

This example raises the question of how the technologies of a medium can affect audience perception of an image. What allowed the fairies to be viewed as real wasn't only the quality of the render, but also the circumstances surrounding the production of the images and audience expectations of the technical capabilities of the medium. This thesis investigates how audience interpretations of images created in the virtual space of video games are affected by the technological expectations of the audience.

The indexical nature of photography has created an ongoing correlation between photographs and the desire to produce high levels of verisimilitude in computer generated images (CGI), as mentioned in 1995 by Lev Manovich in his essay "The Paradoxes of Digital Photography".

The achievement of realism is the main goal of research in the 3-D computer graphics field. The field defines realism as the ability to simulate any object in such a way that its computer image is

indistinguishable from its photograph. (Manovich, 1995).

What is interesting is that to achieve realism in the virtual space computer generated images are designed not to mimic 'reality' but to mimic photography - "not realism but only photo-realism" (Manovich, 1995). This thesis aims to explore the similarities between the photographic image and images of the virtual spaces of video games and how audiences interpret these images. This is to investigate the continuation of the cultural fascination of being fooled by representations and how it relates to the virtual space of video games.

Two kinds of space are referred to throughout this thesis; physical space and virtual space. There are difficulties in referring to these spaces as 'physical' or 'virtual', as it could be argued that the virtual spaces of video games do in fact have an element of physicality, and that physical spaces at times can be perceived virtually. For example, physical spaces can be perceived from afar through the mediation of a screen, and so at this time are perceived virtually. The personal experience of a space can also determine it as virtual or physical, for example never visiting a place but seeing it on television and hearing about it from others. Sherry Turkle has discussed similar ideas in her book "Life on the Screen: Identity in the Age of the Internet" (1995), discussing the complex psychological relationships between people and computers and how this affects the way individuals understand themselves and the world. With this in mind, this thesis defines physical spaces as the spaces that encompass tangible objects, and virtual spaces as the simulated spaces that exist within the framework of a computer game.

To help understand the relationship of these spaces to photography, this thesis explores the concept of a video game, including the background and evolution of its components (display screen and controller) and its software. Different genres of video game are also discussed, and a

rationale given for choosing the Action genre in particular. Three forms of imagery (landscape, urban and material) are used as a basis for the research, providing a range of test scenarios that are used to explore the variables in the structures of the virtual space. A quantitative survey method is used, combined with informal interviews in a gallery setting. Results are displayed with accompanying photo images to provide examples for a better understanding.

The three forms of imagery that make up the basis of the research loosely translate into long (landscape form), medium (urban form) and close-up (material form) photographic shots. Through zooming in from wide to close it is possible to explore the ways in which the virtual spaces and physical spaces compare, and how images constructed with these three forms are interpreted by audiences.

02 Video Game Technology

The virtual space of video games is a relatively new medium when compared to painting and even photography or cinema. Video games emerged from advances in radar and ray-tracing technologies in the 1970's (Manovich, 1993). These technologies were about the mapping of space in real time, allowing people to locate distant objects such as aeroplanes and give updates of their movements to the viewer of the radar screen. This live update technology is similar to the television. The television borrowed its display screen technology from radar, enabling a real time update of transmitted images. This technology differed from photography and cinema which both emerged from successive technologies in the mid to late 19th century. They both used film transparencies for displaying images on a 2-D surface, so the images were not updated in real-time, but were displays from past moments in time.

These new technologies resulted in a new audiovisual grammar that required audiences to undergo a slow and ongoing audiovisual socialization. Similarly, the video game space is a new and emerging space that requires it's own audiovisual grammar and audience socialization, something that is currently developing.

This chapter explores the various technologies required for this new medium so as to help understand what the current capabilities and limitations are and the sociological impact they might have. It outlines what is meant by the term 'video game' and breaks it into discrete elements that are used when interacting with them. These elements include the display screen, the game console and the game controller and are important as they are the mediating factors that shape the aesthetics of what we see as an output and determine how we can interact with the virtual space. It is also necessary to understand the multitude of game types or genres and software such as the game engine. These are terms used to describe the various forms of this new medium.

2.1 Video game

There is no simple definition of what a video game is. Video games are becoming more complicated in their variables, consumer engagement with them is changing and the uses of video games are becoming broader. In his book “The Medium of the Video Game” (2001), Mark Wolf defines the term by breaking it into its two parts - ‘video’ and ‘game’. Wolf defines four components that are likely to make an activity a game: conflict, rules, player ability and valued outcome (Wolf, 2001, p.14).

These elements are present to varying degrees in most games, not just video games, and therefore the definition is too broad. The complexity of video games and the multitude of uses are left unexplored in this definition. More specifically this definition fails to consider a variety of possible uses in the art space that are outside the prescribed notions of interaction that adhere to game rules.

Wolf goes on to define ‘video’ as “the use of an analogue intensity/brightness signal displayed on a cathode-ray tube (CRT), the kind of picture tube used in a television set or computer monitor, to produce raster-based imagery.” (Wolf, 2001, p.16). Again, this definition is problematic in the detailing, as CRT based monitors have been almost entirely replaced by plasma, ‘Liquid Crystal Display’ (LCD) and ‘Light Emitting Diode’ (LED) displays since the publication of “The Medium of the Video Game” by Mark Wolf in 2001, leaving the definition somewhat outdated.

The essence of this definition is that there needs to be a screen of some sort to display a visual representation of the virtual space that can be viewed by the gamer. We more commonly refer to these display screens as television screens or computer screens.

2.2 Display screen

The display screen is a critical element as it is the interface through which the virtual space is viewed. Screen size and resolution play an important part in the ability to render graphics more accurately and thus create the illusion of higher levels of verisimilitude in virtual spaces. These factors affect how audiences interpret and react to the imagery of the virtual space.

Display screen technologies are continually developing, whether through an increase in the pixel resolution or advancements in the way screens display light, for example, from CRT, to Plasma, LCD and LED. An important similarity between CRT screens and the latter three, (Plasma, LCD and LED) is in the ability of these screens to display a real-time image of a continuous input signal. The most obvious difference is the physical volume of space they occupy. CRT screens require a large space behind the screen to house the cathode-ray tube. Technological developments mean the physical size of display screens has become smaller, and has even led to screens that the user can wear as a headset such as the ‘oculus rift’, which provides a more immersive interaction allowing the user to look around the virtual space by physically moving their head. As a photographer this is interesting, because being able to physically move your head to view the virtual space more closely resembles the experience of being a photographer in the physical space.

An interesting shift in rendering images from analogue mediums such as photographic film to digital mediums is that digital mediums use pixels whereas analogue mediums do not. Digital images are constructed from many pixels currently measured in the millions and referred to as ‘mega-pixels’ (MP). Digital cameras use pixels to capture light, and screens use pixels to display light. Resolution of pixels plays an important role in the ability to capture or display an image to a high level of photorealism. Any signs of ‘pixilation’, where resolution is low and therefore allowing the viewer to discern individual pixels means that the image will not be perceived as photorealistic, and therefore not

mistaken for reality.

Standard Definition (SD) display screens use a 4:3 aspect ratio (usually 640:480 pixels). For a long time this was the best resolution for televisions restricting video game producers to create their games with this as the maximum pixel number. SD display screens have now largely been replaced by larger resolution screens referred to as high definition (HD). HD screens use a 16:9 aspect ratio (1920:1080 pixels, approximately 2 MP). When creating images for this thesis it was important to consider the aspect ratio, as people become socialized to viewing media at particular ratios and so can identify the media type by the aspect ratio (for example, wide-screens with an aspect ratio of 16:9 are often used in films).

In reality HD refers to something that when compared to the resolutions of film and digital photography (in excess of 21 MP), is not very high definition at all. Flaxton (2011) talks of this notion, noting that we are in the “middle years” of HD, and that the original title is now somewhat misleading as it refers to a resolution of ‘1920 x 1080’ pixels. This is not very aspirational as this term HD still does not approach the quality of film.

We now seem to be moving out of the “middle years” as screen resolutions are increasing well beyond the original HD limits and these higher definition screens are becoming more widely available at a consumer level. For example, when describing cinema projection resolution, we use the terms 2K (2048 × 1080), 4K (4096 × 2160) and 8K (8192 × 4608). These terms are now being applied to consumer screens with a 16:9 aspect ratio, with 2K being used to refer to 1920 x 1080 pixels (Approximately 2000 pixels wide). Currently screen resolutions higher than 2K are predominantly found in cinemas, although consumer level screens are offering larger resolutions, with most major brands now offering screens with resolutions of 3840 x 2160 and calling them 4K, or “Ultra HD”. Although not strictly accurate, these terms show the intentional (mis)use of terminology to align consumer level products

with a resolution previously only experienced at the cinema.

Display screen resolution is a significant factor in determining photorealism. As the resolution of screens becomes higher, the images on screen become more difficult to distinguish from the physical space. Due to an increase in computer processing power the next generation of game consoles released in November 2013 will be able to take advantage of the higher 4K resolution.

The game console is an important component for understanding the graphical limitations that game producers must work within. Ultimately, this means that the console dictates what a game can look like and thus its ability to invoke a high level of verisimilitude in the virtual space.

As with the term ‘video game’, the term ‘game console’ is difficult to define due to the broad and complex nature of the uses and forms in which game consoles appear. Originally, the term was used to describe a computer dedicated to playing video games stored in cartridges. However there are now a large variety of game consoles available, with a range of software interfaces impacting the way games are loaded into them.

Simply put, the Oxford English Dictionary defines a console as “a panel or unit accommodating a set of controls for electronic or mechanical equipment”. Further, it defines a game console as “a small electronic device for playing computerized video games” (Oxford University, 2007). Game consoles have also been defined as computer units that contain inputs for game controllers (the “set of controls”), outputs for the display screen and a software interface to input a game (for example, cartridges, compact disks or the internet). The development of console inputs from cartridges to compact disks, such as DVD and Blu-ray, enabled the console to function as a movie viewing and music-playing device too. Developments such as the inclusion of internal hard-drives, first introduced with the Microsoft Xbox in 2001, meant the game console could be used more broadly, allowing it to function as a media based personal computer. More recent developments have expanded on the multi functionality of consoles including an Internet connection and an online service provided by Microsoft called ‘Xbox Live’. This means users can not only play games online with other users, but also consume and purchase media such as movies and music, browse the internet and connect with other users through built in applications for social networking. This technology has lead to an immense increase

in the multiplicity of uses for the game console outside the prescribed use of playing a computer game. In particular the example explored in this thesis is found in the use of the game console for creating art from within the virtual game space and how technological advances have enabled this.

Game consoles are categorized into ‘generations’ relating to the period they were produced. The current generation of game console is generation seven, with generation eight due to be released in late 2013. Generation seven consoles have spanned from 2004 to 2013, and include Microsoft’s ‘Xbox360’, Sony’s ‘PlayStation 3’ (PS3) and Nintendo’s ‘Wii’.

Microsoft’s Xbox360 and Sony’s PS3 have the highest computer processing power out of all generation seven consoles. Although, some games released on these consoles are also available on personal computers (PC) and can be custom built to have greater computing power than the generation seven consoles. Despite this, however, games are produced to work on the lowest power, in order to maximize potential sales and market size. This means that if a game requires greater computational power than a game console offers, it will not be playable on that console, thus reducing the market of potential buyers. The console chosen to create images for this thesis was the Xbox360. This console was chosen because it was important to use a latest generation console that supported the chosen games.

An interesting trend exists which demonstrates the desire of people to interact with increasingly photorealistic virtual spaces. Game developers are now enhancing existing games by re-making them using a combination of enhanced hardware, enhanced software and game aesthetics more aligned to photographic aesthetics. The result is a game with a more photo-realistic look, but maintaining the gameplay of the original.

One example of this is Halo (Microsoft Game Studios, 2001). Halo was first released on the Microsoft Xbox, a sixth generation console. Due to Halo's cult status and immense popularity, the developers created a 're-mastered' version for its 10 year anniversary (Microsoft Studios, 2011), designed with contemporary technology and released on the Xbox 360, a seventh generation console. Although several sequels to the original Halo have been created using current standards of HD graphics, the desire of the audience to re-master the original game was large enough to fund and produce this anniversary edition. This supports the notion that players want to see what the game could have looked like had it been produced with the processing and graphics technology available today rather than ten years ago.

An interesting feature of the re-mastered version of the game is that while the developers went to great lengths to retain the original gameplay and level layout they also included a button that could be pressed during live gameplay to switch back to the original graphics. This reinforced the impact of technological advances and gave the user the ability to compare the new HD graphics with the old graphics in real time. This feature demonstrated the advances in both rendering ability of the game engine and processing ability from one generation of console to the next. The two examples (Figures 001 and 002) show screen captures of the original and the re-mastered versions of the game for comparative purposes.

Changing from one generation of consoles to the next allows for greater processing ability, which in turn allows game developers to show greater levels of photorealism within the virtual space. As these levels increase and are aligned with indexical mediums such as photography, the ability to recognize a difference between the two becomes blurred. How the user interacts with this space is also important, as this can determine the level of immersion and the ability to suspend disbelief. Playing the game is only part of the experience as users embrace

the greater degree of photo realism evident in games today in new, unintended ways.

The device used to interact with the virtual space is referred to as the controller. Some knowledge of what a controller is and the many different types is critical in understanding the way in which users are able to interact with the virtual space of video games.

Figure 001 - original graphics from 2001 version of Halo

- Detail; the relatively flat walls in the image on the left have been given much greater depth and detail, similarly the corpse of an alien shows greater detail and rendering.
- Light and shadow; one of the most notable differences is in the way light is rendered. In the image on the left the light from outside is evenly balanced as if it were a high dynamic range (HDR) image. HDR is an effect that means object's exposures can be individually defined. Here, the inside and outside of the virtual space are evenly lit, even though the light levels are very different. This means that the view of the virtual space is not limited by a single exposure such as with a single photograph. HDR is an effect derived from photography, whereby multiple photographs of the same subject are taken at incremental exposure levels and then combined to create one image. The advantage for the artist is the ability to choose the level of exposure for each object depicted in the photograph

Figure 002 - re-mastered graphics from the 2011 version of Halo

rather than having to compromise with one overall exposure setting. When rendering virtual spaces of video games this same technique can be applied, giving the space a comparable lighting aesthetic to HDR photographs. This makes an image appear as though it has a 'special effect' applied to it, rather than it appearing like an index to the referent. In the image on the right, there is 'blowing out' of the highlights, with softening and bleeding of the light filtering in from outside. This implies the 'eyes' of the avatar are adjusted for the interior level of light and so the outside is very bright. The way light propagates through the game space of the re-mastered version aligns itself more closely with the way we see through a single exposure of the camera. This is interesting as it shows an aesthetic decision of developers to move away from a more effect oriented HDR aesthetic to an aesthetic in which people are familiar with viewing indexical referents to the physical world – photography.

The function of a controller is to enable the user to interact with the virtual space of the game, whether to play the game or create art. Examples of the many types of controllers in use in computer games include the keyboard, mouse, touch-sensitive pads and handheld controllers. Although many types of controller are available and each have their specific benefits and drawbacks, all contemporary game consoles use hand held controllers, specific to each console. As the name implies, hand held controllers are ergonomically designed to fit in the hands of the user and include a variety of touch sensitive controls (for example, buttons, triggers and joysticks). Controllers are used to manipulate the images on the screen, typically controlling objects or game characters, creating the illusion of space.

Game controllers have advanced since their inception, with the addition of more buttons, different layouts and developments such as pressure sensitive controls. The seventh generation of consoles saw the introduction of motion capture sensors as a way for users to interact with the virtual space, almost rendering the controller in its traditional form redundant. There have been motion-sensing controllers in the past, however they have not been as successful as the technology was more primitive, leading to inaccuracy and cumbersome control. The future will see controllers that link directly to the brain, allowing the user to control the virtual space by sending impulses from their brain to the controller. Currently, these brain-mapping headsets are available to consumers, but so far no game consoles use this technology. If this technology is successfully used it will likely increase the blur between the physical and virtual spaces, allowing more direct access to control the images on the screen.

An example of how far controller technology has evolved and how it is being applied is found in the United States (Brignull, 2010) and British (Hambling, 2008) armies. Both armies use the Microsoft Xbox360 controllers in some of their military vehicles. This is particularly

interesting as the genre of game used in this thesis is First Person Shooter (FPS), which is modeled on war. The games are designed to mimic the visualizations of war, but now through the use of unmanned aerial and ground assault vehicles it is war that mimics games.

When controlling a game avatar, pressing the joystick forward gives the appearance of the avatar moving forward in the virtual space by the images of the virtual space coming toward the screen. This manipulation of the images on the screen creates the illusion of movement through the virtual space. It is this ability to control the images on the screen that led to my interest in creating art photographs of the virtual space. The user can decide what images appear on the screen, something analogous to choosing what appears in the viewfinder of the camera.

The display screen, game console and controller are the physical components of a video game. There is also a non-physical component that affects the developer's ability to render images, and thus affects the interpretation of these images by the player. This component is known as the game engine.

Game engines are designed for the production and development of video games and provide a framework through which developers can design virtual spaces. There is a complex relationship between the physicality of hardware such as graphics cards and modern software such as the game engine. In contemporary game development the game engine is a software component however early game engines were physical components in the form of chipboards. The game engine provides systems for rendering these spaces (renderer), adding physical laws (physics engine) and determining collisions and responses to objects within the game (collision detection). These factors determine how virtual objects are seen and how they interact within the game. To minimize costs, the same game engine can be used to produce many different games, so different games can have a similar quality of render. Like the computational power of the game console, the game engine also limits the graphic capability, and so the level of photorealism. As the software of game engines develops so too does the ability to create more complex visual aesthetics and higher levels of verisimilitude. This is interesting when creating photographs of the virtual space, as the virtual space becomes more aligned with images of the physical space.

