Abstract

The aspiration for this project was based on investigating if there is a future for 3D in movies and if it can be used for more than just being a "wow-factor". The research made for conducting the experiment delves in to areas such as how we perceive movies and how they affect us. A couple of beliefs arose like for example that a more realistic depiction of depth would trigger stronger emotional responses for the viewer when looking at a 3D versus a 2D movie. Cinematographic theories were also investigated as to help us how to design a good 3D short. These thoughts and research was thereafter taken in to consideration when designing the experiment. An identical 2D and 3D short was made for comparison of change in depth perception. Unfortunately even though we had a brief understanding on how movies are perceived it is evident that sufficient results were not gained in order to draw conclusions. There was found a vague indication of change in perception of the perceived depth in the 3D compared to the 2D version. We could not though conclude on if this change in perception is on a positive note as for future use as a storytelling element without causing distraction.

Preface

This thesis you are about to read deals with the use of 3D in movies. The aspiration for the thesis was to investigate if there is a potential for 3D to be used as a storytelling element and as such become a standard within filmmaking in the same way as sound and color are. Theories such as stereoscopic vision, perception of movies and 3D cinematography will be introduced in search for an answer.

The thesis comes equipped with a pair of red-cyan anaglyph glasses. These can be used each time this symbol ⋘□□⋙ appears in a figure text. This will allow for you to see the image with a 3D effect.

In the end of the report you will be able to find a Glossary which will explain some of the terms used throughout the thesis.

This thesis was made as a part of the requirements for acquiring the degree Master of Science in Medialogy.

We hope you will enjoy the read!

K. Ó. Halldórsdóttir **C. M. S. Hägg**

Acknowledgement

In line of tradition we would like to show our appreciation to the following people who have helped along the way to complete this research.

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Contents

List of Figures

Chapter 1

Introduction

The human vision is stereoscopic meaning that it allows us to perceive the world around us with the sense of depth. Therefore it only seems natural that the film industry would transform the visual communication to 3D stereo. 3D in movies has been around for longer than the television set but never succeeded enough for it to become an industry standard. The reason lies with the technology not being sufficient enough to provide a comfortable and enjoying viewing experience. It is not until recently that 3D is making a comeback with advanced digital 3D technology. When viewing 3D movies in the time of writing there is still the need to wear glasses when going to the cinemas. On the other-hand, the color is preserved and the viewing experience is a lot more pleasurable than during the film industry's last 3D peak in the 1950's. 3D has grown tremendously in popularity lately. Not only with audiences but also amongst filmmakers. The audience can get a more visual amusement out of the 3D experience while filmmakers are using this tool to tell the story in more detail and in a more real depiction than before. This has also allowed for the filmmakers to push the existing boundaries and let the only limit be their imagination. A famous filmmaker, namely James Cameron, has done just this. Ten years ago he had a vision of a movie he wanted to make but unfortunately the technology was not evolved enough. In December 2009 Cameron could finally release the movie he had visioned for for so long and used 3D to an extent that had never been seen before.

Movies are meant as being an engaging experience without distractions. The question that remains is that can 3D really enhance a story and still remain as an enjoyable experience. Or will the movie goers still continue to prefer watching regular two dimensional movies and yet again the 3D popularity fade away.

Chapter 2

Pre - Analysis

2.1 Preliminary Problem

As a conclusion from the *Introduction* this thesis will investigate the impact that 3D in movies can have and if it can be used as a storytelling element.

2.2 Elements Of Movie Making

Movie making has become a big and an important industry during the years and producers are putting more money in the making of movies then ever. This section will discuss elements of movie making that already have a big influence on a story. In the early years these elements were not part of the movie making but today has become an industry standard.

2.2.1 Sound

Sound is all around us and it is hard to believe that the first movies where produced without sound. In the 1920's movie producers started realizing the essential of sound in movies. Talking pictures, or talkies as they where called, used the technique of synchronizing dialogues. Theses where mainly shorts due to the lack of knowledge within the field of sound. The music in the early cinema was often played by a

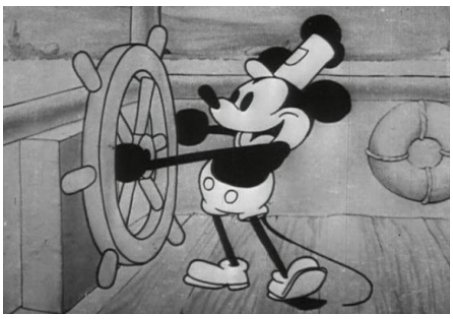


Figure 2.1: *Disney's Steamboat Willie* [1]

theatre orchestra on set that them self chose what to play. This often of course resulted in unfitting or unimaginative music. As technology developed allowing more advanced sound techniques, the soundtrack became a more important part of the film production. It was not until 1928, when Disney's film Steamboat Willie premiered, that a film included sound effects, music and dialogue. [7]

When film producers started to use sound, there where two ways of doing so. One method was to add sound to a film by playing background music/sound from a record player while a silent film was running. This meant that all the sounds that the viewer could hear while watching the film did not necessary have to have any direct influence on what was happening within the film. This was though a great breakthrough but did not last long. Producers started recording sound that should synch according to an action in the film but during showcase the synching did not work sometimes. This was due to the recorder would skip a track or even the operator putting the wrong record on. Another method developed in the late 1920's was when producers started recording sound straight on to there films. This technique made it possible to avoid the sound going out of synch while showcasing. This is the technique that is used still today.

Nowadays sound is one of the essential parts within a movie and producers have found ways to use the many advantages of sound. Sound can be used to bridge shots together, guide the viewers attention to a particular action within the scene and establishing expression of existence of something that the camera does not capture. This is also referred to as an off-screen action. For example the viewer hears a sound of footsteps of a character before actually seeing the character in the frame. Sound can also for example work in a thriller to build suspension and tension. The louder we hear an object the closer we perceive it being. Sound can be used in many different ways to enrich the visuals and also to help enhance the emotional content in a story.

Dialogues can also make the perception of a character different. One examples is the elves from The Lord Of The Rings trilogy. They articulate and speak very slowly with a clear, smooth tone which gives them a characteristic of being wise. While the hobbits speaks very fast and use a lot of jargon they get characteristics of being comic and a bit less concerned about circumstances.

2.2.2 Colors

Figure 2.2: *Becky sharp (1935), first feature length movie to use Technicolor* [2]

During 1920's the Technicolor technique was used for a small number of films. This technique combined two colors to create other hues which resulted in green-blueish and pink tones. In the 1930's some improvements were made. The technique used 3 primary colors and could create a larger amount of different hues. The first feature length movie to use the technique of Technicolor significantly was Becky sharp (1935). Though this technique was said to add extremely to the films, the technique was only used until the 1970's because of the expense and difficulty to produce. The cameras available were also few [2, pp.458-459].

In 1950 Eastman Kodak developed a new technique which was the first 35 mm color negative. This made it possible for producers to work on their production without having to hire Technicolor's cameras and camera operators with this specific technical knowledge. This new development made the cost of color filmmaking drop remarkably and made it possible for producers to make more and more color films. [22] Color in films were said to add a feeling of realism, the viewer could relate to the atmosphere and the chosen style for the film.

Color has many of the same advantages as sounds has. By using different color schemes a scene can be entirely changed from being a warm and nice place to a scary and mystical one. Many films have a whole production team planning the art-direction. They decide the colors to be used in the film in order to achieve the art direction of the film. Two films where the color has played a big role is in Saving Private Ryan (1998) and 300 (2006). In both stories the color gave a deeper emotional content in the story. In Saving Private Ryan the colors were very desaturated to enhance the dramatic story being unfolded. In 300 certain scenes were also desaturated and tinted to establish different moods. This gave an illustrative feel to the movie even though everything was real in it.

(a) (b)

Figure 2.3: *Saving Private Ryan 2.3(a)*[3] *and 300 2.3(b)*[4]

2.2.3 Widescreen

For many years the standard aspect ratio for screens has been 4:3 (also referred to as 1.33:1 which means that the screen is 1.33 times wider than it is high). The past years the most common one used is 16:9 (1.78:1) widescreen. There are many advantages in showing a movie in widescreen. When filming for example multiple characters in one shot, where all the characters need to be visible for the viewer, shooting in widescreen makes the scene less crowded and claustrophobic. This is sometimes done by using the pan-and-scan mode for aspect ratio 4:3, but in spite of that this method often results in lost information within the scene and shaky movements. Wide screen also leaves space around the actors which gives the viewer a better understanding of the surrounding. Thirdly, it allows more space for the visual effects, which can be an important part of a scene [1]. But most importantly widescreen represent the way humans view the world naturally. With eyes side-by-side the viewing spectrum is wider and bares more resemblance to 16:9 than 4:3 format [20].