Due to the graphical limitations of both game consoles and game engines, developers use a structure for the virtual space that saves on processing power. They only render 3D objects that are necessary for the current point of view and leave the rest of the displayed image as 2D backdrops. In the chosen game genre of first person shooter (FPS), which will be discussed in the next chapter, each game level has boundaries determining where the player can move. The virtual space beyond the level boundary uses a 2D painted matte as a backdrop. This backdrop system is also used to display distant objects within the boundary of the level, reducing the number of objects that need to be 3D rendered in real-time. This construction helps in reducing the processing load on the computer system. As objects in the virtual space are approached, they switch from a 2D matte to 3D renders, using combinations of computer coded and image mapped textures. The image-mapped textures use a combination of photographs and digital painting and have a fixed resolution. The use of photographs

to display a texture acts as a direct referent to the physical space, thus more closely aligning the two spaces.

This structure of the virtual space influenced the formal approach taken in this thesis toward image making in the virtual space. This thesis uses long, medium and close-up shots to depict the various space structures. The long shot shows an almost entirely 2D backdrop, the medium shot shows a combination of 3D texture mapped objects as well as a 2D backdrop, and the close up shot shows the 2D textures mapped onto the 3D objects.

In 2011, a multiplayer level from Call of Duty: Modern Warfare 2 was re-released (MW2) (Activision, 2009) to Call of Duty: Modern Warfare 3 (MW3) (Activision, 2011). Both games were released on the same generation of console, only two years apart. This shows the changes in the capability of the game engine and the game developers choice in design aesthetics rather than an increase in the game consoles processing power. The graphics play an important role in the ability of users to be immersed within the virtual space but there are many complex factors that allow the user to suspend their disbelief. One of these factors is the resolution, as discussed earlier. Another factor is the way in which the exposure of light is rendered. The most obvious of the changes between these two versions of the same level is in the way light interacts with the objects. In the re-mastered version (MW3), light is rendered in ways that align more with single exposure photography, allowing objects to integrate into the virtual space in a style that we are already socialized to through photography of the physical space.

This example, along with the earlier example of Halo, show how the combination of processing ability of the game console, programming ability of the game engine, and the decisions about design aesthetics by the developers all combine to affect the way the images are perceived. Another factor that affects the way the images are perceived is in the choices made as an artist to create the images such as framing, composition and subject. These will be discussed in the next chapter about capturing the virtual space.

Figure 003 - 2009 version of video game level from MW2

Figure 004 - 2011 version of video game level from MW3

- Details; there are greater levels of detail in the shaping and rendering of objects as well as the texture mapping of images. The small square tiles in the left image have been changed to larger more reflective granite rock tiles in the right image.
- Light and shadow; the light and shadow of the cart in the right image is more defined, showing it in a way that replicates single exposure photography, rather than HDR effect as seen on the left.

Figure 005 - 2009 version of video game level from MW2

Figure 006 - 2011 version of video game level from MW3

- Light and shadow; this image shows the change from HDR to single exposure rendering of light clearly too, with the highlight of the sunlight coming through the glass window in the left as HDR, and on the right the render is over exposed and bright. As discussed earlier with Halo, this shows a move away from the special effect look of HDR rendering towards a more familiar representation of how light is perceived in a single exposure of the camera.

03 Photographing in the Virtual Space

This chapter discusses approaches to making photographs in the virtual space and compares this to making photographs in the physical space. To understand the similarities and differences here it is first necessary to discuss the chosen game genre for the construction of images and the structure of the virtual space of this genre.

As with literature and film, video games are categorized by genres. Video game genres are categorized by the game subject, for example adventure, action, role-playing or strategy, and then are further categorized by factors such as the style and purpose of the game. This thesis used the ‘First Person Shooter’ (FPS) genre that is a sub category of ‘action games’. An important reason for selecting this genre was that it has a game structure that most closely resembled a space that could be navigated by a photographer. Making images of the virtual space of this genre was analogous to moving around the physical space while looking through the viewfinder of a camera.

The game-play of this type of game is often based around conflict, with the general objective to shoot at your opponents while avoiding being shot. There is an interesting relationship between the language used in photography, and in war, such as to ‘point and shoot’. Rosamund Moon discusses the language used in photography and the relationship to the language of war in the article ‘The Language of Photography’ (2000):

Words originally used with respect to firearms and other weapons have come to be applied to photography. Shoot and shot are obvious examples of this. A snapshot was a shot fired quickly, and without careful aim. Cameras have triggers or firing mechanisms, though button and shutter (release) are less antiquated and less militaristic terms. People load cameras with cartridges or magazines of film; they cock shutters, and they fire off films. (Moon, 2000).

This war terminology is also used in the virtual space of FPS games, and relates to photography further as the ‘aiming’ of the ‘gun’ is actually the framing of the images on the screen, like the framing of the physical space in the viewfinder of the camera.

There are two main modes of gameplay; campaign and multiplayer. The campaign mode follows a story structure that limits the spaces in which the avatar could move. This meant campaign mode was not as conducive for making photographs in as the multiplayer mode, the latter allowing greater freedom of movement. The opponents in the game are either computer controlled ‘bots’ or avatars controlled by other human players through an online interface. Some multiplayer games can only be played online with other players, making the task of capturing images of the virtual space challenging as there was the constant threat of being shot.

Another reason for choosing the FPS genre was its scale and reach within the video game world. FPS constitutes a large part of the gaming market, with game titles frequently in the top best-selling charts. Consequently, there is a large audience engaging with this virtual space. For example, ‘Halo 4’ (Microsoft Studios, 2012), the most recent in the Halo series by Microsoft Studios, sold over eight million copies (VGChartz, 2013), with seven previous titles in the series totaling over 45 million in combined sales. Another title, ‘Call of Duty: Modern Warfare 3’ (Activision, 2011) sold over 6.5 million copies within 24 hours of its release (Crecente, 2011). A third example is ‘Battlefield 3’ (Electronic Arts, 2011) which has sold 16 million copies (VGChartz, 2013). This shows there are significant numbers of people worldwide engaging in the FPS space. The way in which people can engage with this game type has interesting parallels to the physical space, made evident by analyzing the structure of the virtual space of FPS games.

The game structure of FPS games has remained fairly constant and consistent since its introduction in the early 1970's, with games such as 'Maze Wars' released in 1973 (Colley, 1973). These games differed from other games at the time as they incorporated a structure that mimicked a Cartesian perspective, giving the illusion of a 3-D space and the ability to move forward into the space, rather than left, right, up and down as in a flat 2-D space. It was this development that aligned the virtual space with a camera that was used in mediums such as cinema and photography – a step toward photorealism in the virtual space.

The experience of being in, moving through and engaging with these spaces is illusionary, created through the game structure. FPS games get their name from the use of a first person perspective of the games avatar to link the virtual space to the physical screen. This is analogous to using a physical camera to frame a point of view in the physical space. The screen is used as the 'viewfinder' to frame the point of view of the avatar and requires users to interpret and visualize spaces through this avatar's viewpoint, acting as a 'virtual camera'. Mike Jones has discussed the idea of the 'virtual camera' in his article *Vanishing Point: Spatial Composition and the Virtual Camera* (2007). Jones examines how the virtual space is perceived through the construct of a 'virtual camera'. The images on screen are manipulated with the controller and users can move their avatar's view point around the virtual space, choosing where to go and what to look at. The only part of the avatar the user sees are the hands and weapon, which are positioned bottom center on the screen. As the user moves the controller joystick forward, the images of the 3-D virtual space move toward the screen, giving the illusion of the avatar moving through the virtual space. When the controller joystick is moved to the left, the images of the game space on the screen move to the right, giving the illusion of turning to the left. This creates the illusion of the first person perspective of a virtual space that is framed by the screen. In more contemporary

games complex algorithms are used to mimic the physical camera with, for example, the addition of lens flares and depth of field. These techniques are designed to add a sense of 'realism' since audiences are already socialized to perceive visual media through the lens of the camera and thus pose as an index to the referent. Cindy Poremba has rationalized the production of images of the virtual space by comparing them with photography in her article "Point and Shoot: Remediating Photography in Gamespace" (2007), making reference to Susan Sontag's book "On Photography" (1977):

Photos have become the norm for the way things are supposed to appear - our popular representational ideals increasingly based on a lens-centric aesthetic. If traditional photography allows us to "make real" (Sontag, 1977, p. 161) our physical world in this sense, the same process extends to these player snapshots. (Poremba, 2007, p. 49)

Another example is found when moving the avatar through the virtual space. The images of the avatar's point of view on the screen bob up and down and sway side to side to mimic footsteps when walking. This view is similar to that of person in the physical space walking with a handheld camera and creates the illusion of a more human-like avatar, an aesthetic technique used in cinema to create immediacy ("media transparency") (Petho, 2009, p. 48), commonly referred to as cinema verite. Using this technique in the virtual space aligns it with the physical space by helping to make the user feel like they're controlling a human-like avatar rather than a 'flying' or 'hovering' virtual camera. When practicing as a photographer this is an important difference; it is like comparing a person holding a camera to a person remotely controlling a camera attached to a flying machine such as a quadcopter. The freedom to control the virtual camera has improved since the beginning of the genre. In early games the control of the point of

view was limited; the user could only move the avatar in 90-degree increments and only one step at a time. As game technologies have developed, the ability to move the avatar freely in all directions has progressed enabling the ability to precisely frame the virtual space with similar control to framing the viewfinder of a camera in the physical space.

Early games were basic and consisted of converging lines to represent a single point perspective. They did not have texture mapping or destructive objects that the player could interact with, as is the case now with contemporary games. *Maze Wars*, for example, consisted of lines that described a virtual space that users could navigate through, as seen in Figure 007. The objective was to move through a maze of corridors and complete missions by colliding with 'eyeballs' representing avatars. By the early 1990's games had multiple levels with textures mapped onto the surfaces of the objects and game avatars that were designed to represent people from the real world. An example of this development is found in the game *Wolfenstein 3-D* (Apogee Software, 1992), where users were required to shoot a digital rendition of Hitler (Figure 008). The ability to add textures to objects added another layer of photorealism, allowing the development of virtual spaces that were modeled on physical spaces. A high render of verisimilitude is desirable to create the illusion of a corresponding physical space, and the ability to do so has developed with advances in technology. This is something that has driven the photographing of the virtual space in this thesis. An example of a level modeled on a physical space is seen in the game *Medal Of Honor* (Electronic Arts, 2010), where one of the multi-player levels is modeled on a US military outpost in the Korangal Valley at the border of Pakistan and Afghanistan (refer to Figures 009 and 010). This level was designed to look like an outpost known as 'OP Restrepo' and the outlook from the level shows hills modeled from the region.

A further example of the use of physical world referents is found in *Call of Duty Modern Warfare 3* (Activision, 2011). The game used images that were based on visualizations from cameras placed on war machines used in the Gulf War. In this FPS game players remotely control guided missiles, helicopter gunners and unmanned assault vehicles (refer to Figures 011 and 012). It is interesting that modern warfare deploys remote control vehicles using screen displays and controls as the interface similar to video game controllers. Since the video games model their visuals as closely as possible on their physical world counterparts, these images show something very similar to images portrayed during the Gulf War. Jean Baudrillard, in his controversial book 'The Gulf War Did Not Take Place' (1995), has argued that the Gulf war was unlike previous wars, calling it a "virtual war". This was in part due to use of computer-generated imagery generated by the automation and mechanization of warfare vehicles. Using these visualization and communication technologies Armies are able to have a high level of intelligence about an area of operation, referred to as "total battlespace awareness" (Harris, 2006, p. 103). These technologies used in creating "total battlespace awareness" are found within the virtual space of video games in the form of the heads up display (HUD) on the screen. The HUD shows the user vital information such as the location of targets and objectives through a radar map, estimated arrival times of air support and details of weapons and ammunition. This raises the question as to which is influencing which, the physical space or the virtual space?

The use of physical world spaces as the basis for the virtual space, as well as incorporating virtual imagery used to control physical war machines into games, is creating a blur in the understanding of the two spaces. By acting as a photographer in the virtual space, this blurring of the two spaces is taken further, challenging the notion of what photography is. There were certain challenges in making photographs in the virtual space with interesting similarities and differences to photographing in the physical space.

Figure 007 - Screen capture of video game Maze Wars (Colley, 1973) showing the use of perspective to describe a 3D space

Figure 008 - Screen capture of video game Wolfenstein 3D (Apogee Software, 1992) showing a depiction of a real person in video games

Figure 009 – landscape form photograph of a virtual space that was modeled on the physical space. (Medal of Honor 2010)

Figure 010 - Screen capture from documentary movie “Restrepo” (Hetherington, T., Junger, S. 2010) showing the physical space used to model a video game level in “Medal of Honor”

Figure 011 – example of remote controlled war machines in the video game

Figure 012 - example of remote controlled war machines in the video game

Acting as a photographer in the virtual space differed from acting as a player of the game. The ability to control and move the avatar was the same, however why the avatar was moved and where the avatar was positioned were quite different. As a player the intention is to remain hidden from the enemy players' avatars while maneuvering into the best position to shoot them. As a photographer the intention was to move to desired locations within the virtual space, frame them on the screen using the controller and capture the resulting image. This difference caused some difficulties when attempting to make images, in some cases being shot and having to restart from a 'spawn point' before being able to capture an image. This limited the places within the virtual space from which images could be made, something analogous to being a virtual war photographer, but without the obvious threat of physical harm.

The avatar's point of view was essentially the virtual camera, a singular point of view similar to a physical camera. There were common techniques applied when capturing images in the physical and virtual spaces such as image composition, distance to objects and the aesthetic approach. The composition of the virtual space could be controlled with similar creative control as in the physical space. The avatar could be moved around to achieve the desired subject in the frame, and also crouch to adjust the height of the avatar's point of view (the virtual camera). Along with this, there was also a similarity in the important role timing plays in photographing the physical space. The decision of when to take the image, known as 'the decisive moment' still existed when making images in the virtual space. The decision of when or when not to take an image is based on variables that change over time. This was somewhat limited as only some elements of the virtual space are designed to be variable. There were also limitations when controlling the virtual camera as it lacks the basic technical settings such as shutter speed, depth of field and focal length. These elements were essentially fixed.

The images created within the virtual and physical spaces were constructed using aesthetics and techniques taken from standard photographic practice. There were three types of images produced as previously outlined; (1) landscape form; employing techniques from romantic landscape paintings and landscape photography, (2) urban form; employing techniques from urban documentary photography and (3) object or material form; which employed techniques from close up photography. Each form used stylistic tropes commonly found in other forms of existing visual media genres. Each of these methods required a different approach within the virtual space to make the images, affecting choices made as an artist relating to what to show and how to show it.

An important consideration was whether or not an image from the virtual space of a game could be called an original piece of art or whether it was simply a display of the game developers work. Arguably both elements are apparent. Just as a photographer has not designed the objects in the physical space in which they photograph, they have also not designed the virtual space that they created images from within. So in one sense, photographing an architects building in the physical space is comparable to taking a screen capture of a game developers building in the virtual space. This comparison of architects and game developers is interesting, as they both design the spaces in which people exhibit various social behaviors. The difference to date is that in the physical space there are factors that permanently change the space over time, for example; lighting, building development, graffiti and weathering, rather than a virtual space that reverts to its original state whenever the game is reloaded. The interesting thing is that the variables impacting on the physical space are starting to emerge in the virtual space. These changes vary depending on the game, but often include global changes such as lighting from day to night and local changes dependent on user interaction such as the destruction of objects. With the technology to allow games to be continuously online, the virtual image can be

updated in a way that simulates changes in the physical space.

An example of a permanent change in the virtual space is found in the game Everquest Next (Sony Online Entertainment) currently still being developed. The release date is still to be announced, however a beta signup for players has been launched on the Everquest Next website (<https://www.everquestnext.com/beta-registration>) allowing players to apply to test a beta version of the game.

Players will also have the ability to cause the world to change around them, permanently, in dramatic ways. Through the concerted effort of the world's inhabitants, including players, creatures, and non-player characters (NPCs), city walls will be built and destroyed, large-scale wars will be fought and won, and epic stories will unfold over months and years. (Sony Online Entertainment, 2013)

One of the many purposes of photography has long been to document change in the physical space and this can now be applied to documenting change in the virtual space. This is especially relevant when looking at unintended events such as the “Corrupted Blood” incident in 2005 in the game World Of Warcraft (Blizzard Entertainment, 2004). This was when a virus only intended to infect the player avatar in a specific space within the game accidentally escaped and became a virtual epidemic affecting the entire online community. This virtual virus instantly killed lower level characters and only took a short time to kill higher level characters. (Ward, 2005). What was interesting with this incident was the reaction of the 6.5 million online players. Many players panicked and fled to areas of the virtual space that were known to be unaffected. There was a failed attempt by the game developer, Blizzard, to set up quarantine zones and players whose avatars had healing capabilities volunteered to help cure lower level players who would have died,

losing months of time invested in gameplay in the physical space. A more curious reaction by players that is similar to the actions of documentarians and journalists in the physical space was to enter the infected areas of large virtual cities in an attempt to “witness the chaos”. These ‘rubberneckers’ would then attempt escape the infected areas quickly to avoid becoming infected. (Orland, 2008)

This leads to a whole new reason for interacting in the virtual space, no longer simply as a game player but as a documenter of change. These developments in change are now at a stage that people are able to create time-lapse videos within the virtual space showing the progression from sunrise through to sunset, showing the use of a similar visual grammar to the capturing of physical spaces through photography. Due to the complex and varied nature, changes in the virtual space could be a topic for an entire thesis.

Along with the ability to frame an image within a FPS game, the technology to continuously change the virtual space provides scope to create original works of art using existing works within the virtual space. This opportunity is not replicated in other types of visual media such as cinema. With cinema to take a screen-shot is to take one of the many frames (essentially photographs) that make up a film; a frame that the filmmaker has composed and created. In the virtual space the photographer can chose the framing and composition in the same way they would in a physical space.

Although I operated like a photographer when moving around within the virtual space, I questioned whether the resulting image could be called a photograph if it was not made with a physical camera. This led to experimentation in techniques for the capturing of the virtual space, using both hardware and software to create a digital image of the display screen.

04 Construction of Images

The construction of images of the virtual space raised philosophical questions about what photography is and what our expectations of a photograph are. Capturing the images within a game further highlighted that in contemporary photography there is an issue around the capture mediated through the LCD screen. This chapter outlines the methods used for capturing images of the virtual and physical spaces and the formal approaches taken to compose the image for use in tests and exhibitions.

To step back and take the literal translation from Greek of the word photograph, we get two elements, firstly ‘photo’, (from ‘phos’ in Greek) meaning ‘light’ and secondly ‘graph’, meaning ‘to draw’. So by definition and translation we have a ‘drawing made from light’. How the image is captured and drawn are important in how we define a photograph. A photograph is captured mechanically by the focusing of light through the mechanical object that is the camera, something initially achieved through celluloid and now with digital sensors. Celluloid is physical and can be viewed with the eye. By contrast the digital sensor stores a latent image as code that requires a computer and screen to decode and display the image. This has led to a norm of digital ‘photographs’ being viewed on screen rather than being printed, questioning former expectations of what a photograph is. It is important to note that the term photograph initially referred to a piece of sensitized paper containing an image – a physical object. The mechanical production of the image with the camera, moreover the lack of the hand of man, has allowed photographs to be viewed as indexical referents to their subjects. This notion of the absence of the hand of man has an interesting and early precedent found in the title of the first photographically illustrated book by William Henry Fox Talbot, titled; “The Pencil of Nature” (1846). Geoffrey Batchen suggests in his book “Each Wild Idea” (2000), that the shift in photographic technologies, namely digital, is weakening the “truth effect” of photography.

The suggestion is that a diminution of our collective faith in the photograph's indexical relationship to the real will inevitably lead to the death of photography as an autonomous medium. The irony of this scenario is that photography as a separate entity might well be on the verge of disappearing forever, even as the photographic as a rich vocabulary of conventions and references lives on in ever-expanding splendor. (Batchen, 2000 p.109)

The future of photography may lie in a digital form, due to a shift in the way photographs are created, stored and viewed since the rise of digital photography. Some digital cameras offer a mechanical process identical to that of a filmic process right though every detail except for how the image is 'stored', keeping the same method for creating an image. These cameras are equivalent apart from the substitution of the film celluloid for a digital sensor; they use the same lenses, shutter, optical viewfinder and exposure controls. Not all digital cameras are like this however, as some use a 'digital' shutter and have removed the optical viewfinder, using an LCD screen to replace its functional role. The use of the LCD screen to frame the image shows an important shift that aligns the capture of the physical space to the capture of the virtual space. A 'screen capture' typically implies the capture of another form of media displayed on a screen; a remediation of an existing media form. With the use of LCD screens as the viewfinder of a camera (such as with smartphones) it is no longer a remediation of other media forms, but a live capture of the physical space. The screenshot and the photograph become aligned and in doing so lose part of their initial meanings as separates. This is interesting when making images of the virtual space of video games as the LCD screen becomes the viewfinder used to frame the image. The virtual space of video games lies somewhere between the capture of another existing media form and the live capture of the physical space, leaving the question of whether the resulting image can be called a photograph.

A fundamental difference in photographing the physical space compared to the virtual space is whether the light captured is physical or virtual. This highlights an important distinction between photographing the screen with a camera (method 1) and with a screen capture (method 2). When using a physical camera the light is physical; the light from the display screen enters the camera through the lens and is recorded on a light sensitive surface. When capturing images of the virtual space using the screen capture method, the light is virtual and there is no physical light captured; only the virtual camera is used to create the image. This raises a question about what photography is, if only a virtual camera is used is the resulting image a photograph? Lev Manovich has discussed this concept in his essay "The Paradoxes of Digital Photography" (1995).

Rather than using the lens to focus the image of actual reality on film and then digitizing the film image (or directly using an array of electronic sensors) we can try to construct three-dimensional reality inside a computer and then take a picture of this reality using a virtual camera also inside a computer. In other words, 3-D computer graphics can also be thought off as digital - or synthetic - photography. (Manovich, 1995)

Whether using a physical or virtual camera both methods of capturing produce an image that essentially shows the same thing. However the lack of a physical camera in the screen capture method again leaves the question of whether a screen capture can be called a photograph. Manovich's term of "digital – or synthetic photography" is problematic as his essay was published in 1995 and now the term 'digital photography' is used to describe photographs made with a physical digital camera rather than a virtual camera. A more accurate term for an image of the virtual space resulting from a screen capture method could be a 'virtual photograph' since it is made with a virtual camera.

Due to the philosophical differences in the resulting images, two methods were experimented with to capture the virtual space:

- Method 01: Photographing the display screen using a physical camera.
- Method 02: Screen capture, which is essentially a digital interception of the display signal at any given moment.

As both a photographer and a researcher I wanted a clear uninterrupted view of the virtual space so for both methods of capture the in-game HUD and the avatar's hands and gun were removed. This was because I wanted a perspective of the virtual space that was as close to the viewfinder of a camera as possible, and also because the HUD and imagery of the avatar would signify image origin and therefore create a bias in comparative tests. To remove the HUD was simple as there is an option in the game settings to turn it off. Removing the view of the avatar's hands and gun was more challenging and was achieved by pressing the change weapon button. This lowered the hands and gun as the avatar switched weapons, temporarily removing them from the screen and enabling an image to be captured that showed a clear uninterrupted view of the virtual space.

Photographing the display screen with a physical camera was the first method used as my approach to capturing the virtual space began as a photographer. There is a major difference in using a physical camera compared to a virtual camera, as it is the act of using a physical camera that means the resulting image can be called a photograph. The physical camera requires the operator to have a technical knowledge of how to use the camera. For example they must decide on camera settings such as shutter speed and aperture to obtain a correctly exposed image, as well as select the type of lens to use.

The camera used in this thesis was a digital single lens reflex (DSLR) Canon 5D MkII. This has a 21 MP sensor (3744 pixels by 5616 pixels) that is physically the same size as one frame of 35mm film. This camera was chosen as it was the most advanced digital camera that I had access to. A DSLR camera has an optical viewfinder to frame the image allowing the photographer to see through the lens and know exactly what is captured in the photograph. Modern DSLR cameras allow for a 'live view' option that shows the viewfinder on the LCD screen on the back of the camera. On DSLR cameras the LCD screen was initially designed as a playback function to display an image once it was taken. With the addition of video capabilities on DSLR cameras the LCD now functions as a preview screen allowing the operator the choice to use it as a digital viewfinder. Generally professionals want as unmediated view as possible, and so an optical viewfinder that allows them to look through the lens is most desirable.

For this method the display screen was centralized in the frame of the viewfinder, with the camera mounted on a tripod perpendicular to the screen. The lens used was a Canon EF 50mm. This lens has a fixed focal length of 50mm and is known to show objects in the viewfinder at a similar magnification to that of human sight. There is minimal distortion, known as barreling, created by this lens meaning a clear rectangular view of the screen could be obtained without warping of

Figure 013 – method 1 example: photograph of screen before cropping

parallel lines toward the corners of the image.

The video game image was displayed on the screen, and when the desired image of the game was obtained with the virtual camera, a photograph of the screen was taken with the physical camera. The aspect ratio of the screen is 16:9 with a pixel count of 1920 x 1080 pixels. The camera's aspect ratio is 3:2 with a resolution of 5616 x 3744 pixels. Due to the different aspect ratios of the screen and the photograph, the photographs contained an area above and below the screen that was later cropped out to so that only the display screen was in view for use in the exhibition (refer to figure 013 and 014).

As can be seen in figures 013, 014 (above) and 015 (opposite) a consequence of this method was the formation of curved lines running throughout the image. These were diffraction patterns caused by the interference between the two different resolutions of the display screen

Figure 014 – method 1 example: photograph of screen after cropping

and the camera's sensor. These patterns were an interesting effect and something that could be explored further as an art output, however were not desirable for the use in comparative tests as they alluded to the image being a photograph of a screen, and therefore an image of the virtual space.

Experimenting with re-photographing physical spaces displayed on a screen to create the same interference patterns could be used to confuse the reading of the viewer and align the photographs with the images of the virtual space. This was not done however as I was more interested in the viewers interpretation of the virtual space as physical as opposed to the physical space as virtual, so methods were chosen that aligned the virtual space with the physical space aesthetics.

To remove these interference patterns the lens was placed slightly out of focus, however this meant the images were not as sharp and had a 'soft focus' effect. The soft focus effect was interesting as it gave the

images more of a painterly quality. Usually all areas of the virtual space are sharp and in focus so that the user can look anywhere on the screen and see maximum detail, something desirable when playing the game. As Lev Manovich has argued in relation to Hollywood special effects, without a compensating algorithm computer generated images are rendered so that all areas are in sharp focus.

Typical images produced with 3-D computer graphics still appear unnaturally clean, sharp, and geometric looking. Their limitations especially stand out when juxtaposed with a normal photograph. Thus one of the landmark achievements of “Jurassic Park” was the seamless integration of film footage of real scenes with computer simulated objects. To achieve this integration, computer-generated images had to be degraded; their perfection had to be diluted to match the imperfection of film’s graininess. (Manovich, 1995)

Capturing an image through a camera set slightly out of focus created a softening of the game space that began to emulate the aesthetics of romantic landscape paintings. This led to the images produced with this method being physically printed for an exhibition setting, but not used for the comparative tests. The screen capture method provided a more accurate digital rendering of what was displayed on screen, so images using method 2 were used for comparative tests instead.

Figure 015 – method 1 example: interference patterns

As discussed earlier in this chapter, a screen capture differs from a photograph primarily in that a physical camera is not used, and the resulting image could be called a ‘virtual photograph’. The screen capture is a digital image produced by intercepting the signal being sent to the display screen. A screen capture does not capture light on a sensitized surface in the same way as a physical camera, but records what was being displayed on each pixel on the screen at any given moment, essentially ‘grabbing’ the pixels from the screen (often referred to as a screen-grab). This method did not produce interference patterns as with method 1 as no physical camera was needed.

The images on screen could be captured in two ways: the first was to use a device that could intercept and digitally record the video signal between the game-console and the display screen. This method could work with any game as it allows the capture and recording of any digital signal. The second was to use inbuilt ‘replay’ software, referred to as ‘theatre mode’ in MW3, which had a screen capture option. In this mode users can view previously played online multiplayer games and use inbuilt controls to create video and still images from the footage. The inclusion of a ‘theatre mode’ in the software of the game shows the popularity and desirability for users to be able to make videos and images from within their games since game developers are often on a budget when producing games. Uses of this mode are varied and complex; from videos boasting users top scores, most skillful games, as well as analysing strategy to improve skills, even collaborating with other users to create machinima movies. Machinima is defined by Henry Lowood as “the making of animated movies in real time through the use of computer game technology” (Lowood, 2006 pp.25). In his article “High-performance play: The making of machinima” (2006), Lowood discussed the development of the ‘theatre mode’ emerging from a desire to record and watch expert players’ fastest completion times of games known as “speed runs”. The ability to freely move the virtual camera independent of the avatar’s point of view was initially

conceived by Anthony Bailey as a way to improve the visualization of “speed runs” for the video game ‘Quake’ (id Software, 1996).

In order to provide an independent, floating-camera view of the action, Bailey programmed a software utility to “recam” (re-camera) Quake demo movies, building on Girlich’s work on LMPC. He called the program Remaic (“remake”), because it was now possible to revise the camera view on portions of a speedrun recorded in realtime without re-recording the run. Recamming did not literally mean refilming; Quake recorded the movements of player-actors, rendering them into data for the game engine’s built-in replay facility. The software only needed to manipulate the data to produce a new shot. (Lowood, 2006, p.34)

The built in ‘theatre mode’ allows the use of this “floating-camera” that can be positioned anywhere within the boundaries of the virtual space, free of the constraints of the avatar’s point of view. The “floating-camera” enables images to be captured at the edges of the levels, revealing glitches and elements that make up the structure of the virtual space. Similar to seeing the scaffolding behind the facades of a movie set such as in Gregory Crewdson’s photographic series “Sanctuary” (2009), the illusion of space in the video game is broken as hillsides appear like paper cutouts of a diorama (figure 016). An example of the documentation of the edges of the virtual space is seen in a series called “the end of the virtual world” by Robert Overweg (2010). In this series Overweg shows the boundaries of the virtual spaces, depicting roads that lead nowhere and buildings or structures that appear incomplete. Overweg’s series reveals a similar fabricated side to the virtual space as that of a film set; one not intended to be seen by the gamer. This documenting of the edges of the virtual space highlights a use of the

virtual space of video games outside the prescribed use to play a game, and could be yet another topic for an entire thesis.

Although interesting and valuable as a tool to learn about the structure of the virtual space, the free-camera mode was not used for the construction of images used in comparative tests. Firstly because showing glitches would signify the image origin, and secondly the free camera mode allowed perspectives beyond the capabilities of the avatars point of view, therefore beyond the capabilities of my point of view when photographing in the physical space, also signifying image origin. The free camera mode was used however to make images of the virtual space that could show perspectives beyond the point of view of the avatar for use in ranking tests and analysis of the structure of the virtual space.

Figure 16 – example of glitch at edge of video game

Photographs of the physical space were needed for the construction of comparative tests in both urban and material form. The same camera was used to photograph the physical space as outlined in method 1 for capturing the virtual space, and a wide-angle lens comparable to the angle of view in the virtual space was used. The angle was approximately 80 degrees field of view and 28mm as the lens focal length. Choosing this angle meant that the field of view for both virtual and physical space images was comparable so that it was not a signifying factor for image origin.

The photographs were constructed over multiple photo shoots in various locations. The locations were chosen according to different test types and variables, for example places plausible as urban virtual spaces or places that had materials similar to the virtual spaces to test the textures in close up images. The aesthetic approach of images captured in the physical space was chosen according to the output for which they were used. Both urban form and material form outputs were used, each employing a similar approach toward composition and distance from subject. This meant the images of physical and virtual space aligned stylistically. For the aesthetic approach to the construction of images three forms were used, as outlined in the following section.

4.3 Framing the Virtual Image

This section discusses the capturing of images of the virtual space of video games through traditional and emerging photographic methods used to gauge audience responses. Images of the virtual space were used for various outputs and so a formal approach toward aesthetics was needed to allow different variables to be tested. This table summarizes the formalized approach taken to construct images from within the virtual space. (Figure 017) These formal approaches were employed when framing the images of the virtual space on the screen, and guided decisions such as proximity to virtual objects, choice of subject matter and style of composition.

Images using landscape aesthetics were constructed using a physical camera by photographing the display screen and were framed with the virtual camera using a long shot. The subjects depicted were distant in the virtual space and primarily displayed as a 2D backdrop, although some objects in the foreground were 3D renders. These images were used for a physical output in an exhibition. Images using urban form aesthetics were constructed using the screen capture method and a medium shot. The subjects depicted were at a medium distance in the virtual space and primarily displayed as 3D renders and texture mapped objects. Some subjects in the background were 2D backdrops. These images were used in a virtual output for comparative and ranking tests. Images using material form aesthetics were constructed using the screen capture method and a close up shot. The subjects depicted were at a close distance in the virtual space and displayed as 2D texture mapped 3D objects. These images were used in a virtual output for comparative tests.

Image	Form	Aesthetics	Method	Structure of Virtual Space	Output	Shot Type
1. Landscape	Romantic landscape paintings and landscape photography	1. Physical camera photograph of screen	2D painted matte backdrop (some 3D) rendered objects	Physical prints for art gallery	Long
2. Urban	Urban documentary photography	2. Screen capture	3D rendered objects + 2D texture mapping onto objects	Virtual online tests origin and ranking	Medium
3. Material	Close-up photography	2. Screen capture	2D texture mapping onto 3D objects	Virtual online tests origin	Close

Figure 17 – Table of formal approaches, methods and outputs

Figure 018 Landscape form

The first form analysed in this thesis was the landscape form; similar to a long range photographic shot. The aesthetic approaches of romantic landscape painting and landscape photography were applied to images constructed in virtual spaces. For this area of investigation images were created that captured examples of landscape forms being used within the virtual space. These images were then used in exhibitions within an art gallery setting.

There were two reasons for exhibiting these virtual landscapes in an exhibition; firstly to explore and document the possible reasons game designers are using these types of forms and aesthetics within their games, and secondly to assess whether re-contextualizing the virtual space images into a gallery setting changed audience interpretation of the images.

The images created from the virtual spaces drew influence from a wide range of painters such as Joseph Turner, Camille Pissarro, Rene Magritte and photographers such as Ansell Adams, Michael Kenna and Andreas Apse. Early examples of the romantic landscape genre explore themes of beauty in the landscape by showing scenes of rivers, trees and fertile lands. Such places were considered suitable for human colonization and were viewed as holding promise for the future. In more contemporary landscape art the subject has shifted toward beautiful places that are holiday destinations, expensive to visit and inaccessible to the average person.

The virtual spaces of video games employ both the romantic and the contemporary landscape genres. Features such as golden sunset style lighting, elevated perspectives that offer spectacular outlooks such as high-rise rooftops, mountains and canyons, and subjects such as rivers, mountains, trees and oceans. These types of spaces commonly found in video games are often based on well known locations and popular holiday destinations.

This raised the question of whether designers and producers of video games intentionally design these virtual spaces with romantic and contemporary landscape aesthetics in mind. Whether they do this intentionally or not, these aesthetics are a recurring part of our visual culture.

It is common for people to document their holidays photographically and place this documentation in the virtual space through social networking websites such as Facebook and Flickr. It has also become a common practice for gamers to place documentation of their experiences, such as high scores, glitches and achievements in the virtual space in a similar way. This thesis explored how audiences reacted when reversing this cultural practice by using images constructed in the virtual space and placing them in the physical space.

There is an interesting relationship between the types of virtual spaces being designed and their counterpart physical spaces. John Urry (2002) has discussed a shift in the way people perceive spaces when they are vacationing compared to when they are living in the spaces, naming this the 'tourist gaze'. Whether a similar type of gaze is found for the perception of virtual spaces is something this thesis explored.

Using a long shot to view virtual spaces means that what we are looking at is a painted matte - a single two-dimensional [2-D] image depicting the objects in the distance of the virtual space. As we approach this matte the objects depicted in the virtual space get closer and shift from being a 2-D matte to 3-D coded objects. By using a medium shot the use of 3-D objects to depict a virtual space can be explored.