Figure 2.4: *Examples of different aspect ratios* [5]

2.3 Why Do We See In 3D?

Us humans have two eyes. They are placed horizontally aligned in the front of our heads which gives us a wide view-angle. They are spaced approximately 6.5cm apart, each capturing a slightly different image from each other, but with a significant difference. This difference allows us to see things in 3D. To illustrate this slight difference two images are taken with a still camera from slightly varying perspectives, see figure 2.5. These images are superimposed on top of each other, one perspective being red the other cyan. If viewed with red-cyan glasses the 3D image can be seen. Both eyes are required for viewing in 3D.

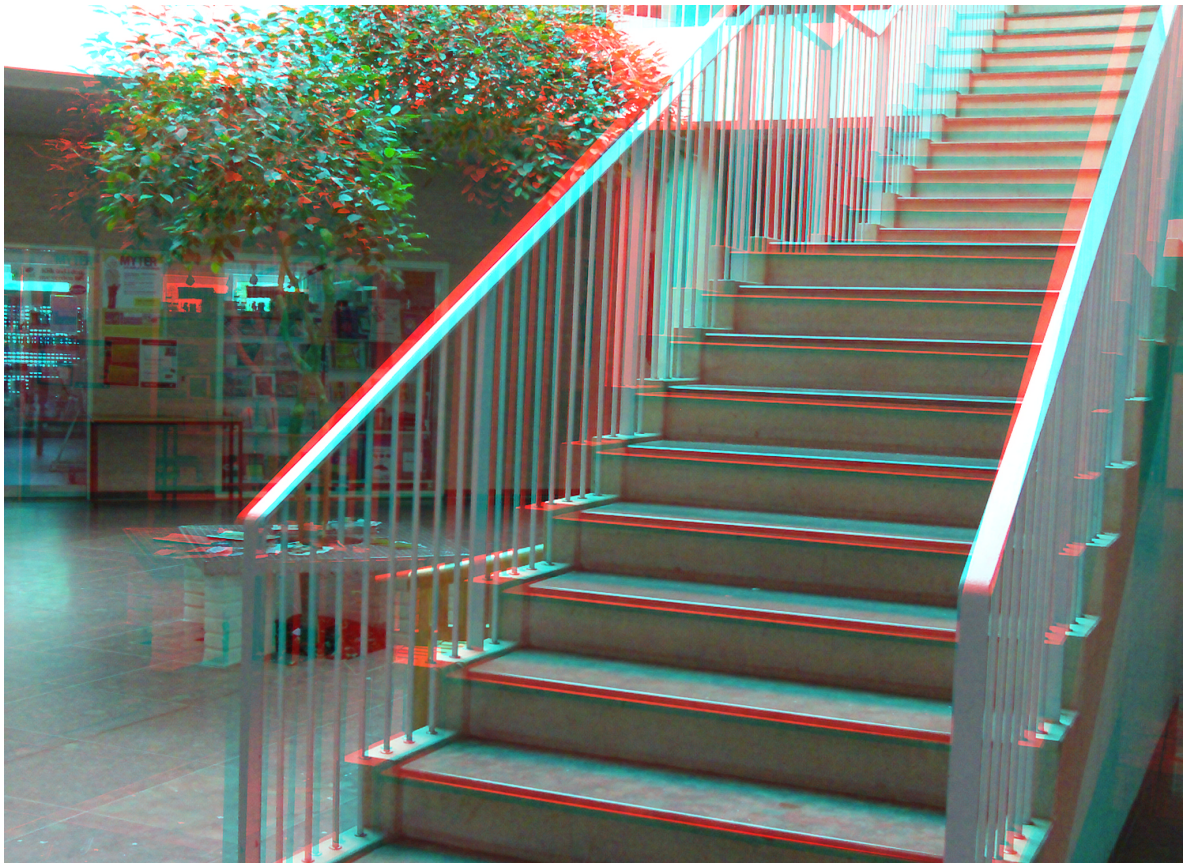


Figure 2.5: *Anaglyph image illustrating why we see in 3D* ⋘□□⋙

To view objects at different distance from each other an operation called *convergence* must occur, see figure 2.6. When the eyes focus on an object the object in question becomes clear while other objects at varying distances blur out. This is due to the eyes centering this object on the optic receptors on the back of the eye. The other objects do not fall precisely on these receptors and therefore becoming unsharp. To focus on an object at another distance convergence occurs, which is the eyes adjusting on a horizontal plane

until a single object is formed, see figure 2.8.

This can easily be demonstrated through a simple experiment. Focus on an object at a far distance. Place a finger in your field-view approximately half an arm-length away. You will now see two fingers appear in front of you. This is because your eyes are adjusted to looking at the object at the far distance and each eye sees the finger in a different perspective producing a double image of it. Now focus on your finger instead. Your eyes will converge horizontally making the background object appear double instead. Continue focusing on your finger and slowly move it towards you and notice how the double objects in the background start drifting further apart.

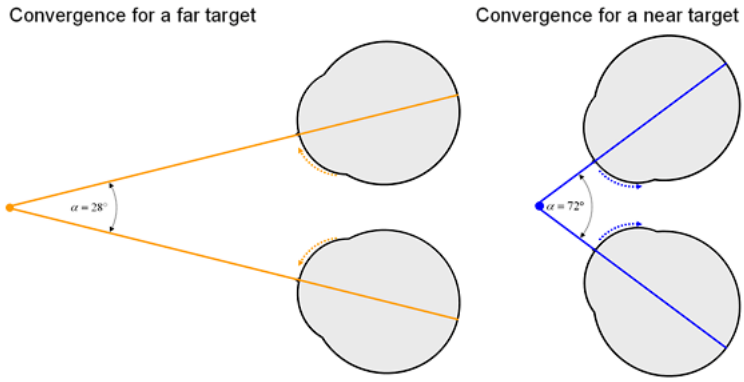


Figure 2.6: *Converging the eyes* [6]

Figure 2.7: *Front view of the eyes converging on a near target*

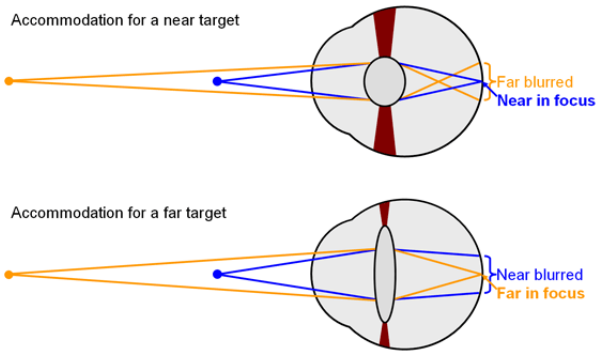


Figure 2.8: *Accommodating the eyes for a near or far object* [7]

2.4 Stereoscopic Projection

In order to create a stereoscopic movie there has to be rendered two different viewpoints which are projected simultaneously. There are different ways of achieving this but the important matter is that both left and right eye gets delivered an independent image. Most projection systems today uses glasses in one way or another. In active systems the viewer wears glasses that have filters over each eye which are triggered electronically to switch between opaque and transparent. The trigger is synchronized with a projector which is alternating between showing the left and the right eye image. In passive systems the glasses are fitted with fixed filters. Each filter for the right and left eye has an unique attribute which allows only the correct viewpoint for each eye to pass through. The most common techniques are listed below.

2.4.1 The Anaglyph Systems

The anaglyph technique was proposed by D'Almeida in 1858 which is a procedure where complementary-colored filters were used over left and right lenses of the projectors to superimpose both images on one screen [18, p.31]. The audience thereafter wears glasses with red and cyan lenses to separate the superimposed image for each eye. This technique is still used today in projection of many movies due to its straightforward manufacturing and it can eas-

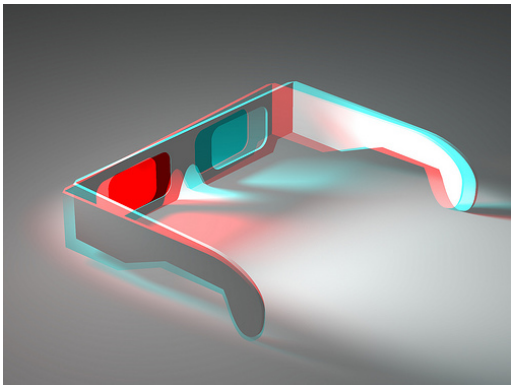


Figure 2.9: *Anaglyph glasses* ⋘□□⋙ [8]

ily be used on home television sets. The downside with using anaglyph is that much of the color gets lost when filtered through the colored lenses and the chance of ghosting is very high. Ghosting is a term used when the images leaks meaning that the right eye sees a part of the image meant for the left eye or vice versa. It results in seeing a double image which when occurring too often destroys the illusion of 3D [21, p.176].