Figure 019 Urban form

4.3.2 Urban form

The second form analysed in this thesis was the urban form; similar to a medium range photographic shot. By getting closer and using a medium shot it was possible to explore how the virtual space changed from vistas inspired by romantic landscape to more intimate urban spaces reminiscent of imagery found in urban documentary photography.

This thesis tested whether or not the incorporation of urban documentary aesthetics in images created within the virtual space directed viewers to interpret the images as being created in a physical space. This brought into question not only how aesthetic and genre techniques direct the viewer, but also whether or not the verisimilitude of the virtual space is close enough to that of photographs of an actual space for the viewer to mistake the source of the image.

Photographers have made documentary images of spaces in the physical world to offer the viewers a deeper understanding of the importance of places to the people who inhabit them, addressing historical, social, behavioral and cultural norms. Similar documentary photographic techniques were applied to the virtual spaces of video games to investigate in what form these same themes emerge. Furthermore images constructed in the virtual space alongside images constructed in the physical space were applied in quantitative tests to understand how audiences interpret these spaces.

Photographers such as Eugene Atget, Henri Cartier-Bresson, Mark Power and Alec Soth, to name a few, have all developed their own unique and distinct styles shaped specifically by their sensibilities toward cultural space. They all employ a documentary style of photography that enables their images to be read as documents, the subjects of which are perceived as ‘found’ images. This perception of the subject as ‘found’ is created by a transparency in the photographer’s intention to record the subject ‘as is’ when discovered by the photographer, and not to manipulate the subject to help communicate their agenda.

Unlike other mediums such as painting, which is ‘drawn’ by hand, photography mechanically ‘reproduces’ an image by capturing light that enters the lens of the camera. Walter Benjamin has discussed the mechanical reproduction of the photograph and its affect on the notion of what art is in the chapter “The Work of Art in the Age of Mechanical Reproduction” from his book “Illuminations” (1968, p224). The fact that a photograph is a mechanically produced, along with the high levels of verisimilitude in the render of photographic images, has led to photographs being viewed as indexical referents to actual events that have taken place – as evidence of reality as Roland Barthes says, referring to Susan Sontag:

The photograph is literally an emanation of the referent. From a real body, which was there, proceed radiations which ultimately touch me, who am here; the duration of the transmission is insignificant; the photograph of the missing being, as Sontag says, will touch me like the delayed rays of a star. (Barthes, 1981, p.34)

In some cases this perception of photography as evidence is deemed shortsighted and even foolish, largely due to the ability to manipulate images during and after capturing as well as due to the editing and sequencing of the images by the artist to communicate their own agenda. A famous precedent highlighting the notion of photography as indexical was discussed at the beginning of this thesis; the ‘Cottingley Fairies’. There is however an attempt by photographers to create images that can be used as historical evidence by photographing their subject as though it was found as it is depicted, and by limiting or not using any postproduction editing. This transparency of technique and approach directs the viewer to perceive a photograph as close to the ‘truth’ [a referent of the indexical object] as one can get when looking at any historical document.

Making photographs of the virtual space of video games to document the spaces that are visited helps to connect the player to the virtual space. It gives the player a physical document, a souvenir of sorts, similar to holiday photographs taken to record places they have visited in the physical space. These photographs offer a long lasting connection between the video game player and the virtual space and act as an index to the virtual space similar to “speed run” (Lowood, 2006) videos that preceded machinima.

This medium view of the virtual space helps give an understanding of the types of spaces used and how they are engaged with at a human level. By zooming in once more it is possible to explore the structure of the virtual spaces and to show the current level of rendering and compare this to levels of rendering found in object photography.

Figure 020 Material form

The third and final form analysed in this thesis was object and material form; the use of close-up photography and its ability to isolate objects from their surroundings. The ability to isolate objects from their surroundings was useful for quantitative tests to compare physical space textures to virtual space textures. By isolating the textures from the rest of the scene the participant must decide on the space source without any other context. This meant that it was the quality and accuracy of the object's render and texture mapping that was used to determine whether or not the space used to make the image was virtual or physical.

Zoom lenses and even microscopes are used to create close-up images that enable us to see the material form of objects, often beyond what is humanly possible. This enables the ability to learn about the structure of materials in a way not possible without the use of technology. This technique of zooming in with a camera to learn about the structure of materials can be applied to the virtual space.

One major difference between close up images of the game space and close up images of physical spaces is what happens when approaching objects from a distance. Getting closer to objects in the actual space reveals more detail, whereas there is no finer detail when getting closer to objects in the virtual space, instead the object becomes more pixelated. This is an area that could be explored by future game developers. Currently only a small amount of magnification is needed for the individual pixels to be visible. As computing and screen technologies have advanced, the resolution of the virtual space has increased, meaning that more magnification is needed before the pixels can be seen. Various levels of zoom were used in the tests to explore at what point this makes a difference to the participants ability to determine the origin of the image's space.

The next chapter discusses how these three formal approaches were used to construct the various tests and exhibitions.

05 Construction of Tests and Exhibitions

This chapter discusses the construction of tests and exhibitions used to gauge audience interpretation and responses. Images corresponding to each of the three forms discussed earlier were used in tests and exhibitions. There were three scenarios tested, the first two of which are commonly found, while the last one is less so. They were taking physical images and placing them in the virtual space, taking virtual images and placing them in the virtual space and lastly taking virtual images and placing them in the physical space. A preliminary test was constructed to help with the construction of more formalized tests that were conducted online. Following the preliminary test, four online comparative tests were constructed. These tests contained images from both the physical space and the virtual space that used urban form and material form aesthetics. This tested the ability of participants to determine image origin. An online ranking test was constructed using urban form images from the virtual space. This asked participants to rank images in order from most photorealistic to least photorealistic, helping to determine how elements within an image affected photorealism. Lastly, images relating to landscape form were used in an exhibition of images at an art gallery. For the exhibition three images constructed from the virtual space were printed, taking virtual space images and putting them back in the physical space. This was to explore how audiences would interpret the virtual images when put back into the physical space.

5.1 Preliminary Test

The initial test was not publically available and was used to help understand how audiences would respond to the images of the virtual space when placed with images of the physical space. Information from the results of this test was used to construct public and anonymous online tests that had the ability to reach a larger and more varied sample audience. There are many factors that affect how audiences interpret images, an example being the order in which images are shown when viewing images as a sequence. This notion is known as the ‘Kuleshov Effect’, getting its name from research conducted in the early 1900’s by Lev Kuleshov. This effect has been well discussed and originated after a series of experiments into audience reactions to films. A typical explanation being:

Kuleshov intercut a perfectly neutral close-up of an actor with a shot of a plate of soup; then the same close up with a dead woman in a coffin; then with a little girl playing with a doll. Audiences raved about the actor’s sensitive projection of hunger, grief, and paternal joy, his subtle shifts of emotion depending on what he was looking at. Kuleshov proved that the order of shots in a sequence influenced the perception and meaning of any given action. (Giannetti and Eyman, 2009 p. 90)

To limit the effect of sequencing on audience’s interpretation of the images, they were placed individually rather than side by side, and participants had to scroll down to view the next image in the test. This meant that only one image could appear onscreen at a time. Even this was problematic, as the previous image would no doubt have been in the memory of the participant, something difficult to avoid, and that could be experimented with in future tests.

The preliminary test consisted of 10 images, five from the physical

Figure 021 – Photograph from preliminary test; virtual space (MW2)

space and five from the virtual space. The order of the images was randomized so that audiences could not determine image origin by guessing a pattern of virtual to physical space images. The images were shown to participants who were asked to indicate whether they believed the image was from a physical or virtual space.

The physical space images were taken at a quarry, a space that is commonly used to model a virtual space of a video game level. The lens was set so that the photographs had a short depth of field. This was different to the virtual space that uses a large depth of field, with all objects in the foreground through to the background appearing sharp and in focus. This was done to determine if participants would identify the origin of the images through the quality of the depth of field. The virtual space images were constructed in the game ‘Call of Duty: Modern Warfare 2’ (Activision, 2009) and were composed knowing that a 3:2 aspect ratio would be used for tests. This meant that they

Figure 022 – Photograph from preliminary test; virtual space (MW2)

required cropping from their original 16:9 aspect ratio. Apart from cropping the images were unaltered. A future test could use aspect ratio to determine whether or not audiences use this as a factor to identify image origin, something that was informally tested in the exhibition in this thesis. Due to these varied aesthetic qualities I hypothesized that the images origins would be clearly identifiable. The average score was 88%, showing that participants were very good at identifying the origin of the images. When analyzing the individual results however, there were two images that participants had particular difficulty in identifying the origin (refer to figures 021 and 022). Both were from the virtual space and their subjects were interiors of buildings, one an office space and the other an airport.

There was a space at the end of the test where participants could write comments about their experience. Participant feedback of this test raised several points on how the images were perceived, and the qualities of

Figure 023 – Photograph from preliminary test; physical space

the images that influenced the decision-making. Participant's responses were varied, suggesting that individual understanding of images as well as the personal relationship to content of the images has a considerable effect on their interpretation. Some participants showed a complex process used to understand and interpret the images.

It was noted that the physical space images had a softer quality of light compared to harsh light used in the virtual space. Furthermore, one participant wrote that the physical space images were seen as having much higher detail, including areas that had a complexity beyond the ability of current levels of technology for rendering the virtual space. One participant commented about the changing depth of field and wrote that this enabled them to determine image origin. Another participant noted that the virtual space images appeared to have lower resolution; making them appear more pixelated, as well as containing an over-sharpened feel. These responses were expected due to the

short depth of field used and the diffused light in the photographs from taking them on a cloudy day, and the sharpness of the detail in the virtual space from large depth of field and high contrast lighting.

There was one participant who noted an issue about the ‘ratio of order and disorder’ in the arrangement of objects. This was an unexpected response. They wrote that some images contained ratios of order to disorder that were too high or too low. For example, they believed that in image of the container and pallets (Figure 023) the bushes in the background were “too random in their arrangement” to be constructed virtually. It was understood by this participant that computer game developers have a tendency to overdo random spreads of objects when trying to imitate randomness in a scene, making them feel evenly dispersed, rather than naturally random. This showed a very sophisticated decision making process, and helped this participant to correctly identify the image origin of all images. This also highlights an idea for game producers to consider in the development of photo-realistic graphics.

Findings from this preliminary test affected the way future tests were constructed. The aperture of physical space photographs was set to give a large depth of focus to more closely resemble the sharpness of the virtual space. Image order was randomized so that patterns of sequencing could not be guessed. For the use in online tests images were all resized to the same resolution and file size. This eliminated a difference in resolution being a factor in determining image origin and enabled the images to load at the same speed in the participant’s screen.

Urban form and material form images were used in four online comparative tests, two using urban form and two using material form. A set of twenty images was created for each form from both the virtual and physical spaces that were placed into a virtual space (online) to gauge audience interpretations of image origin. The colour palettes of images of the virtual space differed from the colour palettes of images captured with the camera in the physical space. This was because the physical space images were constructed using a digital camera, and so were ‘raw’ images, while the images of the virtual space had colour grading applied as an aesthetic trope by the developers. Colour grading is used as part of an overall genre aesthetic that helps guide the viewer on how to read the images; they can be obvious and overused, but also subtle and innovative. Flaxton refers to these tropes as “tactics” in his article “HD Aesthetics” (2011):

Within contemporary cinematographic aesthetics, whether in film, analog or digital video, or electronic cinematography, there are a series of tactics to ‘say something’ with light. These tactics, if listed, become mundane: a warm look for safety and comfort, blue for threat and alienation – and so on. (Flaxton, 2011, p.117)

Flaxton writes of the a more mundane use of tropes to communicate a ‘mood’ to the audience, and goes on to discuss examples of Directors of Photography (DPs) who push the boundaries of cinematographic aesthetics such as Storaro, who “worked with color and light and the physiology of light enmeshed with the psychology” (Flaxton, 2011, p.117), and Hall whose “inventiveness and commitment was to the photographic within the cinematic arts” (Flaxton, 2011, p.117). By using a similar aesthetic language the virtual space of video games was aligned with cinematography, helping audiences to read the images in a way that they are used to, one that implies the indexicality

of the camera. There is a trend in games that is moving away from aligning the virtual space with aesthetics of cinema toward aligning it with photography, such as a shift toward ‘natural’ colour palettes and single exposure lighting rather than HDR. An interesting example of the use of graded colour casts in games is found in *Battlefield 3* (Electronic Arts, 2011) that has a colour grading affect applied to the game graphics. Often with modern games there are game mods (modifications) developed to change the way light is rendered within the game. Some users found this colour grading effect undesirable and so a game mod was developed to remove the colour grading and make the light appear more ‘natural’. These modifications became popular and were shared online, and so for next game released in the *Battlefield* series, *Battlefield 4* (Electronic Arts, 2013), the developers limited their use of the colour grading effect opting for a ‘natural’ colour style of lighting. Another common game mod is one that allows users to add the depth of field effect to make the graphics appear more photorealistic.

To test how much the colour played a part as a signifier of image origin, each set of twenty images was tested twice; once with the original colours and once with manipulated colours. The manipulated images were converted to black and white, then had a sepia filter applied. This tested audience’s ability to determine image origin based on factors other than the colour gamut.

All comparative tests were placed online and people were invited people to participate. The results of the tests were anonymous and data was collected using an online survey website. Participants were first asked to complete five questions about themselves, before being shown a series of twenty images. The five initial questions asked the participants age, gender, profession, what game hardware systems they use and how often they consume different forms of media such as television, cinema, video games, smartphones and photography. This helped to understand who was taking the surveys, and what their background

socialization was to image recognition. Participants were then shown the twenty images one at a time and had to indicate whether each image was created from a virtual space or a physical space. The sample techniques used for the online tests included convenience sampling and snowball sampling.

Images constructed for these comparative tests using the screen capture method had a 16:9 aspect ratio. As with preliminary tests, these images were cropped when placed into online tests to match the 3:2 ratio of the physical space photographs, avoiding participant identification of image origin as a result of aspect ratio (figures 024 and 025).

A significant factor to consider when constructing these tests was the resolution of the images as this plays a role in audience engagement. Terry Flaxton (2011) has shown that in tests moving from lower to higher resolution images audiences would linger longer on a high-resolution image than on a low-resolution image, so there was more engagement with the high-resolution images. (Flaxton, 2011, p. 114) Images from both the virtual space and physical space were resized so that they had the same resolution and also so that they would load in a reasonable time on the tests website. This meant that resolution as a variable was not tested for the online comparative tests, however it could be experimented with in future tests to help understand how resolution affects audience's interpretation of the virtual space. Resolution is likely to become more important as a factor for audience interpretation as the resolution of screens and outputs of game consoles increases and starts to approach that of the digital camera. Currently the maximum video game resolution is much lower than the photographs, so for tests the photographs were downsized to match the resolution of the virtual space. It was observed that when comparing the same video game on two screens simultaneously, one the lower resolution of SD, the other being HD there is a noticeable period of adjustment when shifting from the higher-resolution screen to the lower-resolution screen. The

pixilation of the SD screen is immediately apparent, but allowing a short period of time to adjust, this pixilation becomes less noticeable. One quick glance to the HD screen and the pixilation on the SD screen again becomes apparent.

This is evidence of a switching between two states in the suspension of our disbelief – with high definition eliciting more visual fascination. What is really interesting to me, as an artist, is the boundary between the two states. (Flaxton, 2011, p.114)

It seems this ability to adjust to the current level of image quality causes the suspension in our disbelief in our memory when moving back to older, outdated systems. Extrapolating this idea would mean that in time our perception of the current HD resolution will also look pixelated and thus not photorealistic when compared to future screens of higher resolutions.

Figure 024 – method 2 example: screen capture image before cropping

Figure 025 – method 2 example: screen capture image after cropping

Two comparative tests were constructed using urban form images. This helped to understand responses to aesthetics of urban documentary photography, and whether those aesthetics could be used to change the reading of a virtual space to a physical space. The images of the virtual space were made first, followed by the physical space. The locations of the physical space were chosen as to align with the types of spaces used in the virtual space. A variety of locations and subjects were chosen to eliminate test variables as much as possible such as whether participants might recognize the location of the space. The urban form images used an urban documentary approach to the capturing of space, and used a medium length shot. This was to show both spaces in a consistent way, so that both spaces aligned aesthetically in terms of framing and composition.

There were 20 images used in total, 11 from virtual space and 9 from physical space. Two tests were constructed from the set of 20; one with the original colour of the captured images, the other with a colour grading to unify the colour palette and remove it as a variable in the test. The graded images were first converted to black and white and then a sepia filter applied.

Figure 026 - Collage of photographs used for urban form comparative tests

The material form images of textures used a different style of photography that focused more the textures of objects. This approach helped to show how the rendering of the virtual spaces compared to photographic rendering of the physical space. A variety of materials were photographed in physical spaces that were chosen to align with images of materials in the virtual space. This included brick walls, concrete, building facades and garage doors. The images did not show much depth in space, focusing on flattening of space to highlight the textures of the materials.

As with the urban form tests, there were 20 images in total, 11 from virtual space and 9 from physical space and the same two versions created; one with original colour and one with graded colour.

Figure 027 - Collage of photographs used for material form comparative tests

Five sets of five images from the virtual space were used in online ranking tests. This took images created using urban form from virtual spaces and placed them back in the virtual space (online). In these tests audiences were asked to rank each image within each set in terms of the image's level of photorealism. The aim of this test was to examine what characteristics of the images audiences viewed as most photorealistic.

The colour palettes for each set was similar thus eliminating it as a variable for determining photorealism. This gave a clear coherence in the colours of each set of 5 images, and also a notable difference in the colours between each set. The images were all constructed using compositions based on an urban form of photography. Each of the five sets were constructed within the video game Call of Duty Modern Warfare 3, (Activision, 2011). The tests were hosted online and the same five questions were asked of participants as were asked in the comparative tests to determine some background information. The sample techniques used were convenience sampling and snowball sampling, as well as some judgment sampling.

Figure 028 - Collage of photographs used for urban ranking tests

Figure 029 Landscape form photograph printed for exhibition

Images that used landscape form were printed and mounted for an exhibition held at a small private gallery in Nelson, New Zealand. Figures 131 – 133 show the three images used and figure 134 shows the prints mounted and hung on the wall of the gallery. The images were created within the game Medal of Honor (Electronic Arts, 2010), showing mountain vistas comprised mostly of 2D backdrops, with some 3D rendered objects in the foreground. The particular image space was chosen as it was modeled on the Korangal Valley, a physical world space in northeastern Afghanistan. Choosing a scene that could be plausible as a physical space helped to provide a context for the images to be read as photographs. A few clues formally indicated the virtual space origin of the images. For example, the game's aspect ratio of 16:9 was retained when printing the images, and differed from the usual 3:2 ratio produced by a digital SLR camera.

Figure 030 Landscape form photograph printed for exhibition

The images were printed onto 400mm x 400mm square pieces of paper that had a fiber texture and left a white border. This white border is reminiscent of slide photographs, mimicking a recognizable aesthetic used in holiday snapshots. The prints were then block-mounted on 4mm pieces of wood so that they could be hung in the gallery space. The texture of the images slightly disrupted the pixilation, seen in some of the closer objects, and so enabled the images to be inspected at a close range without pixilation indicating image origin.

A convenience sampling technique was used to gather audience responses to the images. Those selected were asked their thoughts on where the images were taken and how they came to their decision.

Figure 031 Landscape form photograph printed for exhibition

Figure 032 Landscape form photographs mounted at exhibition

06 Responses to Tests and Exhibitions

This chapter presents the results from the online comparative tests; ranking tests and exhibitions. It examines the results of these tests to better understand the way in which audiences interpret and react to images of the virtual space.

There were a range of themes identified in participants' comments alluding to how they determined the photorealism of images and how they decided the origin of the images. The themes identified were:

- (1) The plausibility of the place
- (2) The plausibility of the subject matter, and
- (3) The quality of the render

A summary of the three themes is presented in this section, providing some insight into the thoughts and criteria participants used to determine photorealism. For each of the three tests, ten images that had a notable pattern of recognition are presented and analysed in more detail, out of a possible 20.

(1) Plausibility of place

Plausibility of place looks at the type of location in which the image is set, taking into account the scene and the components making up the scene. The following were identified in participants' responses relating to this theme:

The place looks like a warzone:

- If the place depicted looked like a warzone some participants were more likely to perceive the image as from a virtual space. One example of an image where this judgment occurred is figure 142, which will be discussed later. A warzone is an uncommon scene in New Zealand and so unlikely to appear in physical space photographs. For a future test images from the physical space of warzones could be used in comparative tests.

The place was not likely to appear in a video game:

- Some participants used their prior knowledge of video games to judge the likelihood that the place depicted in the image would be used in a video game. For example, in the preliminary test one participant commented on an image set in an airport terminal (figure 021), thinking it was a physical space as it was too unlikely that an airport would be used as a place in a video game.
- Some participants judged certain scenes as places that were “too romanticized” and so were judged as images constructed for the virtual space. An example of this in the ranking tests was the photograph depicting three waterfalls, a feature that was perceived as an indicator of a virtual space by one participant (figure 151).

Recognition of space:

- Some participants knew the photographs were made in New Zealand and so looked for signifying factors to determine if this was the case. Some participants recognized the photographs of physical spaces in New Zealand such as in figure 062, as it had a New Zealand brand name and phone number of a waste management company.
- Some participants, who were gamers, were able to recognize the virtual space as being from a particular game, and used this to identify the origin of the image. For example figure 030 was recognized as being from Medal of Honor (Electronic Arts, 2010) in the exhibition.

(2) Plausibility of subject

Participants used the subject in an image as an identifier of the

photorealism and origin of the image. A summary of responses relating to this theme are described below.

- Debris and destruction; some participants judged the origin of the space according to how much debris or destruction was in the scene. For example, figure 142, which had a lot of destruction depicted was most often perceived as from a virtual space. Whereas, figure 043, which had no destruction depicted was most often perceived as from a physical space.
- People; participants used their expectation of people in a scene as an identifier of its realism and origin. If there were a lack of people in a scene that would usually be expected to contain people, some participants saw this as a signifier of a virtual space, such as in figure 140 where there are several emergency vehicles blocking off a road but the scene is void of people. Another factor may have been based on the perceived likelihood of a photographer having access to such scenes.
- Detail; level of detail in an image was used as a signifier of photorealism. For example, participants perceived a high level to signify a physical space image, rather than virtual space. An example of this is figure 053 that has high detail in the foreground objects.

Signage and branding:

- The presence of signage and branding in a scene was used by participants to help determine the image origin and to judge photorealism. For example, in figure 062 there is a recognizable brand name and phone number. In figure 157 there are several fictional brands. If the participant recognized brands within an image it was likely to raise suspicions of the image origin being a physical space and vice versa. It is possible that a FPS video game would incorporate branding as product placement or sponsorship

such as in sports games, but this was not the case for the game used to construct images from (MW3).

- If the image incorporated photographic artwork such as posters, advertisements and billboards within the scene they became physical space referents. This is seen in figure 153, which was ranked the most photorealistic of its set.

(3) Quality of the render

Render quality was judged by participants as an indication of photorealism. Images rendered to a high quality were more likely to be perceived as photorealistic or from a physical space. Participants commented on the following regarding this theme:

The consistency of lighting and shadows:

- Some participants noted the shadows in figure 060 didn't look right. The image used an HDR effect or a single exposure effect to light the scene that changed the way objects appeared in the scene. An image that used HDR and was identified to a high degree of accuracy as from a virtual space was figure 060. An image that used single exposure lighting and was not identified to a high degree of accuracy as from a virtual space was figure 044.
- The position and angle of the light source in the scenes affected the perceived form of objects in the scenes. An overhead sunlight source depicted objects with strong form, whereas interior light sources tended to flatten objects, giving them low definition of form that participants identified as not photorealistic. In the ranking tests that had five sets of five images to be ranked by participants, Figure 143 had overhead sunlight was ranked first in its set, while figure

147 used interior lighting and was ranked the lowest in the set.

- Lack of apparent shadows for some objects allowed participants to identify the origin of the image as a virtual space and lowered perceived photorealism, as seen in figure 046 with the plant boxes.
- Inconsistent lighting meant that objects were not perceived as photorealistic and appeared "floating" in the scene. This is seen in figure 046, where participants noted the three photographs appear to float above the wall. This is due to the lack of consistent shadows from the wall across the images. Another example of inconsistent lighting is seen in figure 145, where the couch cushion lacks a shadow consistent with the left arm of the couch.
- Ambient occlusion is a technique applied to the rendering of light in the virtual space to mimic the way light radiates in the physical space. This effect is most noticeable in the fine detail of shadows cast by objects onto one another, and tends to create cohesion between elements within a scene. Participants noted differences in the shadow quality of some images. For example, if the shadow edges were hard and abrupt rather than diffused with a soft gradient, they were perceived as low in photorealism, such as seen in the shadows of the trees on the wall in figure 054. If a shadow edge was soft and diffused, for example like the shadow of the drainpipe against the wall in figure 093, it was perceived as high in photorealism. Images with little or no use of ambient occlusion were not perceived as photorealistic compared to images that included it.

High detail of render:

- Some details in the images were perceived to be beyond the capabilities of a digital render, such as the debris on the ground in figure 053.

- Another comment about high level of detail is in virtual space elements looking “too perfect”, or not random enough, such as the graffiti in figure 141.

Low detail of render:

- Numerous participants commented on curved objects in images, portrayed as a series of straight lines – known as aliasing. This was viewed as a badly rendered object, and indicated image origin as from a virtual space. Examples of this are seen in figures 060, 142 and 146.
- Participants commented that the detail and rendering of organic objects, such as trees and grass, gave an indication of the photorealism. Some organic objects were perceived as low quality of rendering, such as figure 056, and thus low in photorealism. One comment referred to “plants or grasses of any kind” as “so much easier to distinguish” saying that the games [developers] never quite do a good enough job [in rendering]. There was one participant who contradicted this trend who commented at their surprise of the reasonable quality of render of the trees in figure 143 stating that [the game developers] “had actually done a pretty good job of the trees [which was] unusual.”
- Vehicles in the virtual space were perceived as low quality renders that had low detail and looked “cartoon like”, for example, figures 152 and 162. Both of these images scored the lowest rank in their respective sets, indicated participants considered them low in photorealism. This is likely not a reflection on vehicles being more difficult to render and more likely related to do with the vehicles being less important in terms of gameplay, meaning they are not rendered as well as vehicles in games such as car racing games.

- Repetition of patterns or objects such as bricks and windows was identified as lowering the photorealism of an image. This is seen in the windows of figure 140. This repetition of objects is known as tiling, and it used to speed up the design process, perhaps to the detriment of photorealistic imaging.

- In some images the pixilation of objects was evident, which indicated image origin as a virtual space, and lowered photorealism, for example figure 109.

An understanding of the themes identified in the results helps to provide a basis for detailed analysis of each test and image individually. This section goes on to discuss the two tests conducted and the exhibition results.

6.1 Online Comparative Tests

This section discusses results from the four online comparative tests:

- Colour and graded for urban form, and
- Colour and graded for material form

Ten out of a possible 20 images for each comparative test are analysed in detail in this section, split into urban and material form. The chosen images either scored high, scored low, or had a large difference between the colour and graded versions.

People from a variety of demographic groups participated in the urban form comparative tests, as seen figures 033, 034, 035, 036 and 037, which show the age, gender and profession of the participants. The most common media hardware type used by the participants was a personal computer (PC), followed by a smartphone. There were a higher percentage of participants who used game consoles compared to portable game devices (figure 038, 039, 040, 041 and 042). For frequency of media consumption, the majority of participants indicated that they consumed television, short videos such as YouTube and smartphone applications daily, whereas, only 30% of participants consumed video games daily. Cinema and photography were mostly consumed monthly.

The average percentage for correctly identifying the image origin for the colour test was 88%, and for the graded test was 82%. This shows that the graded test, on average, was more difficult for participants to correctly identify image origin by a factor of 6%.

There were several images that participants were able to identify with a high degree of accuracy. The highest of which was from the physical space and was identified with 100% accuracy for the colour version and 98% for the graded version (figure 062). The most accurately identified image from the virtual space was figure 056 which scored 95% accuracy for the colour version and 92% accuracy for the graded version.

The most difficult image for participants to identify the origin of was figure 043, scoring 55% accuracy for both colour and graded versions. This image was from the physical space. The most difficult image from the virtual space was figure 044 with 77% correctly identifying the colour version and only 62% correctly identifying the graded image.

Figure 033 - Urban form colour comparative test analysis: Age of participants

Figure 034 - Urban form colour comparative test analysis: Gender of participants

Profession

Urban form colour comparative test analysis: Professions of participants

Game Hardware System Usage

Figure 036 - Urban form colour comparative test analysis: Game hardware systems used by participants

Media Type Usage

Figure 037 - Urban form colour comparative test analysis: Frequency of use of various media types

Figure 038 - Urban form graded comparative test analysis: Age of participants

Figure 040 - Urban form graded comparative test analysis: Professions of participants

Figure 039 - Urban form graded comparative test analysis: Gender of participants

Figure 041 - Urban form graded comparative test analysis: Game hardware systems used by participants

Media Type Consumption

How to understand all results

How to understand all results:

All images shown have a caption underneath that allows quick and easy reference to the figure number, the image type (virtual or physical) and the percentage of participants who correctly identified the image type. This diagram shows how to interpret the caption underneath each image.

Figure 042 - Urban form graded comparative test analysis: Frequency of use of various media types

6.1.1.1.3 Urban Form: Colour Results

Fig. 043 - Physical - 55%

Fig. 044 - Virtual - 77%

Fig. 045 - Physical - 81%

Fig. 046 - Virtual - 82%

Fig. 047 - Physical - 82%

Fig. 048 - Virtual - 86%

Fig. 049 - Virtual - 86%

Fig. 050 - Virtual - 91%

Fig. 051 - Physical - 91%

Fig. 052 - Physical - 91%

Fig. 053 - Physical - 91%

Fig. 054 - Virtual - 91%

Fig. 055 - Virtual - 95%

Fig. 056 - Virtual - 95%

Fig. 057 - Virtual - 95%

Fig. 058 - Virtual - 95%

Fig. 059 - Physical - 95%

Fig. 060 - Virtual - 95%

Fig. 061 - Physical - 95%

Fig. 062 - Physical - 100%

6.1.1.4 Urban Form: Graded Results

Fig. 063 - Physical - 55%

Fig. 064 - Virtual - 62%

Fig. 065 - Physical - 65%

Fig. 066 - Physical - 69%

Fig. 067 - Virtual - 72%

Fig. 068 - Virtual - 75%

Fig. 069 - Physical - 80%

Fig. 070 - Virtual - 80%

Fig. 071 - Physical - 85%

Fig. 072 - Physical - 87%

Fig. 073 - Virtual - 87%

Fig. 074 - Physical - 87%

Fig. 075 - Virtual - 88%

Fig. 076 - Virtual - 88%

Fig. 077 - Virtual - 90%

Fig. 078 - Physical - 90%

Fig. 079 - Virtual - 90%

Fig. 080 - Virtual - 92%

Fig. 081 - Virtual - 95%

Fig. 082 - Physical - 98%

6.1.1.5 Urban Form: Images

This section looks in detail at ten of the 20 urban form images used in the online tests. These images were selected due to their notable results. For each image, the statistics are displayed showing the percentage of participants who correctly identified the image origin, followed by some analysis.

Fig. 054 - Virtual - 91%

Statistics

This image had a relatively large difference of 19% between the colour and graded versions. For the colour image, 91% of participants were able to correctly identify the origin as from the virtual space, whereas only 72% could correctly identify the origin in the graded test. It was the first image for the urban form tests.

Analysis

- Subject and Plausibility; the image subject is a grassy courtyard containing several trees in front of the wall of a building. The scene is plausible to exist in the physical space in an everyday environment and there are no signs of destruction or war. Although this has been a factor considered to make the image more likely to be identified as being in the physical space, other factors affected the overall result.
- Light and contrast; the graded image has higher contrast, resulting in an increase in shadow depth and detail in the grass area. The colour image is softer with less contrast, making the tree trunks

Fig. 067 - Virtual - 72%

appear flatter. More shadow and depth is common in physical space photographs, this is likely to have contributed to participants wrongly identifying the graded image as being from the physical space.

- Shadow; the shadows on the wall have low detail showing some aliasing, which makes the shadow appear low in render quality and so less photorealistic. This is more apparent at the edges of the shadow in the colour version compared to the graded version due to the two tones at the edges of the shadow being evident in the colour version and not the graded.
- Colour palette; the colour palette of the image is subdued, with mostly grey colours of concrete and greens of the trees, grass and leaves. This subdued colour palette is unlikely to exist in a photograph of this subject, the greens of the grass and leaves would likely be brighter and more saturated, meaning that the colour image would be easier to identify as form a virtual space compared to the graded image.

Fig. 044 - Virtual - 77%

Statistics

This image was difficult for some participants to correctly identify as a virtual space image and also had a notable percentage difference between the colour and graded versions. For the colour image 77% of participants were able to correctly identify the origin as from the virtual space, whereas only 62% could correctly identify the origin in the graded test.

Analysis

- Subject and plausibility; the subject is plausible as a scene in the physical space and has no signs of war and destruction, likely to add to a perception of the image being from a physical space, rather than virtual.
- Light and contrast; the lighting type is virtual sunlight directly above the building that is hard light and creates strong form and contrast. This makes the image appear more photorealistic in both versions of the image.

Fig. 064 - Virtual - 62%

- Shadow; the eaves of the building cast shadows onto the table and chairs in the foreground. This, along with the interior of the building through the window being quite dark, shows a single exposure lighting technique rather than the HDR technique being used. This adds to the perception of photorealism, and for this image to be incorrectly identified as from a physical space in both versions of the image.

Fig. 053 - Physical - 91%

Statistics

Participants were able to identify the origin of this image with a high level of accuracy, and there was only a 1% difference between the colour and graded versions. 91% correctly identified the colour image as from a physical space and 90% correctly identified the origin of the graded image.

Analysis

- Subject and plausibility; this image shows the interior of a building that was being demolished. The top part of the rear wall is missing and there is wooden framing exposed and debris on the ground. There is a ladder on the rear wall leading up to a bright area of a grey, overcast sky. The debris and destruction may account for some participants judging this image as from a virtual space.

Fig. 078 - Physical - 90%

- Detailing; the edge detail in the debris and damaged parts of the building is high, with no aliasing of curved lines as commonly found in virtual space images. There is a mattress and some insulation wool on the ground that has a high level of detail and the floor space is very busy. These details make this space unlikely to be a virtual space.

Fig. 043 - Physical - 55%

Statistics

This image was one of the most difficult for participants to correctly identify the origin. Only 55% correctly identified the image as from a physical space for both colour and graded versions.

Analysis

- Subject and plausibility; the image shows a street scene with a street sign on the right of the image, a pair of red doors in the center and a red sign with white writing on it to the left of the doors. There are no signs of war or destruction in the image; the scene is plausible as either a virtual or physical space.
- Lighting; the image was taken at night, so the only lighting is three fluorescent lights mounted under an awning that protrudes from the building façade. The lights are overexposed and are shown as three glowing bright white spots in the image. This lighting type is common in the virtual space.

Fig. 063 - Physical - 55%

- Texture and repetition; the concrete facade of the building has an uncommon linear block pattern recessed in the concrete. The repeated pattern appears similar to tiled elements within the virtual space, possibly contributing to the perception of this image as from the virtual space.

Fig. 046 - Virtual - 82%

Statistics

Participants were able to identify the origin of this image as from the virtual space with a high level of accuracy; 82% of participants correctly identified the origin of the colour image, and 88% correctly identified the origin of the graded image. There was a difference of 6% between colour and graded versions, this shows it was marginally easier to correctly identify the origin of the graded image.