2.4.2 Polarized Light

Polarized stereoscopy is the most commonly used technique in todays cinema theaters with the RealD system setup [32][31]. It uses neutral grey filters placed in front of the projector lens. These filters orient the light waveforms from the projector[21, p.172]. A 90 degree difference in orientation is given for the left side and right side image. The images are cast on a silver screen or other highly reflective screen. The viewer wears spectacles with differently oriented filter on each eye to block the light which is not appropriate for one or the other eye. There are two different orientations of polarization, linear and circular. Circular systems are more acceptable to head tilting and is used by the RealD system. Unfortunately this system is very expensive and mainly only used by movie theaters.

(a) (b)

Figure 2.10: *RealD glasses 2.10(a)* [9] *and RealD projector 2.10(b)* [10]

2.4.3 The Eclipse Systems

Figure 2.11: *Shutter glasses* [11]

The eclipse system, also referred to as shutter system, uses a different approach to deliver separate images to each eye. Two projectors are mounted with shutters in front of them while the audience are equipped with a pair of shutter glasses [18, p.31]. As the left projectors shutter is opened so is the left shutter of the glasses opened, and

continues to alternate between left and right. This method ensures the viewer to only see the image meant to be viewed by either eye when working correctly but requires the viewer to wear bulky and expensive spectacles. Also by not allowing the eyes to see images simultaneously it creates a rippling effect which can be very disturbing in fast on-screen motion.

2.4.4 Free View Images

It is also possible to view stereoscopic images without the use of glasses but it requires much training though. This can be achieved by crossing your eyes when viewing two parallel images. The two images need to be viewed by converging your eyes on a point at a further distance. By doing so your eyes cross and the two images will form a third picture in the middle creating the 3D effect. You can try this technique by looking at figure 2.12.

Figure 2.12: *Parallel free view image. By looking at the image and forming a third image in between, a stereoscopic image is formed* [12].

2.5 History Of Movies in 3D

Stereoscopic images are almost as old as the invention of photography. Since the birth of photography the aim has always been to achieve as realistic results as possible. The stereoscopic history has been divided into four general periods by Ray Zone [34, pp.1-4] which will be listed in the following.

The Novelty Period - 1838 to 1952 The novelty period for stereoscopic cinema lasted for more than a century after the discovery of 3-D by Charles Wheatstone back in 1838. This was partly because there was a continuous technical evolution of the conventional cinema and the huge variety of technological ap-

Figure 2.13: *Sir Charles Wheatstone* [13]

proaches to the creation of stereographic imagery. There were few 3-D feature length films produced during this time but towards the end of the period technical fundamentals had been created and both techniques such as anaglyph and polarizing image became widely used.

An Era of Convergence - 1952 to 1985
It was during the 1950's that 3-D movies saw its first major peak with a general audience where more than 50 movies were released. Different aspect ratios were tried out during this period and the first real wide release of a stereoscopic motion picture was *Friday the 13th Part III* released on August 12, 1982 which screened on over 1000 silver screens around North America.

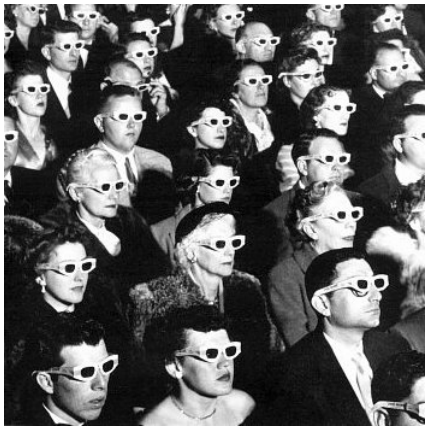


Figure 2.14: *3D audience in the 1950's* [14]

The Immersive Era - 1986 to Present
The introduction of the innovation of 70-mm IMAX film introduces the third period of stereoscopic cinema. By its massive screen size and six-channel sound this new stereoscopic large format fought the problems that the 1950's peak had by eliminating the awareness of the frame. During the immersive era virtual reality and head-mounted displays were also introduced. These techniques can be used at home but still needs to establish themselves.

Digital 3-D Cinema - 2005 to Present The digital format has introduced a whole new era with wider possibilities for the 3D cinema. It is becoming a widespread movie phenomena with 16,405 digital cinema screens globally of which 9,000 of them are equipped with 3D capabilities as of 5th of March 2010 [30]. This is an increase of over 200% in the past year. One of the reason for this explosive increase is the release of James Cameron's 3D movie *Avatar* which is becoming the biggest grossing movie of all time as well as due to the new polarized technology the audience can have an enjoyable viewing experience.

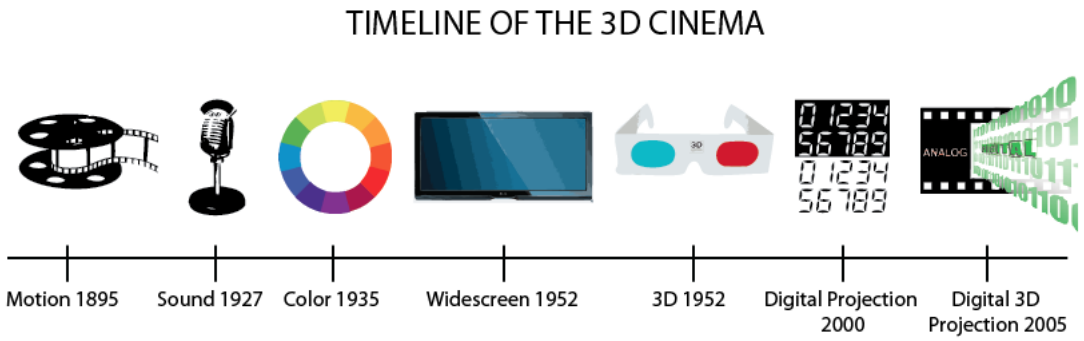


Figure 2.15: *Timeline of the 3D cinema* [15]

2.6 The 1950's 3D Peak

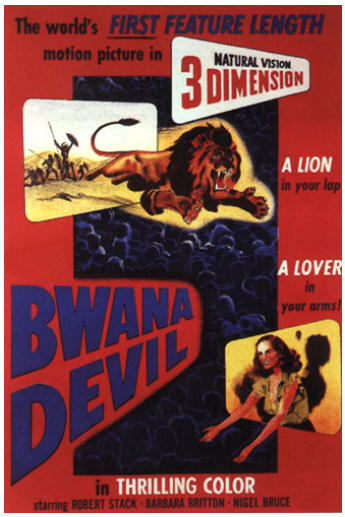


Figure 2.16: *Bwana Devil, 1952* [16]

There was an immense decline in attendance in the American cinemas during late 40's and early 50's [18, p.37]. This was blamed on the rising popularity of the television. Due to this something spectacular was needed to regain the interest of movie goers. On November 27, 1952, *Bwana Devil* was shown in Los Angeles, being the first American color and 3D feature film [18, p.38]. In just one week screening at one theater it grossed in US$100,000 which therefore paved the 1950's boom for 3D cinema. This 3D boom slowly declined after the impressiveness of it was gone. The technology was not mature enough yet to make it into a completely enjoyable experience and remain an industry standard. The audience often experienced headaches, nausea and eyestrain while watching 3D cinema due to inadequate shooting rigs, inexperience in stereoscopic photography and mismatched stereoscopic projection [18, p.41].

2.7 The Challenge Of 3D Today

Back in the 1950's when 3D became popular it was almost used as a tool to create a comic genre film where arrows were flying towards the audience and people were responding by dodging and laughing and getting distracted of the actual story taken place in the

film. Today filmmakers has started seeing stereoscopic movies as not only pure visual entertainment but as an important tool that can add an emotional significance to their story. Filmmaker Henry Selick saw the opportunity with using 3D and created Coraline (2009) which has impressed audiences and sparked an even greater interest towards creative use of 3D. The challenge for 3D in movies today is to embed it into movies such as color and sound already is. For it to be fully efficient and rather support the story than take the attention away from it it needs to go unnoticed but affect the perception. Henry Selick has been cited for saying

> *"There's that ability to give comfort, and, like many other tools in filmmaking – lighting, performance, everything – 3D is now a powerful tool to influence emotions."* [9]

2.8 Initial Problem Statement

In conclusion of the research done on the preliminary problem the following initial problem statement has been formed:

> *In what way can 3D be used to change the perception of movies or scenes, in similar ways as sound and colors does?*

In order to further investigate what 3D can do it is important to understand what 3D actually is and how we perceive it.