Analysis

- Subject and plausibility; this image shows an interior space with three large photographic fashion posters on the wall. Underneath the images are three plant boxes, and two seats. The scene is plausible as a location in a shopping mall. The use of texture mapped photographic material adds a sense of photorealism as they act as referents to the physical space, however other elements within this image may have accounted for this factor not being represented in the results.

Fig. 076 - Virtual - 88%

- Lighting and shadows; the space is lit from spotlights above the three images on the wall. Although adding a sense of realism to the scene, the fashion photographs appear to hover over the wall rather than being attached to it due to the wall shadows not continuing onto the fashion photographs. This is more evident in the colour version as the wall and fashion photograph are different colours, making them easier to distinguish. In the graded version this colour difference is not apparent. As well as this, the plant boxes and seats appear to float above rather than sit on the ground due to lack of surrounding shadow details. Both of these elements signify a lack of ambient occlusion in the scene and so the image origin as a render of a virtual space.

Fig. 057 - Virtual - 95%

Statistics

Participants were able to identify the origin of this image as from the virtual space with a high level of accuracy. There was a 5% difference between the colour and graded versions. For the colour image, 95% of participants were able to correctly identify the origin as from the virtual space and 90% correctly identified the origin in the graded test.

Analysis

- Subject and plausibility; the subject of this image is a construction yard with a shipping container and large upright concrete pipe. Although there are no signs of war related destruction, the scene is relatively uncommon due to the restricted access available at construction sites. This is likely to have contributed to participants perceiving the space as virtual.
- Lighting and shadows; the light source is virtual sunlight positioned above, in front and to the left of the image, casting shadows from

Fig. 079 - Virtual - 90%

objects onto the ground and concrete pipe. The shadows show signs of aliasing and a low level of edge detail. This is contrary to a physical space, so making the image appear as from a virtual space.

- Texture and detail; the texture of the pipe and the container has a high level of detail, which can make an image appear as more from the physical space than the virtual space. In this case, however, this high level of detail was overridden by other factors such as the aliasing in the shadows.

Fig. 062 - Physical - 100%

Statistics

Participants were able to identify this image's origin as a physical space with a high degree of accuracy and a small difference between colour and graded versions (2%). It was the highest scoring image, with 100% accuracy for the colour version and 98% accuracy for the graded version.

Analysis

- Subject and plausibility; this image shows an exterior loading zone at the rear of a building. There is a Daily Waste bin, which is a New Zealand based company and the phone numbers on the bins would be easily identifiable as New Zealand numbers to New Zealanders. There is also a 'Streets' logo, a well-known international ice-cream company. This branding may be a factor that overrides other elements in this image as they are not companies that would be included in an FPS game.

Fig. 082 - Physical - 98%

- Detail; the detail in this image is very high, for example the objects within the garage are high in detail and the two waste bins on the right hand side have visible writing and phone numbers on them.
- Lighting; due to the low lighting available in this space, a medium to large aperture was used, creating a relatively short depth of field. This created a softening and blurring toward the bottom corners of the image, something that would be sharp if in the virtual space and therefore indicating origin as a physical space.

Fig. 056 - Virtual - 95%

Statistics

Participants were able to identify this image origin as a virtual space with a high degree of accuracy and a small difference between the colour and graded versions (3%). The results were 95% for the colour version and 92% for the graded version.

Analysis

- Subject and plausibility; this image is set in a shopping mall and shows a plant in a large pot on the right hand side of the image, two pillars either side of a shop façade covered by security bars. The scene has no signs of destruction and is plausible as being from either a virtual or a physical space.
- Shadow; the lack of shadow detail underneath the pot makes it appear as though it is not sitting on the ground, this is from a lack of ambient occlusion and some aliasing of the shadow edges which

Fig. 080 - Virtual - 92%

lowers photorealism. There is also a lack of shadow detail in the shadow cast by the overhead virtual sunlight onto the curved pillar, which shows signs of aliasing.

Fig. 052 - Physical - 91%

Statistics

Perceptions of this image origin varied by 26% between the colour and graded versions. For the colour image, 91% of participants were able to correctly identify the origin as from the virtual space, whereas only 65% could correctly identify the origin in the graded test.

Analysis

- Subject and plausibility; this image shows a storage yard with large silos. The scene in this image is plausible as either a virtual or a physical space.
- Detail; the image contains high levels of detail, making it less likely to be perceived as from the virtual space.
- Colour palette; there are yellow handrails around the top of the silos and bright blue barrels to the center left of the image making the colour version seem bright and saturated; not an aesthetic commonly found in the virtual space. This bright colour, along with

Fig. 065 - Physical - 65%

the greens of the background hills is likely to have played a large part in participant's ability to recognize the origin of the image, as there was a decrease of 26% of participants correctly identifying the graded version's origin. The image seems more plausible as a virtual space without the bright-saturated colours of the blue barrels and yellow hand railings, something that was commented on by participants.

Fig. 060 - Virtual - 95%

Statistics

95% of participants were able to identify the colour version and 90% the graded version of this image. The difference between colour and graded versions was small, at 5%.

Analysis

- Subject and plausibility; this image shows a round concrete tube that forms a tunnel in the center of the image. It has debris either side of the tunnel and the background is the facade of a concrete building. The site is plausible as a physical space, however uncommon to most people to due restricted access of construction sites, similar to a previous image set in the same level (figure 057). Both images were identified correctly by at least 90% of participants.
- Detail; the objects in this scene have a lower level of detail compared with the ground texture, leading the objects to look less like they would be found in a physical space.

Fig. 079 - Virtual - 90%

- Render detail; a coil of cable to the right of the concrete tunnel shows signs of aliasing, making it appear as a render rather than a physical object that would be smoothly curved, again contributing to the perception that this is a virtual space image.
- Colour palette; the colour palette of this image is grey and monochromatic, not a likely colour palette for a physical space photograph. This could account for the lower statistic for the correct identification of origin of the graded image.

6.1.2 Material Form

The two material form tests were completed by a variety of participants as shown in the graphs showing age, gender and profession (figures 083, 084, 085, 086, and 087). The media type used by participants and frequency of consumption for different types showed a similar pattern to the urban form tests (figures 088, 089, 090, 091 and 092). There were several comments made by participants giving details about how they made their decisions and what elements they thought were well rendered.

For the colour tests, one participant wrote about the way light and shadows were displayed and how this was used to determine origin of images. The use of repeated patterns was highlighted by another participant as useful in identifying image origin. Another participant commented about shadows and sharpness, saying virtual space images “are those with something wrong with the shadows and high contrast between similar picture elements”. A participant also commented contrary to this, praising the virtual space images, saying it was “very difficult to tell them apart”.

For the graded tests, one participant commented on the tone of the images. They noted that the graded version of the images “lends itself more to the brick textures” and that they had to go back and re-evaluate some images that they had previously seen in the colour tests as virtual space in origin. One participant commented that it was a lot harder than they had first thought it would be to identify the origin, and another saying that it was “extremely difficult to distinguish, especially not being into video games”. One participant commented that their decisions were “purely guesswork” as they had no system for distinguishing the origin. One participant commented about being able to recognize that the images were from New Zealand, or conversely not from New Zealand, and they determined that the physical spaces were made in New Zealand. This allowed them to determine origin based on plausible locations found in New Zealand.

The average percentage for correctly identifying the images origin for the colour test was 81%, and for the graded test was 78%. This shows that the graded images on average were more difficult for participants to identify image origin, by 3%.

There were several images that participants were able to identify with a high degree of accuracy, the highest of which was from the virtual space and was identified with 92% accuracy for the colour version and 100% for the graded version (figure 106). The most accurately identified image from the physical space was figure 111 which scored 96% accuracy for the colour version and 88% accuracy for the graded version. The two equally most difficult images for participants to identify the origin of were figures 093 ad 095, scoring 55% accuracy for the colour version and 51% accuracy for the graded versions. These images were from the virtual space. The most difficult image from the physical space was figure 096 which scored 55% accuracy for the colour test and 66% accuracy for the graded test.

6.1.2.1 Participant Characteristics

Figure 83 - Material form colour comparative test analysis: Age of participants

Figure 84 - Material form colour comparative test analysis: Gender of participants

Figure 85 - Material form colour comparative test analysis: Professions of participants

Figure 86 - Material form colour comparative test analysis: Game hardware systems used by participants

Figure 87 - Material form colour comparative test analysis: Frequency of use of various media types

6.1.2.2 Material Form: Graded Analysis

Figure 088 - Material Form graded analysis, age

Figure 089 - Material Form graded analysis, gender

Figure 090 - Material Form graded analysis, profession

Figure 091 - Material Form graded analysis, hardware usage

Figure 092 - Material Form graded analysis, media type usage

6.1.2.3 Material Form: Colour Results

Fig. 093 - Virtual - 55%

Fig. 094 - Virtual - 55%

Fig. 095 - Virtual - 55%

Fig. 096 - Physical - 55%

Fig. 097 - Virtual - 67%

Fig. 098 - Physical - 74%

Fig. 099 - Virtual - 74%

Fig. 100 - Physical - 78%

Fig. 101 - Physical - 88%

Fig. 102 - Virtual - 88%

Fig. 103 - Virtual - 88%

Fig. 104 - Virtual - 88%

Fig. 105 - Physical - 92%

Fig. 106 - Virtual - 92%

Fig. 107 - Physical - 92%

Fig. 108 - Virtual - 92%

Fig. 109 - Virtual - 92%

Fig. 110 - Virtual - 96%

Fig. 111 - Virtual - 96%

Fig. 112 - Physical - 96%

6.1.2.4 Material Form: Graded Results

Fig. 113 - Virtual - 51%

Fig. 114 - Virtual - 51%

Fig. 115 - Physical - 53%

Fig. 116 - Physical - 58%

Fig. 117 - Physical - 66%

Fig. 118 - Virtual - 66%

Fig. 119 - Physical - 68%

Fig. 120 - Virtual - 70%

Fig. 121 - Virtual - 78%

Fig. 122 - Physical - 85%

Fig. 123 - Physical - 87%

Fig. 124 - Virtual - 87%

Fig. 125 - Physical - 87%

Fig. 126 - Virtual - 88%

Fig. 127 - Physical - 88%

Fig. 128 - Physical - 88%

Fig. 129 - Virtual - 93%

Fig. 130 - Virtual - 93%

Fig. 131 - Virtual - 97%

Fig. 132 - Virtual - 100%

6.1.2.2 Material Form Images

This section looks in detail at ten of the 20 material form images used in the online tests. These images were selected due to their notable results. For each image, the statistics are displayed showing the percentage of participants who correctly identified the image origin, followed by some analysis.

Fig. 100 - Physical - 78%

Statistics

This image had a large difference in origin identification of 25% between the colour and graded versions. 78% correctly identified the colour version origin as being from the physical space, and 53% the graded version.

Analysis

- Subject and plausibility; this image shows a seven story building façade from a low angle perspective. Above the building the sky is dark and bluish. The scene is plausible as a physical space and shows no signs of destruction or war.
- Lighting and shadows; There is a high level of detail in the shadows of the curtains behind the windows. The lighting of the windows is complex and detailed. The windows and curtains of the graded version appear more coherent due to the unified colour of shadows. This signifies a photorealistic image and may have contributed to

Fig. 115 - Physical - 53%

nearly half of participants incorrectly identifying the origin of the graded image.

- Colour palette; the building has warm saturated colour which is typical of a colour palette created when making images at night with a digital camera. The colour difference between the window frames and wall is noticeable and lacks the unified colour palette of a graded image found within the virtual space, which may have been a signifier of a physical space. The graded version shows coherence in the colours since the original colours had been removed, which is possibly another reason why the graded version scored substantially lower.

Fig. 093 - Virtual - 55%

Statistics

This image scored low for participants correctly identifying the image origin, with only 55% of participants correctly identifying the colour version and 51% the graded version. There was a small difference of 4% between colour and graded versions.

Analysis

- Subject and plausibility; this image shows a brick-building facade with two windows as the main subject framed formally with the wall perpendicular to the camera. This image could realistically be in either the physical or virtual space. There are no distinguishing features in terms of the subject.
- Shadows and detail; there is a vertical drainpipe in between the two windows, with a diffused shadow on the wall. A small amount of cobbled ground is visible at the bottom of the image. The shadows

Fig. 113 - Virtual - 51%

in the cobbles and bricks show depth and have high contrast. The shadow of the drainpipe is soft and diffused, showing use of ambient occlusion. This creates a high level of photorealism.

- Details and tiling; the two windows have diffused glass that blurs the objects behind them, which are repeated, showing the use of tiling. This could account for half of the participants reading this image as from the virtual space. However, the two windows appear visually different due to the right window having a reflection of a bright sky, giving it a lighter luminosity compared to the left window. This allows the tiled windows to appear different and be viewed as more photorealistic.

Fig. 106 - Virtual - 92%

Statistics

Almost all participants identified this image of a garage door as from the virtual space. 92% correctly identified the colour version and 100% the graded version.

Analysis

- Subject and plausibility; this image shows a roller style garage door, the walls either side are cinder block and the ground below is cobbled. It is a plausible scene for either the virtual or physical space. It shows no signs of destruction or war.
- Detail of render; the detail of the roller door is low, showing pixilation, thus indicating the origin as from a virtual space. This appears as a major indicator and may dominate any photorealistic elements such as little to no tiling in the textures and patterns of the bricks and roller door.

Fig. 132 - Virtual - 100%

- Colour palette; the colour palette is subdued and almost monochromatic with low contrast and a lack of depth to the blacks in the shadow areas. The colour image appears similar to the graded image, but with a warmer colour tone and more saturation. This makes the difference between the colour and graded versions less apparent, leading each to a similar score.

Fig. 095 - Virtual - 55%

Statistics

Participants had low accuracy in identifying the origin of this image as from the virtual space. The colour version scored 55% and the graded version 51%.

Analysis

- Subject and plausibility; this image shows only the bricks of a cinder block wall. There are no signs of war or destruction. There is no context given by other objects in the scene as only the wall is in frame. This subject is plausible to be in a physical space.
- Detail; there is little repetition of textures, however a one noticeable repetition of a brick on the top right and bottom right that has an identical dirt spot. This is a small detail so may not have been noticed by all participants, but may account for some participants correctly identifying the image origin.

Fig. 114 - Virtual - 51%

- Render quality; there is some pixilation in the details of the grout between the bricks, which could have accounted for half of participants correctly identifying the image.
- Colour palette; there is low saturation and a monochromatic colour palette, creating a very minimal distinction between the colour and graded versions. The bricks each have some variation in tone and pattern, creating a more photorealistic image.
- Shadows; there are no shadows cast onto the wall from surrounding objects, there is good shadow detail between the bricks showing use of ambient occlusion and creating a photorealistic image.

Fig. 101 - Physical - 88%

Statistics

For this image there was a large percentage difference between the colour and graded versions of 20%. For the colour version, 88% of participants correctly identified the image, and 68% correctly identified the graded version.

Analysis

- Subject and plausibility; this image shows a facade and diagonal profile of a stairway on the exterior of a building. The lower part of the building is clad with roofing iron and the top part of the facade is clad with concrete board panels. The cladding type is typical of a New Zealand building style, possibly contributing to some participants identifying as a physical space
- Shadow and detail; this image has no signs of pixilation and has a complex variety of luminosities in the shadows under the railings

Fig. 119 - Physical - 68%

due to multiple light sources from overhead, creating a photorealistic perception of the image.

- Colour palette; the green colour of the roofing iron was a factor in recognizing the origin as there was a 20% drop in participant's ability to recognize the origin of the graded version of this image. This bright green is an unlikely colour to exist within the colour-graded palette of the game, and so could have accounted for the higher percentage accuracy for the colour version.

Fig. 109 - Virtual - 92%

Statistics

Participants had a high accuracy in determining image origin for this image as from the virtual space, with 92% correctly identifying origin for the colour version and 97% for the graded version.

Analysis

- Subject and plausibility; this image shows a white brick wall with metal stairs to the bottom left of the image. There are two pipes on the wall in the center of the image. There is no destruction or signs of war; the subject is plausible as a physical space.
- Detail of render; there is low detail in the grout of the bricks and some pixilation of the brick wall toward the bottom. This, along with some aliasing of the detail in the metal stairs shows low detail and reveals the scene as from a virtual space.

Fig. 131 - Virtual - 97%

- Shadow detail; there are no shadows by the protrusion of the wall or the metal stairs bottom left, making the stairs appear floating rather than attached to the ground, lowering the photorealism of the scene.

Fig. 104 - Virtual - 88%

Statistics

For this image there was a large difference in correct origin identification of 30% between the colour and graded image versions, with 88% correctly identifying the colour version and down to 58% for the graded version.

Analysis

- Subject and plausibility; this image is a close up texture of a garage door with no other elements to give the context of the surrounding environment. This image could realistically be from either a visual or physical space.
- Detail of render; there are rust and drip marks from where water has corroded the metal surface that are high in detail and show no repetition or tiling. This level of detail in such a close-up image is unusual for a virtual space and may have contributed or the texture to be interpreted as from a physical space

Fig. 116 - Physical - 58%

- Colour palette; the drop in accuracy between the colour and graded versions shows that colour played an important role for the interpretation of this image. The colour version shows high level of colour detail in the rust toward the top of the image that is not visible in the graded version. This detail was likely a factor in the low accuracy for the graded version, as the virtual space was unlikely to have such colour depth as seen in the colour version.

Fig. 111 - Virtual - 96%

Statistics

Participant's scores were to a high accuracy for this image, with 96% of participants correctly identifying the colour image and 88% correctly identifying the graded image as from a physical space.

Analysis

- Subject and plausibility; this image shows a cinder block wall with a concrete stair rail and two doors recessed into the building. There is a large patch of paint missing from the concrete handrail and a security light in the top left of the image. This scene could realistically be from either the physical or virtual space. There are no distinguishing features at this point.
- Detail; there is a high level of detail in this image with no aliasing of edges and no repetition from tiling. The cinder block wall is similar to figure 61 however there is dust and dirt buildup than spans across multiple bricks, coating the wall in a texture not found in a virtual

Fig. 127 - Physical - 88%

space image. This is due to the wall not being cleaned, and shows the image as from a physical space. There is also a high level of detail in the peeling paint at the bottom right of the image that exposes some worn off tar sealant on the concrete wall underneath the paint. This shows a complex layering revealing the construction process and alluding to a physical space.

- Shadow detail; the image has high shadow detail and a feathered edge to the shadow in the doorway. There is a security light in the top left corner that has complex soft shadow underneath it. These details in shadows allow for the image to be read as from the physical space.
- Colour palette; the natural colour palette of the colour version is more photorealistic compared to the grade version. The grading of the image may have contributed to it being perceived as a virtual space by some participants as this aligns the palette more with images of the virtual space.

Fig. 094 - Virtual - 55%

Statistics

Participants had a low accuracy when identifying the origin of this image with an accuracy of 55% for the colour version and 66% for the graded version.

Analysis

- Subject and plausibility; this image shows a concrete block wall with a shadow line dividing the image into two halves, from bottom left to top right. There are no other objects to give context to this image. It is a plausible texture to be found in both the physical space and the virtual space.
- Detail; there is some repetition of textures as seen in the centre of the concrete blocks, showing the use of tiling, and signifying a virtual space image. However, the repetitive shadows in the centre could have been interpreted as dirt or residue that would have built up from water running down the wall as a continuous line or a type

Fig. 118 - Virtual - 66%

of dirt build-up rather than tiling.

- Shadow detail; the shadow depth in the grout between the concrete blocks shows high contrast, and the large diagonal shadow line shows slight variations in the edge line and no aliasing. This shadow technique is not typical of a virtual space image and may have accounted for some participants perceiving the image as from a physical space.
- Colour palette; the image is quite monochromatic with a minimal amount of colour depth and no bright colours. The colour version shows the concrete as a cold bluish colour, which is close to the colour of concrete in the physical space, whereas the graded version shows the concrete as a warm colour tone, something more likely found in a colour graded palette of the virtual space. This possibly accounted for the increase in accuracy in identifying the colour version as from the virtual space.

Fig. 096 - Physical - 55%

Statistics

Participants had a low accuracy in identifying the origin of this image with a score of 55% for the colour image and a rise to 66% for the graded image. This shows an 11% increase in accuracy from the colour to the graded version.

Analysis

- Subject and plausibility; this image shows a dilapidated building facade, with smashed windows and covered in graffiti. There is a blue pipe vertically running through the center of the image. There is a double door sized opening on the bottom right, blocked by some shelving units. The space shows signs of destruction, leading some participants to perceive the space as virtual, as evidenced in their comments earlier.
- Detail; There is text written above the door opening saying 'inwards outwards goods' which is generic enough to be plausibly

Fig. 117 - Physical - 66%

found within the virtual space, or the physical space. There is a variety of graffiti along the lower part of the wall; one such graffiti painting is repeated twice on the wall. Although both versions of the painting are actually unique, the graffiti artist has painted each version to a similar enough degree that they appear as repetitions, as though they have been tiled and are in a virtual space. This may be an element that participants recognized incorrectly as being from a virtual space. There is a high level of detail in the smashed windows at the top of the image, showing no repetition and reflections of the sky behind. Reflections are likely to have led participants to perceive the image as physical space, as the detail is great.

- Shadow detail; the two lower windows show the interior as being very dark. This shows a single exposure image rather than HDR, typically found in physical space photographs, but not uncommon in the virtual space. The large blue pipe in the center of the image does not appear to have a drop shadow, something that might appear

missing due to the drainpipe with a shadow to the left of it. Although this is a physical space image, this apparent lack of shadow on the main pipe may have allowed for a reading of the image as from the virtual space.

- Colour palette; The colour version of the image shows warmth of the reflected sky in the windows, which makes them stand out and appear as slightly surreal. This type of reflection is something found in earlier virtual space images and may have accounted for the colour version being interpreted less accurately. The windows of the graded version have no colour reflection, making them appear flat and showing the high level of detail and lack of tiling in the smashed glass. This may have accounted for the higher accuracy in the graded version.

6.2 Ranking Test

This section discusses responses to the online ranking test. Five sets of five images were shown to participants and ranked in order of most to least photorealistic. A graph for each set shows the average ranking for each image (figures 163, 164, 165, 166 and 167).

6.2.1 Participant Characteristics

Participants were asked to answer the same 5 questions as with the comparative tests when completing the ranking tests. These questions covered age, gender, profession, types of game hardware used and the frequency of consumption of various types of visual media (figures 133, 134, 135, 136 and 137).

76% of participants were male, and 24% female. The majority of participants were between the ages of 16 and 39, with 43% between 16 and 25, and 41% between 26 and 39 years old. 2% were under 16 and 13% over 40. Not all participants played games, with 40% of participants using a personal computer and 18% using a smart phone. 10% or less use other game hardware. Participants professions were varied, 45% answered other and specified professions in areas such as student, construction, hospitality, communications, theatre, architecture, 3d animation and retired. Most participants consume television, short videos and smartphone media on a daily basis. Users of a smartphone were either daily, weekly or not at all.

Participants interpreted the judging of photorealism in two different ways; some judged photorealism on the plausibility of the subject of the scene, and others on the render quality of any type of scene. Similar themes emerged as in the previous tests such as level of detail, the use of tiling, signs of aliasing, and coherence in shadows.

6.2.2 Ranking Analysis

Figure 133 - Ranking test analysis: Age of participants

Figure 134 - Ranking test analysis: Gender of participants

Participant Professions

Figure 135 - Ranking test analysis: Professions of participants

Participant Game Hardware Usage

Figure 136 - Ranking test analysis: Game hardware systems used by participants

Participant Media Type Usage

Figure 137 - Ranking test analysis: Frequency of use of various media types

Set 1

Figure 138

Set 2

Figure 143

Set 3

Figure 148

Set 4

Figure 153

Set5

Figure 158

1st

2nd

Figure 139

Figure 144

Figure 149

Figure 154

Figure 159

3rd

Figure 140

Figure 145

Figure 150

Figure 155

Figure 160

4th

Figure 141

Figure 146

Figure 151

Figure 156

Figure 161

5th

Figure 142

Figure 147

Figure 152

Figure 157

Figure 162

These set images were made within a level that is modeled on a British subway station. It includes ‘black cabs’, police vehicles with British police insignia, double decker buses, a subway map reminiscent of the London underground, a large clock over the subway station main building and rubbish dumpsters down dark alleyways.

For this set a pattern emerged for which images were most photorealistic looking, as seen in figure 163. The image ranked most photorealistic was the image of the subway map and it’s surroundings (figure 138). There were several comments left by participants for this set of images that show how people were making their decisions. A comment from a participant about image 04 (figure 138) noted the high level of detail around the train map. There was a comment about the images overall: “Repeated textures in several of the images really jar my eye. All of these images instantly struck me as virtual spaces partially because of subject matter, and partially because of a certain ‘polygon-ness’ that makes things look like they are floating”. Another participant discussed elements of the image judged least photorealistic, mentioning aliasing in image 01 (Figure 142) that would have shown smooth curves in a photograph. “There are several bent pieces of metal rod sticking out of a fallen piece of road that appear as a series of straight lines rather than a smooth curve. This immediately looks like a digital render, as the metal rods appear linear rather than curved”. The plausibility of the subject was brought up on several occasions, one participant said they thought image 01 (Figure 142) “looked real” but was an unlikely scene, so was ranked lower. Another commented, “the images that are of a more normal/everyday situation seem more realistic than the bomb site type image - not because of the image quality/texture but because of the normality of the scene”. Several participants commented on the second image (figure 141) saying that it “looks really fake”. Also about this image participants thought the tiles on the ground rendered with a low quality, the graffiti looked “too perfect”, and there was “something not right with the perspective”. There was a comment about repetition,

Figure 163 - Set 1 Images: 1 - 5. Overall ranking graph.

saying that the windows in image 03 (figure 140) looked identical, a signifier of the virtual space due to the use of tiling which takes away from the photorealism. The vehicles in image 03 were said to be less refined in their detail, “making the images appear less photorealistic.”

Figure 139 - Image 01 (2nd)

Figure 141 - Image 02 (4th)

Figure 140 - Image 03 (3rd)

Figure 138 - Image 04 (1st)

Figure 142 - Image 05 (5th)

Figure 139 - Image 01 (2nd)

Analysis

- Subject and plausibility; the image contains a destroyed bridge as the main subject, surrounded by debris, smoke and smashed metal and concrete. This image was noted to have an unlikely subject matter due to the destruction of the bridge and road appearing like a bombsite.
- Detail of render; the lines of the metal reinforcement are aliased making them appear as a series of straight lines rather than curves and therefore lower the photorealism.
- Lighting and shadows; the sky in the image has large clouds that are texture mapped and unchanging. The light is hard light casting shadows from the objects on the left into the image.

Figure 141 - Image 02 (4th)

Analysis

- Subject and plausibility; in this image there is an alleyway framed symmetrically with a large dumpster bin at the end. There is rubbish in the form of paper and cardboard scattered around on the ground, and graffiti on the walls.
- Lighting and shadow; it is quite a dark image, with only ambient light from above as the source of light.
- Detail; there were comments about this image relating to it looking “really fake” due to the graffiti, tiles on the ground and the perspective being very constructed. Symmetry is a device used by photographers to signify the constructed nature of photographs.

Figure 140 - Image 03 (3rd)

Analysis

- Subject and plausibility; scene plausibility is low as the scene depicts a major incident has happened requiring multiple emergency service vehicles, however there is a distinct lack of people in the image.
- Detail; the vehicles are at a medium distance and were perceived as low detail and not photorealistic. The windows in the building on the right are repeated showing the use of tiling and so meant interpretation was seen as less photorealistic.

Figure 138 - Image 04 (1st)

Analysis

- Subject and plausibility; this image was rated the most photorealistic in this set. The subject matter is modeled on a train station and the framing of the image is tight in on the seating shelter showing rubbish bins and a texture-mapped image of a train line map. There is little to no destruction in this scene, with the exception of the rubbish on the ground in front of the bins. This was a factor brought up in the participant comments where more normal type scenes were voted higher in realism compared to a 'bomb site' style image.
- Detail; the map, along with the detail surrounding the map, was seen as the most realistic part of this image. The train line map is a texture-mapped element that uses the same design format as subway and train station maps found in the physical space. This means it acts as an indexical referent to the physical space, even though the map is fictional.

Figure 142 - Image 05 (5th)

Analysis

- Subject and plausibility; this image was ranked second in this set. The scene itself is plausible with the only element depicting signs of destruction being a knocked over road cone. There is a pedestrian crossing centered at the bottom of the image, leading up to a train station facade with a clock at the top.
- Detail; the cobblestones were seen as photorealistic with one participant commenting on them as an element rendered in high detail.

This set of images has a subject that is modeled on the streets of Paris, France. The Eiffel tower is visible in the backdrop of the level. For this set there is a combination of interior and exterior subject matter, with the exterior images ranking higher in photorealism than the interior images. One participant commented about the definition of shadow detail noting that the edges of the shadows are aliased and don't look like physical space shadows that "appear to fade slightly at edges and not be so abrupt". Another participant commented about the three interior images (figures 145, 146 and 147) have "unnatural lighting" and "box-like" objects. They went on to say that the trees in image 05 (figure 143) were surprisingly well rendered however the "jagged" shadows didn't "make sense" and so did not look photorealistic. The interior images lacked ambient occlusion lighting.

Figure 164 - Set 2 Images: 1 - 5. Overall ranking graph.

Figure 147 - Image 01 (5th)

Figure 145 - Image 02 (3rd)

Figure 146 - Image 03 (4th)

Figure 144 - Image 04 (2nd)

Figure 143 - Image 05 (1st)

Figure 147 - Image 01 (5th)

Analysis

- Subject and plausibility; this image was ranked the lowest of the five. It shows an interior scene with three chairs and a couch, wooden floors with coffee table in the center on a rug. There is a bookshelf, fireplace and cabinet, with two lamps on the mantle and cabinet that show aliasing and low shadow detail.
- Lighting and shadows; the lighting is both diffused from the windows on the left and artificial from a light on the ceiling. There is a lack of shadow detail under the objects, particularly the coffee table and couch. This gives the impression the objects are not sitting on the floor, but appear slightly floating; showing a lack of ambient occlusion lighting.

Figure 145 - Image 02 (3rd)

Analysis

- Subject and plausibility; this image was ranked third, and was ranked the most realistic of the three interior images. There is a broken lamp with debris and a picture falling off its mounts on the wall, leaving a faded imprint of where it used to hang.
- Lighting; the lighting is flat, and the main source is diffused through the window to the left. There is a couch as the main subject, which has uneven distribution of light on it, making the image feel rendered and not photorealistic.
- Shadow detail; there is a hard shadow on the left arm of the couch, however the seat of the couch lacks a shadow consistent with the arm. Render detail; the detail of the objects on the table is low, showing aliased edges where they should be smooth and curved.

Figure 146 - Image 03 (4th)

Analysis

- Subject and plausibility; this image shows an interior scene modeled on a kitchen. There are cupboards on the top left and a bench top surface with plates positioned bottom left.
- Detail; this image is framed closer in than the previous image and has fewer aliased objects, which may contribute to the ranking slightly higher than the next. However there is aliasing on the plate edges.
- Lighting and shadows; there are two light sources visible in the image, one an overhead artificial style light bulb, the other is virtual sunlight diffused through the blinds on the window. The light on the counter top with plates on it seems flat and neutral, with low shadow details, which does not align with the light sources and lacks ambient occlusion. This, along with the aliasing of the plates making them rectilinear rather than curved, makes the scene less photorealistic.

Figure 144 - Image 04 (2nd)

Analysis

- Subject and plausibility; this image was ranked very similarly to the top ranked image. It is a street scene of cobbled road with a building facade in the background of the image. In the foreground there is a bicycle leaning on a wall and a lamppost. While this is a plausible setting for a physical space, the detail of the objects in the space didn't qualify this image as ranking first in the set.
- Lighting; the lighting is from above and casts shadows from the window ledges down and to the right, which seems to compliment the textures of the road and buildings, giving them depth and detail. This is characteristic of a physical space image.

Figure 143 - Image 05 (1st)

Analysis

- Subject and plausibility; this image was ranked the most photorealistic of the set. The scene is plausible with no signs of war and destruction. There are two tables with umbrellas above them that look like seats outside a cafe. There is more depth to this image compared to the next ranked image that is flatter and also compared to the three interior images which all show no far background context. The depth in the scene gives the seats and umbrellas context within their environment that may account for this image being ranked highest.
- Detail and lighting; the detail in the walls and ground is high, and the light angle being from above compliments the form of the objects. There was a comment about the high quality of the render of the trees, and compared to the interior images the outdoor lighting gives the objects a greater contrast and form.

6.2.3.3 Set 3

This set of images was made on a level within the virtual space based on a countryside setting. All images are exterior. Several comments about the set mention that the clouds and sky look photorealistic, and that the truck in image 04 (figure 152) does not. There is a comment about the trees in the first three images (figures 148, 149 and 150) noting that they “stick out too much from the background”. There was also a comment about the cliff face in image 05 (figure 151) having low detail, breaking the photorealism for that image.

Figure 165 - Set 3 Images: 1 - 5. Overall ranking graph.

Figure 148 - Image 01 (1st)

Figure 149 - Image 02 (2nd)

Figure 150 - Image 03 (3rd)

Figure 152 - Image 04 (5th)

Figure 151 - Image 05 (4th)

Figure 148 - Image 01 (1st)

Analysis

- Subject and plausibility; this image is set outdoors and is plausible scene for either a virtual or a physical space.
- Detail; the clouds and grass were said to look photorealistic, while the background was said to look like a painting. There are country buildings, perhaps barns, with single wire lines leading from the left to the right of the image. Aliasing of power line wire are not photorealistic and appear rectilinear rather than curved. There is a lot of highlight detail in the grass and flowers, making the image look photorealistic.
- Lighting; the lighting is a single light source from above and to the left. This angle casts a shadow on the facade of the building on the left, which adds to the scenes photorealism.

Figure 149 - Image 02 (2nd)

Analysis

- Subject and plausibility; the main focus in this image is a tree positioned on the right hand side. There is a pipeline at the bottom of the image and fields that extend to the horizon. There is no destruction in this image, and no visible buildings; the only man-made structure is the pipeline at the bottom of the image.
- Lighting; the lighting is sunlight and there are no strong shadows visible. There is softness to the background of this image that likely added to the photorealism, most objects are depicted as a backdrop. This could have been a factor affecting the high rank of this image.

Figure 150 - Image 03 (3rd)

Analysis

- Subject and plausibility; this image was ranked third but was closely ranked to the second place image. The main subject is a building that looks like a barn or farm style building. There is a tree on the left of the image in the foreground, and a large gas tank covered in plant growth on the bottom right of the image. There are no signs of a warzone or destruction.
- Lighting; there is a single overhead light source casting shadows on the building.

Figure 152 - Image 04 (5th)

Analysis

- Subject and plausibility; this image was ranked the lowest, most likely due to it being the only image with a vehicle, a truck that is the main focal point and is in the center of the image. Vehicles were earlier noted as being a key giveaway as an image being from a virtual space because they are rarely rendered well in FPS games.
- Detail; the rendering of the vehicle is not as detailed as the background elements. The textures of the truck are low in detail giving it a carton aesthetic.
- Shadows; there are no deep dark shadow areas in the image, making it appear more like an HDR image than a single exposure. This is common in virtual images.

Figure 151 - Image 05 (4th)

Analysis

- Subject and plausibility; this image was ranked 4th, and has a different point of view to the other images as it is looking upward isolating the cliff and three waterfalls. This image fits into the romantic landscape aesthetic, the scene is not as plausible and the three waterfalls are identified as too romanticized.
- Details; the texture detail on the cliff is emphasized by the single overhead light source, something that consistently helps to make textures look photorealistic.