2.9 How Is 3D Perceived

Most humans perceive their surrounding as three-dimensional (3D). The human vision has evolved so that even though a two-dimensional image is seen on the two eye's retina a sense of depth is provided [19, p.163]. There are three situations where distance perception is important, namely egocentric distance, relative distance and depth perception [19, p.163]. Egocentric distance is the distance to an object from one self. Relative distance refers to the distance between two objects. And lastly depth perception refers to the perception of objects being three-dimensional. When perceiving objects in 3D one acknowledges the objects having depth and thickness, height and width. Seeing as the current thesis deals with three-dimensional content it seems prudent to subject the last of the three to further exploration.

2.10 Depth Perception

2.10.1 Monoscopic Depth Cues

Most of our depth information around us is monocular [19, p.164]. Monocular information means that only one eye is required to obtain the depth. This entails that people that are blind in one eye can still have depth perception, but can not see things three-dimensionally. These monoscopic depth cues plays a substantial role in films that are not portrayed in 3D. We can extract a lot of 3D information by using just one eye, a single 2D view [21, p.11]. Following is a list on a few of these depth cues:

Relative Size When seeing a picture portraying a man and a building with the same size one can easily assume that the man is standing closer due to the relative size of the two objects [21, p.12].

Perspective Looking at an image with a railroad the tracks seems to meet in the distance even though the distance between the tracks will always remain constant [19, p.167].

Texture Gradient A texture with a repetitive pattern will appear to get smaller as it approaches the horizon [21, p.12].

Occlusion When one object is occluding another, the occluded object gets judged to be further away than the object which is fully visible. For example this document will appear closer than the desk behind due to the desk being partly occluded by the document. This distance cue is sometimes considered being the primary source of information of distance [19, p.165].

Atmosphere Blur When standing on a hill watching mountains in a distance they often appear to be more blurry and blueish. This is due to the air in between which may not be entirely clear, as well as particles in the air that bends the light so distant objects seems blueish [19, p.168].

Motion Parallax As you move your head objects at different distances appear to be moving in different directions and at various speeds. Motion parallax also occurs for example when sitting in a train watching out of the window. The objects further away seem to pass the window much slower than for example light-poles that passes in an instance [19, p.172].

2.10.2 Stereoscopic Depth Cues

Stereoscopic depth cues are a distinct kind of motion parallax cues. Instead of using just one eye both eyes are used, and we make a comparison between those two view points. The brain process these two images simultaneously looking for disparities. Disparity is the distance between a points position on the two eye's retina. By doing so the brain can extract even more information more accurately than from just regular motion parallaxes [21, p.17]. Following is a list on stereoscopic depth cues:

Horizontal Parallax When looking at a stereoscopic image, for an instance an anaglyph picture with red-and-cyan glasses, the brain computes the different disparities to determine the distances of varying objects [21, p.17].

Shape Change Imagine holding a dice in front of your eyes. Both eyes will be able to see the number on the front of the dice while the left eye only can see the number on the left side of the dice and vice versa. This is due to our eyes being fixated with an average of 6.5cm apart. If viewing a house you can not see the sides of the house due to the width being bigger than the width between your eyes. The two images from each eye will be combined in the brain to form a coherent 3D object. The distance between the eyes is also referred to as interpupillary distance. The interpupillary distance plays a major role when filming 3D. By changing the distance it will create size effects of objects, either making it feel gigantic or small [21, p.19].

Occlusion Revelations Stereoscopic occlusion works the same way as monoscopic occlusion with one difference. When viewing stereoscopically one eye can see a bit more of the occluded object than the other eye. This supplementary information is a considerable cue for the brain to reconstruct the scene. This cue is also the most dominant which will supersede any other cue [21, p.18].

2.11 Perceiving The Surroundings

The world we live in is astonishingly rich and complex. To comprehend it, it needs to be understood through sensation, perception, thought and emotion [26, p.1]. The *Initial Problem Statement* (2.8) poses the question how 3D can be used to change the perception. As presented in the previous section *Depth Perception* (2.10) the world around us can be perceived by means of sight, both through monoscopic as well as stereoscopic depth cues. Stereoscopic depth cues though are even more informative and depicts the world

more pragmatic. Most movies are still viewed in 2D where only monoscopic depth cues are given. By adding the stereoscopic depth cues through viewing a movie in 3D, is it possible to also add more "realness" to the scene? And are stereoscopic depth cues in movies perceived in the same way as in real life, adding more richness to the scene?
While watching movies we can feel transported in to it. Sometime we can feel compassion towards the characters, laugh and cry. During a dark and mystical scene with a lot of suspension we get scared.

> *"In contemporary culture, moving pictures are the most immersive of all media. Until VR is perfected and becomes widely available, no other form of representation will approximate their ability to combine the spatial extension and fullness of detail of still pictures[...]."* [28, p.120]

With the possibility today to also portray stereoscopic depth in movies the question remains on if this addition does change the perception of the scene. By changing the perception does not necessarily mean that something entirely different needs to be perceived than if the same scene was shown in 2D. Rather meaning that there would be some extra affection towards the scene and one would perceive it more realistically, hence, perceive the scene more intensely. Jane Murray describes a similar phenomena called *Immersion* with her general definition being:

> *"A stirring narrative in any medium can be experienced as a virtual reality because our brains are programmed to tune into stories with an intensity that can obliterate the world around us. [...] The experience of being transported to an elaborately simulated place is pleasurable in itself, regardless of the fantasy content. We refer to this experience as immersion. Immersion is a metaphorical term derived from the physical experience of being submerged in water. We seek the same feeling from a psychologically immersive experience that we do from a plunge in the ocean or swimming pool: the sensation of being surrounded by a completely other reality, as different as water is from air, that takes over all of our attention, our whole perceptual apparatus [...]"* [23, p.98]

2.12 Delimitations

In order to focus the project better it is necessary to delimit it. The initial problem statement that was presented in (2.8) was the following:

In what way can 3D be used to change the perception of movies or scenes, in similar ways as sound and colors does?

The pre-analysis has looked in to the different parts of both the preliminary and initial problem statement in order to get closer to a final problem statement. Since the field of 3D in movies is not that well researched yet the pre-analysis started by looking in to current elements of moviemaking which affects our perception. The different elements seems to affect our perception and all be a valuable storytelling element to use. A lot of publications of speculations of the future of 3D can be found. But there are no publications on the direct effect that 3D has on our perception. A lot of movies have had success with integration of 3D but there can not be found research of why it has been so popular. In order to attain findings if 3D also can be used as a valuable storytelling element which so little previous research in the field a rather general investigation needs to be done for the project to be kept attainable.

In order to investigate the effects of 3D it seems prudent to test a scenario containing a lot of depth. Hypothesizing that 3D in movies has an effect on the perception this would allow the viewer to get more immersed than if the scenario had been portrayed in 2D. As already explained the difference in distance between the same point in the two 2D images the brain receives is called disparity. The ability to perceive this disparity as depth is called stereopsis. By use of stereopsis immersion often gets enhanced [24, p.2]. So the question that arrises is what scenario is already immersive and contains the opportunity to display a lot of depth which could be enhanced by the use of 3D?

> *"In the most complete forms of spatial immersion, the reader's private landscape blend with the textual geography. In those moments of sheer delight, the reader develops an intimate relation to the setting as well as a sense of being present on the scene of the represented events."* [28, p.122]"

Depth can be viewed in two ways, horizontally or vertically. Below are two images depicting these two simultaneously.

(a)

(b)

Figure 2.17: *Examples of scenarios which include both vertical and horizontal depth. Construction workers lunching on a crossbeam, September 29, 1932 2.17(a)* [17] *and King Kong (2005) 2.17(b)* [18]

To have the opportunity to use 3D to its full potential a scenario portraying both depth attributes, horizontal and vertical depth, will be used. Vertical depth can be seen from two different angles; from below looking upwards or from above looking downwards. The vertical depth will be used in form of height, looking downwards, in order to have a greater visual impact. The horizontal depth will not matter whether it is to be portrayed from left or right.

2.12.1 Final Problem Statement

The following final problem statement has been formed:

> *How does the existence of stereoscopic depth in a scene including both great horizontal and vertical depth influence the audience's perception of the scene?*

2.13 Methods

To solve the final problem statement there are a number of topics that need to be further researched. The research will help the design and implementation of a product that will be testable and supply the needed answer. To understand if there is a difference in perception when viewing a movie in 3D versus 2D it is important to understand how humans generally view movies and make sense of it. Therefore the following chapter, namely *Analysis*, will start up by focusing on perception theories on movies. This will be followed by how to

design a 3D movie in means of camera setup and cinematography. It is important that it will be done in the best way possible to ensure there are no disruptions or distractions that will harm the purpose of the testing. If successful this will allow to extract constructive information to be concluded upon.

Chapter 3

Analysis

The following chapter will further investigate on how movies are understood by an audience and what to take in to consideration when making a 3D movie. The first half will present theories on the perception of the audience in a movie while the second half will discuss how to present a 3D movie for an audience.

3.1 How Do We Perceive Movies

In order to investigate if 3D in movies can be used as a storytelling element it is prudent to have a brief understanding of how we perceive movies in the first hand. In the following section is firstly a brief explanation of what a story is and the PECMA Flow theory by Torben Grodal on the processing flow of a film experience. Secondly there will be a discussion on how we emotionally simulate a movie and how we can connect with characters in a movie.

A story is a narrative which is either true or fictional and can be made up of a series of events. Storytelling is the ability to tell a story. As already mentioned in the section *Elements Of Movie Making* (2.2) movies today already exists with three primary storytelling elements, namely *Sound*, *Color* and *Widescreen*. These three elements add something to the story in their own way without taking something away in return. By taking away something from the story would be for example to create a distraction that would draw attention away from what the story tries to express. A story is told well when different storytelling elements are used in conjunction to each other in congruity. Therefore the question arises; *Can 3D be used as a storytelling element without causing distraction?*

3.1.1 The PECMA Flow

It is our brain that shape our experience of a film. They way we determine the film experience and its aesthetic is by the basic architecture and evolution of the brain [11, p.145].

> *"We watch movies with our eyes and ears, and our senses have not evolved in order to be abstract processors of information, but to provide information as background for motor actions that can implement the preferences of our embodied brains - preferences that are expressed in our emotions."*[11, p.145]

In other words, our sensory system has not evolved with the purpose of viewing movies but with the purposes of translating incoming stimuli into appropriate actions. Different emotions help prepare us to perform actions and do to a large extent shape our experience of those events. In order to understand visceral and auditory stimuli from movies it is important to reconstruct the brain and its feelings on how it shapes what is experienced. In his acclaimed book *Embodied Vision* Torben Grodal introduces a general theory on how we perceive movies named *The PECMA Flow*. He argues that emotion is linked to motion, that our senses are directed outwards [11, p.146]. PECMA stands for the following words ; perception, emotion, cognition, and motor action. The theory describes how the film experience is structured according to follow the brains architecture. See figure 3.1. This flow starts by perception of the ear and/or eye, via visual and acoustic brain structures followed by the association area and frontal brain structures to lastly action. Action refers to motor activation such as muscle activity [11, p.146].

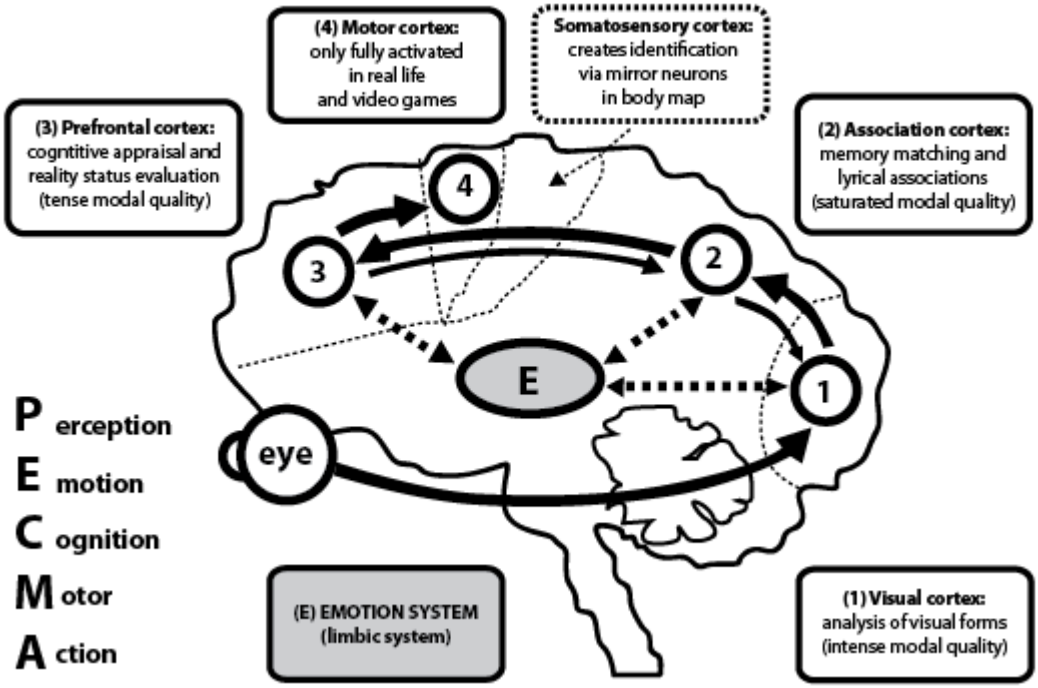


Figure 3.1: *The PECMA flow model* [19]

> *"When we watch a horror movie, for example, our hearts beat faster, we get an adrenalin flush, our muscles tense, and our fear focuses our perception of sounds and visual stimuli."*[11, p.146]

The PECMA flow (figure 3.1) shows how a film narrative is aimed to shaping and controlling actions which also forms emotions. Emotions are directions for telling the body what to approach and what to avoid [11, p.146]. Our emotional system is always alert due to evolutionary reasons. Us humans today still fear snakes, spiders and sharks more than we fear cars and cigarettes even though the latter kills substantially more people yearly. The emotions we feel individually will be referred to as first-person emotions. When afraid of something, your body will respond to it and perform some sort of action and sometimes without yourself even being aware of it. The most fundamental emotions can only be fully experienced in first-person [16]. But when watching a movie you experience emotions from a third-person viewpoint. Ryan similarly distinguishes between first-person emotion and those induced by fiction (third-person quasi-emotions) by stating

> *"[...] in real life we have beliefs that and desires leading to emotions; in fiction we have make-beliefs and make-desires leading to "quasi-emotions." "* [28, p.154]

Some emotions seems to be congruent in all cultures, as well as appear in different animal species. This suggests that some of our emotions are primary and given to us by nature [10, p.84]. There are endless discussions on emotion theories, how many there really are and what an emotion is. The theory used on emotion is based on Robert Plutchik's theory, which is one of the most influential approaches today. Plutchik considers there being eight primary emotions, namely; *anger, fear, sadness, disgust, surprise, anticipation, acceptance* and *joy* [27, p.540]. Figure 3.2 illustrate how different cognitions are associated with emotions.

Stimulus Event	Inferred Cognition	Feeling	Behavior	Effect
Threat	"Danger"	Fear, terror	Running or flying away	Protection
Obstacle	"Enemy"	Anger, rage	Biting, hitting	Destruction
Potential mate	"Possess"	Joy, ecstasy	Courting, mating	Reproduction
Loss of valued individual	"Abandonment"	Sadness, grief	Crying to be reunited	Reintegration
Group member	"Friend"	Acceptance, trust	Grooming, sharing	Affiliation
Gruesome object	"Poison"	Disgust, loathing	Vomiting, pushing away	Rejection
New territory	"What's out there?"	Anticipation	Examining, mapping, organizing	Exploration
Unexpected object	"What is it?"	Surprise	Stopping, alerting	Orientation

Figure 3.2: *Different languages for the description of emotion* [20]

3.1.2 Simulation and Emotional Engagement

Films often seek to evoke a strong emotional response and can be done through presenting a story that triggers innate emotional dispositions [11, p.6]. We often see fictional films where there are a lot of fights and violence. Somehow we are able connect to these scenarios through our basic instinct of survival even though most of us live in societies where we never even have to face violence of same degree. We can understand/feel the connection and emotion a parent has for his/her child even though we might not have children of our

own.

> *" The central elements in action-adventure films - physical motion, fighting, the quest to find particular objects and mating partners, and so on - represents pivotal ways in which the life of our hunter-gatherer ancestors who roamed the Pleistocene would have been structured."*[11, pp.6-7]

On the other hand, many film theories imply that a film is experienced from the viewpoint of an observer [11, p.181]. One of these theories are described by Noël Carroll in his book *Toward a Theory of Point-of-View Editing: Communication, Emotion, and the Movies* [4]. He claims that when we watch a fiction film our emotions are not as participants but similar to an onlooker or observer. The viewer will not share the same emotions, goals or perspectives as the characters on screen. Grodal argues against these theories claiming that those who take on this observer view dismisses the belief of that the film viewer often simulates the same emotions as the characters on screen. He says that those theories fails to take account for the emotional impact that we may experience when watching a fictitious event [11, p.182]. A good example of such an experience is when watching Armageddon (1998). Many experienced being very sad and emotionally affected when Grace's dad calls her and tells her he wont be returning back. Instead he sacrifices his life to save the earth from an approaching asteroid. This emotional state we got in is due to we connected to Grace and felt what she might have felt receiving this phone call. If we had only been observers and not participants we would not have felt as affected by the situation.