This set of images was created within a level called Arkaden, meaning arcade in German. It is based around a shopping mall and includes interior and exterior areas. The overall colour palette is primarily bluish and cold, with some warmth of oranges coming from exterior sunlight. There was a comment about image 3 (figure 153) relating to the “images within the image”, saying that they “draw your eye in”. This image ranked the highest for photorealism, likely due to the fashion photographs that are texture mapped into the virtual space, acting as a physical space referent. Image 04 (figure 155) was deemed low in photorealism due to having no context to the subject and a participant commented about image 05 (figure 154) that subject matter “lends itself to computer graphics”.

Figure 166 - Set 4 Images: 1 - 5. Overall ranking graph.

Figure 157 - Image 01 (4th)

Figure 156 - Image 02 (3rd)

Figure 153 - Image 03 (1st)

Figure 155 - Image 04 (2nd=)

Figure 154 - Image 05 (2nd=)

Figure 157 - Image 01 (4th)

Analysis

- Subject and plausibility; this image shows an interior of a perfume store at a mall. There is a small photograph of a woman texture mapped onto the wall, but is a small part of the scene.
- Details; the words and brands in the image do not exist in the physical space so were unrecognizable. This is something that could be used by game designers to bridge a gap between the virtual and physical space by creating physical space referents, similar to product placement in cinema and television. The low resolution and simple rendering of objects on shelves are not convincing for a perfume shop in the physical space.
- Lighting; the lighting is artificial, appearing unnatural, with overhead lights for the general scene and backlight lights for perfume displays.
- Shadows; the lack of shadow underneath objects such as the desk on the ground make it appear to be floating; they don't look to have weight to them, and are also very linear, not curved.

Figure 156 - Image 02 (3rd)

Analysis

- Subject and plausibility; this image is set at a shopping mall and shows a shop window with mannequins, and security bars covering it. There is a plant pot on the right hand side of the image.
- Shadows; the plant pot appears floating due to lack of shadow detail underneath the objects, thus making the image less photorealistic.
- Lighting; it is an interior, however is lit with a warm sunlight through skylights in the roof of the building. The shadows that are cast onto the curves of the pillar show signs of aliasing, lower the photorealism of the image.

Figure 153 - Image 03 (1st)

Analysis

- Subject and plausibility; this image shows a fashion photograph of a woman in a dress that is texture mapped into the virtual space. The photograph is behind glass and to the left is a concrete wall with shadows cast on it from the structures of the building above out of frame. The texture mapped photograph is a physical space referent resulting in this image being ranked the highest of the set.
- Lighting; there is a combination of artificial lights and virtual sunlight, however the scene is mostly lit by the virtual sunlight. The diffusion of light through the glass on the right of the image creates softness to the space and increases the photorealism since the virtual space images have all objects rendered with sharp detail and the effect of aperture in photography is to soften the focus of background objects.

Figure 155 - Image 04 (2nd=)

Analysis

- Subject and plausibility; this image is a of a car park space with a downward looking point of view. It is more abstract than the other images in this set. It shows the concrete car park with shadows and a brick wall surrounding the parking building.
- Shadows; the shadows appear very linear and so not photorealistic.
- Details; the are cracks in the paint of the car park space markings showing a high level of detail and thus appearing more photorealistic. However there are aliased lines in the shadows making them appear rectilinear and low in photorealism.

Figure 154 - Image 05 (2nd=)

Analysis

- Subject and plausibility; this image is framed with an upward looking perspective. The framing excludes any of the ground and elements in foreground allowing only two buildings and the sky in frame.
- Lighting details; the reflections of light in building windows appear as though the sun is lighting them and help add sense of photorealism to the scene. The overhead light gives the facade of the building large depth of form.
- Details; there are no rectilinear curves so no signs of aliasing which would lower the photorealism of the image, allowing for this image to be ranked highly for photorealism.

This set of images was made in a level based on a commercial construction site. There are cranes and other machinery for building, a lot of concrete structures in the process of being built, and it includes interior and exterior areas. Comments mentioned that shadows were sharp and textures had high detail. One participant commented that they looked to reflections and shadows to assess photorealism. Another comment said that the clutter in the pictures was “too clean”. The aliasing in the cables in image 05 (figure 161) were mentioned, and the vehicle in image 04 (figure 162) was said to be not very photorealistic. Overall there was less distribution between ratings of these images compared to other sets.

Figure 167 - Set 5 Images: 1 - 5. Overall ranking graph.

Figure 160 - Image 01 (3rd)

Figure 158 - Image 02 (1st)

Figure 159 - Image 03 (2nd)

Figure 162 - Image 04 (5th)

Figure 161 - Image 05 (4th)

Figure 160 - Image 01 (3rd)

Analysis

- Subject and plausibility; there is the base of a crane tower as the subject in the foreground, and containers stacked up in the background. There are several metal barrels on the left of the image. The scene is plausible as a construction site and there is no destruction due to war.
- Lighting; the lighting is virtual sunlight from above and left giving objects strong depth in form and shape, an effect that likely raises the photorealism of the image.
- Shadow detail; the shadow detail of the objects in the foreground shows aliasing as it is linear rather than curved, lowering the photorealism of the image.

Figure 158 - Image 02 (1st)

Analysis

- Subject and plausibility; this image was ranked the highest in the set. It shows an interior area of a building in the early stages of construction. The walls are unpainted and show exposed plastering. There are a couple of safety signs on the walls and a black and yellow strip at the top of some stairs or a drop. These elements appear normal for the type of subject and are not common objects due to restricted access of a building site. This would mean fewer participants would be able to recognize something not correct with the subject.
- Lighting and shadows; the light source is from the exterior sunlight, which casts a shadow on the bottom left of the image. The right side of the image is mostly in shadow, making the texture of the wall quite dark. This aligns with a single exposure type of photography thus appearing photorealistic.

Figure 158 - Image 02 (1st)

Analysis

- Subject and plausibility; this image was ranked 2nd in the set. There is a large concrete cylinder pipe on the right half of the image with a shadow cast on it. There are containers on the left side of the image, mostly in shadow and a crane and building behind in the background. The large concrete tube is an uncommon object and again, the scene is uncommon due to restricted access of building sites.
- Lighting; the light source is sunlight from above and to the left, casting shadows to the right of objects. The parts of the cylinder that are lit show the texture with a high level of detail due to the angle of the light, raising the photorealism of the image.
- Details; the ground is rough concrete and again the angle of the light shows the texture well however the undulations of the ground appear rectilinear showing aliasing, which may account for the image not being ranked first overall.

Figure 162 - Image 04 (5th)

Analysis

- Subject and plausibility; this image was ranked the lowest of the set. The image is framed from the interior under a building looking out to a sunlight area containing the vehicle. The interior has a construction warning sign and some graffiti on the wall. Similar to other low ranking images it contains a vehicle, which seems to lower the interpretation as a photorealistic image.
- Details; the texture of the vehicle appears low in detail and the wheels don't seem to sit on the ground due to low detail of shadow detail underneath.

Figure 161 - Image 05 (4th)

Analysis

- Subject and plausibility; this image shows a centered round concrete tube that forms a tunnel. It has debris and materials either side of the tunnel and the background is the facade of a concrete building. It is quite a strange/unusual scene as the objects are not common due to the restricted access of a construction site.
- Detail of render; the objects in this scene are rendered with lower detail than the texture of the ground. The coil of cable to the right of the concrete tunnel is rectilinear, showing signs of aliasing and lowering the photorealism.
- Lighting and shadow; the angle of the sunlight gives the objects high detail in their textures and depth in their form, however casts a high contrast shadow of the large pipe that appears linear due to aliasing.

Figure 029 Landscape form photograph printed for exhibition

The exhibition was set up to test people's perceptions of images in a real-life setting and to receive real-time feedback as they saw the images for the first time.

I printed photographs taken of my computer screen showing images of the virtual space from video games and placed them in an art gallery setting. The images on the screen were composed so that they were reminiscent of landscape photographs. I then talked to members of the audience to ascertain how they interpreted the images.

One man, who made it clear to me he was a regular and sophisticated member of the art gallery scene, was quite embarrassed when he couldn't pick the location of the photographs and learned that they were taken in the virtual space. He guessed Nepal, Afghanistan and Pakistan. When I pointed out that the photographs were made in my bedroom and were of a virtual space displayed on my television, he

Figure 030 Landscape form photograph printed for exhibition

almost seemed offended that I had confused his ability to recognize the origin of the art.

The only person in the audience who immediately identified the space in which the images were made was a teenage boy. He knew the particular video game I had used to make the photographs and recognized the scenery.

Two people I spoke to found the images "strange", as if something wasn't quite right, and noted that they might have been layered or manipulated somehow, but did not pick video games as the source. One of these two picked up of the 16:9 ratio and said they thought they might be shots from a movie.

Figure 031 Landscape form photograph printed for exhibition

Most of the people I spoke to asked me where the images were taken, and made guesses of the origin. One person thought Pakistan, two asked if they were from Nepal, and the most common guess was India. It seemed from reactions that the mountain scenes appeared to be from the Himalayas, which is not far off the referent as the level was modeled on the Korangal Valley, between Pakistan and Afghanistan [see figure 103 - 106]. It is worth noting that the game used texture mapped backdrops for the mountain ranges in the distance, however the avatar can travel to some of the semi-distant mountains, therefore showing that they are 3-D models of space.

The people who had no idea where the images were from, nor an idea that they were a virtual space, were all between the ages of 40 – 65, and were not currently gamers (although some had played early video games “years ago”).

Figure 032 Landscape form photographs mounted at exhibition

The exhibition provided interesting results, with most of the audience noticing some abnormalities in the images, compared to photos they had seen before, but were unsure of what exactly was different.

07 Conclusion

7.1 Conclusion

This thesis has discussed how technology has advanced significantly, creating broad opportunities within the virtual space of video games. This rapid growth in technology has opened the door to a whole new art space and changed the way people interact with virtual spaces. The development of a new visual form regarded as deceptively ‘realistic’ is not new however and, as this thesis has demonstrated, linkages to the phenomena witnessed in games today can be traced back to similar events in history.

From the 15th century to the present day, there have been anecdotes regarding the confusion of audiences’ perceptions of reality when viewing an image. Up to the 19th century many of these anecdotes concerned the medium of painting. In the late 19th century, with the invention of the camera and film transparencies, there was a shift in the purpose and aesthetics of painting. A camera could not only render higher levels of realism, but it was also indexical and removed the hand of man (as exemplified in Fox Talbot’s book, “The Pencil of Nature”, 1846). Throughout this time, anecdotes of audiences confusing the depiction of reality continued, but came to be associated with the new indexical mediums of photography and cinema, rather than painting.

The indexical nature of photography and subsequent realistic imaging has become a norm for naturalistic representation, termed photorealism. Computer generated images have begun to align with the qualities of photographic imaging in an attempt to allow audiences to interpret the images of the virtual space as though it were a physical space.

It seems, regardless of the chosen medium (painting, photography, cinema or video games), the desire to create representations to a high level of verisimilitude and the notion of being fooled into thinking that the depictions are real, will continue to appear in the future. The question remains however, at what point the virtual space will become

indistinguishable from the physical space, and at what point people may no longer confuse the two spaces, but see them as the same. As advances in digital rendering technologies continue and audiences become increasingly socialized to the virtual space, we may no longer require the term ‘photorealistic’ to describe high levels of verisimilitude; it may be that in the future new terms such as ‘renderrealism’ will emerge.

The tests and exhibitions conducted in this thesis were a valuable way to explore and understand the virtual space as an art medium from the perspective of both an artist and a researcher. The tests enabled comparable insight into what makes an image look photorealistic, while the exhibition provided a chance to quiz the audience on their thoughts as they viewed each image. The results showed that audience interpretation of the images is highly complex, and is influenced by a multitude of factors. In some cases, the technical theory could explain the thought process of the participants, however in other cases there were some dominant factors that more significantly impacted the interpretations, despite what theory suggested. This highlights the blur that is emerging between the physical and virtual spaces.

7.2 Future research

The aforementioned dominant factors provide an interesting area for further study, whereby certain image attributes could be isolated and tested for their impact on participant perception. This could include elements such as render detail, shadows, resolution and display time of the test images.

As well as audience perception, other areas surrounding the use of video games spaces could be researched from the point of view of a photographer. For example, transitions between digital asset states (changes in the virtual environment). Whether affected by external factors or by gamers, these changes in the virtual space are becoming more complex and even permanent, with the ability of games to be continuously online. They are designed to mimic the constant change of the physical space and will simulate ‘natural’ fluctuations over time like lighting and atmospheric conditions. Furthermore players will be able to permanently reconstruct and reshape the virtual environments, leaving traces for others to discover. One of the roles of photography has long been to document growth and change over time, something now applicable to the virtual space.

Another area in need of further investigation is that of the relationship between audience socialization to the virtual space and the way in which their perceptions of photorealism change over time. As audiences become more sophisticated in their ability to interpret images, video games that were previously deemed photorealistic may no longer be perceived as such. This has been evident in past media forms, such as seen in photography with the Cottingley Fairies, in cinema with the Lumiere Brother’s approaching train and in painting with Leonardo’s Buckler. Interviews with gamers could be conducted whereby they are asked to describe past games that were perceived as photorealistic. These responses could be compared to their current interpretation of the same game. Longitudinal studies could be set up now with the intention to intermittently return to gamers over the course of their

lives. The responses, along with images of the virtual spaces they describe, would make an interesting and potentially ongoing project that would show comparisons in responses to the virtual space over time accompanied by images that show a timeline of the increase in photorealism in the virtual space.

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Figure 115 Material form graded comparative test results: Authors photograph, physical space, 53% of participants correctly identified image origin.

Figure 116 Material form graded comparative test results: Authors photograph, physical space, 58% of participants correctly identified image origin.

Figure 117 Material form graded comparative test results: Authors photograph, physical space, 66% of participants correctly identified image origin.

Figure 118 Material form graded comparative test results: Authors photograph, virtual space, 66% of participants correctly identified image origin.

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Figure 119 Material form graded comparative test results: Authors photograph, physical space, 68% of participants correctly identified image origin.

Figure 120 Material form graded comparative test results: Authors photograph, virtual space, 70% of participants correctly identified image origin.

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Figure 121 Material form graded comparative test results: Authors photograph, virtual space, 78% of participants correctly identified image origin.

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Figure 122 Material form graded comparative test results: Authors photograph, physical space, 85% of participants correctly identified image origin.

Figure 123 Material form graded comparative test results: Authors photograph, physical space, 87% of participants correctly identified image origin.

Figure 124 Material form graded comparative test results: Authors photograph, virtual space, 87% of participants correctly identified image origin.

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Figure 125 Material form graded comparative test results: Authors photograph, physical space, 87% of participants correctly identified image origin.

Figure 126 Material form graded comparative test results: Authors photograph, virtual space, 88% of participants correctly identified image origin.

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Figure 127 Material form graded comparative test results: Authors photograph, physical space, 88% of participants correctly identified image origin.

Figure 128 Material form graded comparative test results: Authors photograph, physical space, 88% of participants correctly identified image origin.

Figure 129 Material form graded comparative test results: Authors photograph, virtual space, 93% of participants correctly identified image origin.

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Figure 130 Material form graded comparative test results: Authors photograph, virtual space, 93% of participants correctly identified image origin.

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Figure 131 Material form graded comparative test results: Authors photograph, virtual space, 97% of participants correctly identified image origin.

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Figure 132 Material form graded comparative test results: Authors

photograph, virtual space, 100% of participants correctly identified image origin.

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Figure 133 Ranking test analysis: Age of participants.

Figure 134 Ranking test analysis: Gender of participants.

Figure 135 Ranking test analysis: Professions of participants. (Other: Student, Media Design, Architecture, and Technician).

Figure 136 Ranking test analysis: Game hardware systems used by participants.

Figure 137 Ranking test analysis: Frequency of use of various media types.

Figure 138 Ranking test: Set 1, Authors photograph, virtual space, rank 1.

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Figure 139 Ranking test: Set 1, Authors photograph, virtual space, rank 2.

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Figure 140 Ranking test: Set 1, Authors photograph, virtual space, rank 3.

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Figure 141 Ranking test: Set 1, Authors photograph, virtual space, rank 4.

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Figure 142 Ranking test: Set 1, Authors photograph, virtual space, rank 5.

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Figure 143 Ranking test: Set 2, Authors photograph, virtual space, rank 1.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 144 Ranking test: Set 2, Authors photograph, virtual space, rank 2.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 145 Ranking test: Set 2, Authors photograph, virtual space, rank 3.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 146 Ranking test: Set 2, Authors photograph, virtual space, rank 4.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 147 Ranking test: Set 2, Authors photograph, virtual space, rank 5.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 148 Ranking test: Set 3, Authors photograph, virtual space, rank 1.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 149 Ranking test: Set 3, Authors photograph, virtual space, rank 2.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 150 Ranking test: Set 3, Authors photograph, virtual space,

rank 3.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 151 Ranking test: Set 3, Authors photograph, virtual space,
rank 4.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 152 Ranking test: Set 3, Authors photograph, virtual space,
rank 5.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 153 Ranking test: Set 4, Authors photograph, virtual space,
rank 1.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 154 Ranking test: Set 4, Authors photograph, virtual space,
rank 2.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 155 Ranking test: Set 4, Authors photograph, virtual space,
rank 3.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 156 Ranking test: Set 4, Authors photograph, virtual space,
rank 4.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 157 Ranking test: Set 4, Authors photograph, virtual space,
rank 5.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 158 Ranking test: Set 5, Authors photograph, virtual space,
rank 1.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 159 Ranking test: Set 5, Authors photograph, virtual space,
rank 2.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 160 Ranking test: Set 5, Authors photograph, virtual space,
rank 3.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 161 Ranking test: Set 5, Authors photograph, virtual space,
rank 4.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 162 Ranking test: Set 5, Authors photograph, virtual space,
rank 5.

Call of Duty: Modern Warfare 3 (Activision, 2011)

Figure 163 Ranking test analysis; overall ranking graph – Set 1

Figure 164 Ranking test analysis; overall ranking graph – Set 2

Figure 165 Ranking test analysis; overall ranking graph – Set 3

Figure 166 Ranking test analysis; overall ranking graph – Set 4

Figure 167 Ranking test analysis; overall ranking graph – Set 5