We can to some extent look at ourselves in an object-centered way and analyze the surrounding we are in [11, p.193]. Through evolution we are naturally inclined to cognitively and emotionally become involved in hypothetical situations to enable us to analyze a situation and alternative strategies. For example if facing an enemy if we should fight or flight [11, p.152]. Our minds can partly experience ourselves in a third-person viewpoint. Due to this phenomena we can to some degree view a character in a movie, in the same way as we view ourselves, and connect emotionally. As already mentioned we humans were not evolved to watch movies but our capability of watching movies with an emotional connection is due to our ability to model and simulate ourselves as seen from an outside perspective.

> *"We infer how other people experience things by extrapolating from our own experiences"*[11, p.165]

When we watch someone else perform an action we simulate or activate the same neurons in our brain as if it was ourselves performing the task. But when doing so we do not actually activate our motor cortex which would otherwise lead to us actually performing the task [11, p.197]. So while watching a movie, for example a fighting scene, we simulate the onscreen action as if we were there. We simulate dodging a punch and when the character gets a hit in his stomach we can feel his pain but we do not actually move around and lose our breath while doing so.

> *"It is only through such immersed simulations, in which the feelings and action tendencies prompted by events on screen are closely integrated with one another, that a film is able to induce fundamental emotion such as fear."*[11, p.197]

3.1.3 Misperceiving Distance

New studies shows that people with fear of heights have troubles perceiving vertical dimensions. People who suffer from acrophobia, extreme fear of height, considerably overestimate vertical distances. The stronger the fear the greater the error [3]. Russell Jackson, a cognitive psychologist at California State University says that an important factor with people who suffers from acrophobia is that they are perceiving something different in the first place [3]. To prove this Jackson did a test where participant standing on top of a building had to estimate the height. Participants with stronger fear of heights estimated the height much larger than those with less fear. Jackson also states that *"There's no-one that's fearless when it comes to heights"* [3]. By introducing 3D in a film, making a scene more realistic, the belief is that the height should also be perceived as larger than if viewed in 2D. Not because the depth cues would be different or entirely inducing acrophobia, but due to the scene becoming more realistic and triggering some protective evolutionary instincts of keeping away from the edge.

In many of us a picture, like seen in figure 3.3, can already trigger a sensation of fear, even though it is only viewed in 2D. This picture is taken from a personal blog online with a comment; *"I didn't realize you could experience vertigo just by looking at a picture....yikes."*[22]. The comment very much describes the simulation and imaginations that goes on in the commenters mind. But to some of us this picture is only seen as aesthetically nice and exciting. But if viewed in 3D, where the height could be more realistically perceived, the outcome could be misperceived even larger and therefore induce a sense of fear.

Figure 3.3: *Kjeragbolten, Norway* [21]

3.2 Orthostereoscopy

When a 3D image is said to be orthostereoscopic it is perfectly replicated by the human vision. There should be no difference at all when viewing the image in a 3D representation or its original scene [21, p.78]. As an ortostereoscopic image is a perfect replication the perceived sizes of objects are equal to the original ones resulting to the stereopsis process being much easier. The brain does not need to interpret other metrics of the scene as it is all natural. To achieve an orthostereoscopic movie, it needs to be filmed with a focal length that perfectly matches the human angular field when viewed in the theater [21, p.78]. The limitations are that it is crucial where the person sits and views the movie and what kind of projection system is used to create the illusion. To ensure it will work one needs to have a replica of the theater where it is to be shown and a constant visual testing procedure. A perfect orthostereoscopic approach is not used much because of the time consuming process of trial and error.

It is often believed that the camera has to be perfectly replicated to the distance between the eyes in order to produce 3D movies. This is not the case, and there are situations where it should be quite the opposite [21, p.78]. By moving the interocular distance different effects can be achieved. These effects will be further elaborated in section 3.4.

3.3 The Stereoscopic Comfort Zone

In the real world, when we look at an object, our eyes adjust and converge to the same point in space. The two most important indications for a human brain to comprehend and see depth are *focusing* and *parallax* [12]. When looking at a 3D image of an item flying in the room, our eyes adjust on the screen but cross somewhere between the screen and where the viewer is sitting. When viewing 3D our brain actually forces our eyes to function this way. When the brain combines the two 2D images to a single 3D image it is called *fusion*[17]. This begins with seeing two blurred images which together form into one 3D image. People can fuse things close to them and far away from them, but not at the same time. This means either we choose to fuse the foreground or the background, which leads to one of them being out of focus[17].

3D illusion is created by displaying two somewhat similar images on a screen where the parallax varies depending on the screens size. When making a 3D it is important that the parallax is designed so the viewer is able to combine the two images and watch comfortably. The depth in the scene should be designed so the parallax is within the viewers comfort zone. The parallax is the horizontal separation of the right and left images on the screen and this separation determines the amount of depth[12].

The *interpupillary distance* is the distance between peoples right and left eye and makes it possible for the eyes to see somewhat similar picture of the same object. The distance between the eyes is approximately 6,5 cm for an average adult[14]. To describe the parallax we will use the left eye view as a steady image and the right eye view as the moveable image in regards to the same object. When an object is said to have an positive parallax it means that the right eye representation is to the right of the left eye representation on the screen[8], see figure 3.5(b). When an object on the screen has an positive parallax of 6,5 cm the brain interprets the objects situated at infinity. This is because the interpupillary distance is the same as the parallax, see figure 3.5(c). This

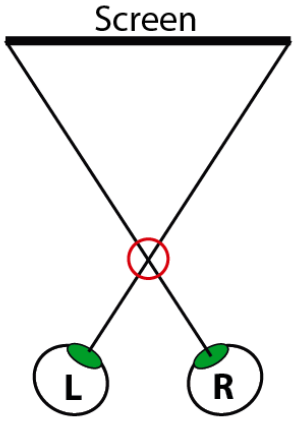
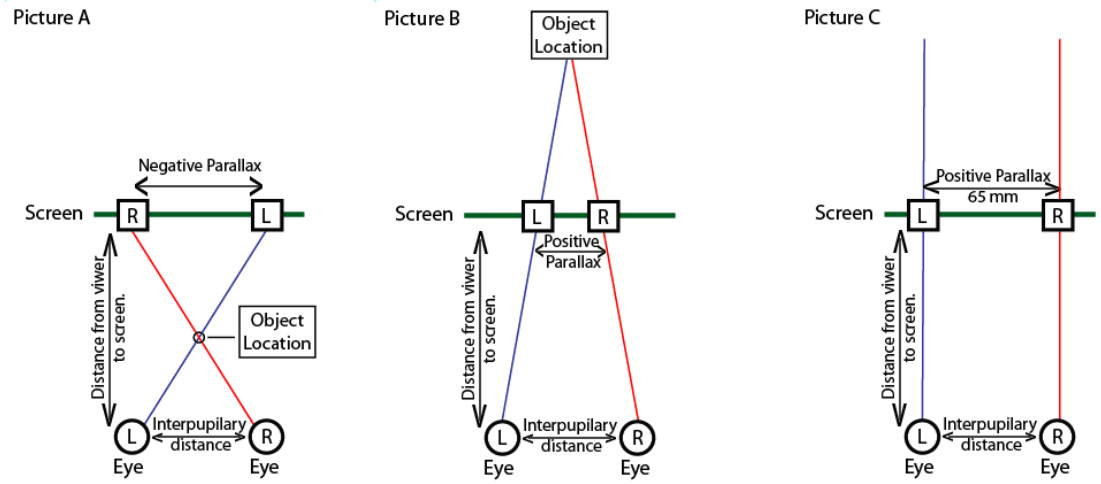


Figure 3.4: *The red circle indicates the position of the eyes crossing when looking at an object located at this distance from the screen.*

is often used to present for example distant landscape. Exceeding the 6,5 cm positive parallax has the effect of separating the eyes to an abnormal distance and resulting in headaches when watching a movie. The parallax is said to be negative when the right eye's representation is on the left side of the left eye representation, see figure 3.5(a). This forces the eyes to cross somewhere in front of the screen depending on the amount of the negative parallax, see figure 3.4. Because of this the object the viewer is looking at seems to float in the air in front of the screen. If the negative parallax is huge, it will cause the eyes to converge to much and therefore result in bad headaches[8].

Example of an image with a negative parallax can be seen in figure 3.12(a) and a positive parallax in figure 3.12(b) while illustrations can be seen below.



(a) Object in front of the screen (b) Object pushed into the screen (c) Object at infinity

Figure 3.5: *The way we see 3D* [23]

The comfort zone size is determined by how close the viewer is sitting to the screen and the size of the screen. A viewer sits closer to a TV screen then a movie screen. Therefore the comfort zone is smaller on a TV screen then on a movie screen.

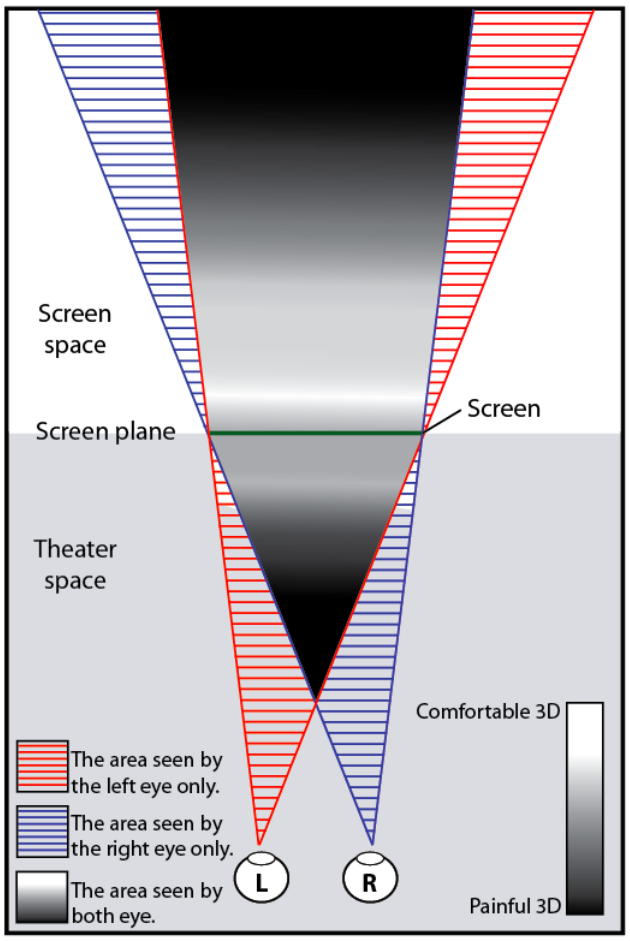


Figure 3.6: *The Stereoscopic Comfort Zone* [24]

Figure 3.6 shows a picture of the stereoscopic comfort zone. The area with white and black gradient is the area that determines the comfort zone. The white to light gray area is where the 3D is most comfortable viewing. The black and dark gray area can also be used but to an limited extend. These areas are very sensitive and can cause eye strain over time. The red and blue stripy area are only seen by one eye. The surrounding gray areas are invisible to the viewer. The little gray triangle between the eyes can be used for fast moving objects, but should be used cautiously [21, p.82]. Objects that are displayed outside the stereoscopic comfort zone tend to result in uncomfortable viewing experience and can cause a really bad headache. If there is allot of flares, specular light or shiny surfaces within the comfort zone it can have the same effect.

Figure 3.7: *Result of an uncomfortable viewing experience* [25]

When viewing a 3D movie, making it a comfortable viewing experience is really important. Keeping the separation of the right and left stereo images within the viewers comfort zone is not the only thing. Many other different discomforts comforts can occur. Imbalance, hence not properly aligned horizontally and/or vertically, between the two 2D images can lead to the eyes tracking in different directions, meaning that one eye can for example track down and the other upwards. This can lead to fatigue and uncomfortable viewing experience. This is because the eyes are intended to work in conjunction on the same horizontal level. Too shaky and sudden transition from one shot to another can lead to what is call hunting time, hence the eyes hunt for something to focus on. This can have the effect that the viewer can not adjust and converge to the fast movements and therefore the 3D will appear as a blurred 2D image[14].

3.4 3D Camera Setup

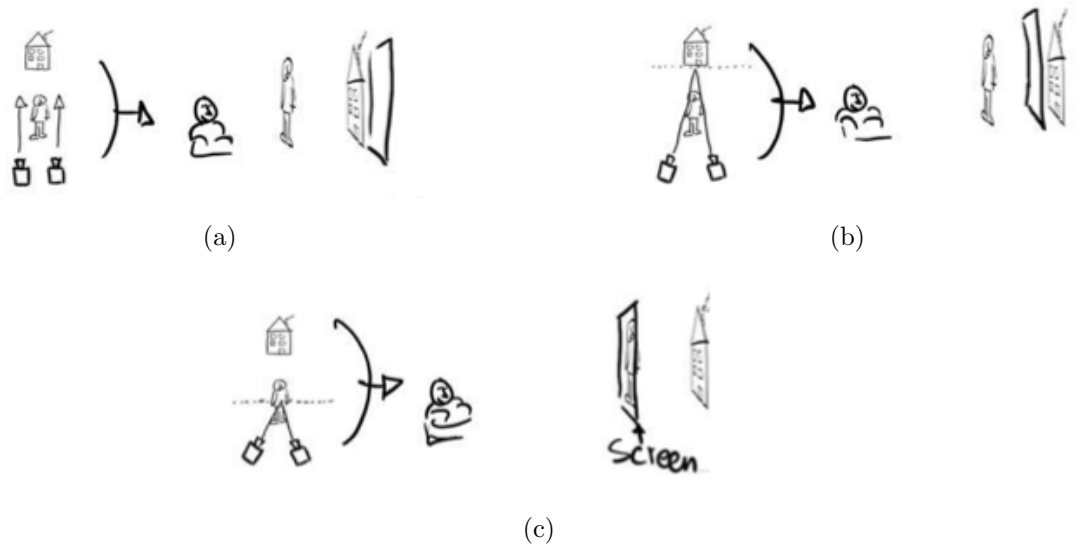
The following section will describe the two techniques *Interocular Distance* and *Convergence* which are two important techniques used for the designing of stereoscopic movies.

3.4.1 Interocular Distance

The most important parameter in stereoscopy is the distance between the two cameras. This distance controls the strength of the 3D effect. If you pull the two cameras apart the subject will grow. If on the other hand you push the two cameras together the subject will shrink. There is no wrong or right way to do this, unless you want to achieve an orthostereoscopic image. It all comes down to an artistic and technical decision [21, p.73]. As for a starting point it is good to begin with placing the cameras the same as the average interpupilary distance which is 6,5 cm. When successful shots have been done with this distance one can start playing around and try different distances to accomplish various effects if needed.

3.4.2 Convergence

The second most important parameter after deciding on the distance between the cameras is the convergence point [21, p.74]. This is the same principle as converging your eyes but the difference here is that it is seen from a camera setup perspective and how changing the convergence effects the image.



(a) (b)

(c)

Figure 3.8: *Convergence points* [26]

If you place the two cameras exactly parallel to each other, see figure 3.8(a), the 3D picture will appear 100% in front of the screen. The only objects that will be appearing on the screen are those objects that are at an infinite distance to the camera. These objects do not either have any disparity hence no 3D effect.

If you would like the objects to partly appear behind the screen as well as in front of it you will need to converge the cameras. To converge the cameras you simply need to adjust the axis of the two cameras towards each other as can be seen in figure 3.8(b). The exact point where the two camera axis cross will appear to be on the screen. Objects in front if this crossing point will appear to be in front of the screen whereas objects behind the cross point will appear to be behind the screen [21, p. 75].

To make all objects appear behind the screen you need to converge the cameras towards the foremost object in the scene [21, p. 75], see figure 3.8(c).

By converging the cameras on different objects and defocusing a background it is possible to control the audience's eyesight. It is possible to converge the cameras in postproduction with the help of image processing, but for live 3D events manual convergence is still needed [21, p. 76].

3.5 3D Cinematography

Cinematography is the part in the production that concerns all the aspects of the camera, the lens and framing. If a movie is designed for 3D, meaning every choice is taken in consideration to 3D cinematography, it should also be viewed as a 3D movie. When viewing a movie that is shown in different dimension than intended, the flaws are clear. As Selick, the producer of Coraline, said

> *"I wish Coraline could have been released only in 3D, not in both flat and stereo"*[9].

Many of the magnificent scenes in Coraline (2009) are lost when viewed in 2D. The movie was never intended to be viewed in 2D but due to the general public not having access to 3D viewing at home, or some not even in movie theaters, it was released in both dimensions.

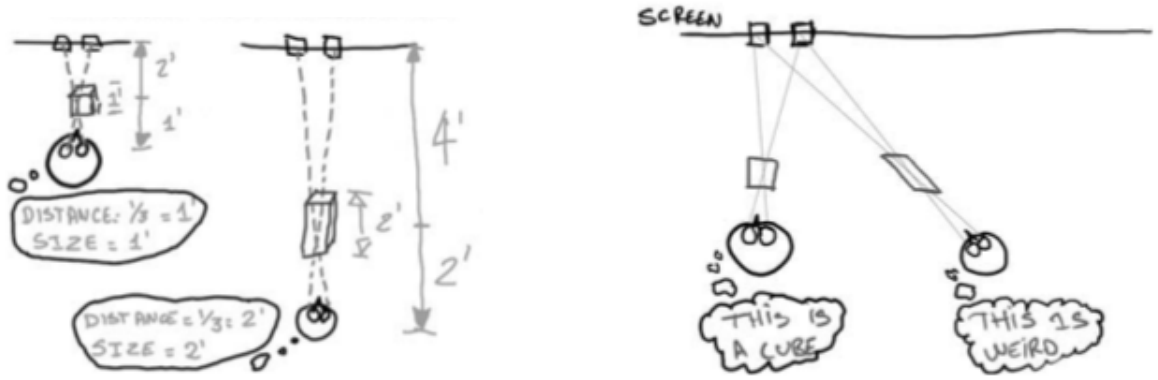
This following section will discuss about the fundamentals of cinematography in 3D movies.

3.5.1 Depth Perception In the Theater

When viewing a movie it makes a difference which size the screen is, the color range of the movie and the sound associated[21, p.76]. When viewing a 2D movie the screen size is more related to the viewers viewing explorations. A 2D movie is not equally as enjoyable on a cell phone as on a television or in a movie theater. The same goes for 3D movies but the effect of the screen size is more dominant. In movie theaters the viewer has more tolerance towards long scenes with much varying parallax, especially positive, and a lot of fast pace movements. Having the same movie shown on a normal TV screen the viewing experience becomes unpleasant since this is not normal conditions for the eyes and the brain[13].

As mentioned in section (4.3.5) the 3D effects in movies are established by showing two images with some extent of distance between them. One image for the left eye and one

for the right eye. There is a great difference in perceiving a 3D effect from a small cell phone screen then a movie theater screen. Bernard Mendiburu has an example in his book *3D Movie Making* of the consequence when looking at a 3D postcard which is about 13 centimeters wide and then scale the same image up to a 12 meter movie theater screen. The object in the postcard has an negative parallax of 3 centimeters which has the effect of the eyes crossing in front of the card and give the perception of the object flying towards. This scenario gives the viewer a possibility to fuse the two images into a 3D image. When looking at the same image being projected and scaled on to an 12 meter movie screen the negative parallax changes to approximately 2,5 meters. This makes it impossible for the viewer to fuse and therefore only see two blurred images [21, p.76]. By this it is important to keep in mind that when making 3D the creator should visually look at the 3D on the intended screen size. When designing the movie one should already know on what size of screen it is intended to be projected. If it is supposed to be released for both the cinema screen and for iPods then two separate versions should be made.



(a) (b)

Figure 3.9: *Effect of screen distance 3.9(a)* [27] *Effect of side seating 3.9(b)* [28]

When sitting in a movie theater the effect of the 3D is perceived differently depending on where the viewer is placed. When sitting in the front rows the object out of the screen becomes closer to the viewer, but when sitting further back in the movie theater the object that comes out of the screen appears bigger, see figure 3.9(a). If sitting more to the sides of the screen the viewing experience becomes irritating since the object shapes become distorted, see figure 3.9(b) [21, p.78].

3.5.2 Framing in 3D

Many believe that making a 3D movie is not much different than making a 2D movie, but that is far from the truth. The knowledge when making a 2D movie can often come in handy for 3D production, such as protocols and management. To become a good 3D movie maker the experience is the most powerful tool. Phil McNally, a stereoscopic supervisor on *Monsters vs. Aliens*, *How to Train Your Dragon*, said

> *"One can teach the whole theory of stereoscopy in two hours. You can learn all about 3D moviemaking in two months. That will never give you the 10 years of experience needed to master it. Good movies are made with experience, not knowledge"*[21, p.35].

The workload when making a 3D movie can almost be said to be the double amount than when making a 2D movie. This means that the storage space for the data has to be bigger and the manipulation of the movie is twice as much. When making a 3D movie there is a lot of different elements to think about. The decisions made for the shot composition for a 2D movie can often harm a 3D movie. Some of the most used tools for a 2D movie post-production are *Rotoscoping* and *Paint*, but these tools are risky to use in 3D production. Rotoscoping is often used as a cut-out tool such as cutting out a part of a background that is not essential for a scene while paint is used for painting over unwanted elements such as marker or create objects[21, p.38]. The reason why these tools are risky using in 3D production are as mentioned before, the 3D effect is created by two superimposed images. If one images is slightly manipulated differently then the other the 3D effect can get lost. Another example is to avoid simulation of depth, such as models that are scaled and backlight effects[21, p.108].

A new technique has recently been introduced within the creation of 3D movies. This technique consists of taking a 2D movie and converting it into a 3D movie. *Clash of the Titans* is an example of such a movie which used this technique. The scenes were digitally reconstructed in post production creating the illusion of 3D. There has been much negative response to this movie as it was never initially meant to be shown in 3D. As Kim Pedersen, chairman of Danske Biografer mentioned in an conducted interview with him;

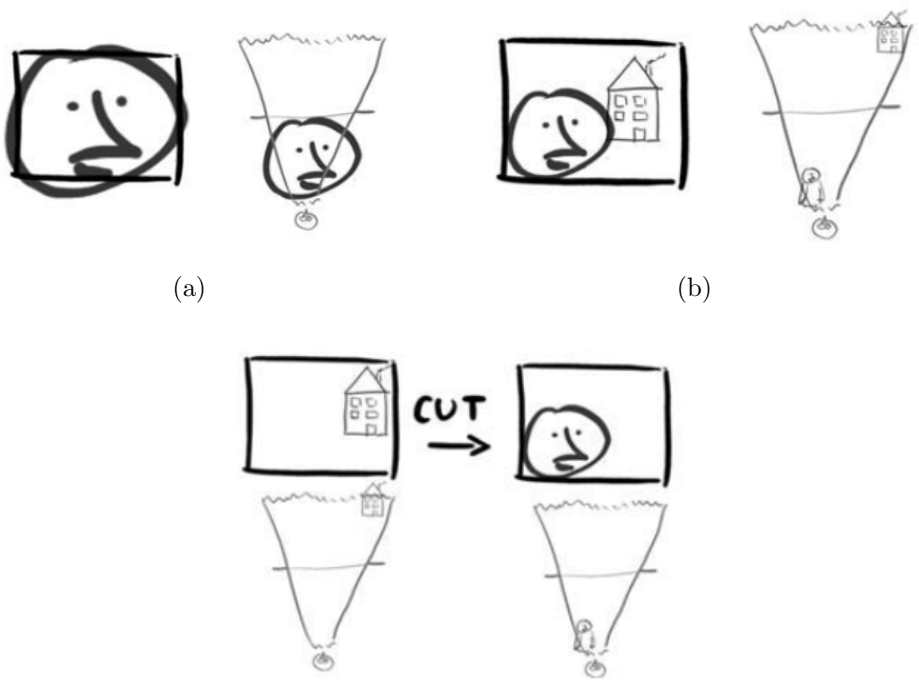
> *"I do believe that once they start rereleasing Star Wars, Titanic and Lord of the Rings in 3D, the audience will be disappointed, because those films where never meant to be in 3D"* [25].

When watching a 2D movie the edges of for example a television frame are defining the space of the flat 2D image. But the 3D movie is presented in a window that is called *the stereoscopic window*. This is different from 2D in the sense that not only is the image defined by the edges of the screen but also the volume[21, p.79]. This means that when compositing for a 3D movie the producer has to design the movie in terms of volume composition rather then picture composition as in 2D movie production. Everything within the stereoscopic window has to be placed according to the space and this can be a difficult venture. Framing is one of the important elements to use to keep the objects, characters and everything that belongs within the space. Framing your shot, can play a very influential part in a movie. What you see on the screen is what the producer decides for you to see. When making a movie it is important to keep in mind the framing of the scenes and the editing of the movie. If these parts are not executed well the movie can suffer to a great extent. As the screenwriter and film director David Mamet, from Chicago, Illinois states

> *"You do not have a movie until you have shot it, and then you still have no movie until you edit it"*[21, p.91].

Bernard Mendiburu listed in his book *3D Movie Making*, three of the most important visual constrains that can occur in 3D that film producers should be aware of. These are

- *"Objects can not cross the edges of the screen. As an example, an extreme close-up with the talent's face reaching all four sides of the frame must be set behind the screen*
- *You can not look at something reaching far inside the theater, in front of a background that is far behind the screen.*
- *You can not jump cut, such as from a shot centered inside the theater, to a shot far behind the screen."* [21, p.94]



(a) (b)

(c)

Figure 3.10: *A close-up framing 3.10(a)* [29]*. Framing in front of a distant background 3.10(b)* [30]*. A jump cut between different convergences 3.10(c)* [31]

It is often called *Stereoscopic window violations* when items are placed wrongly within the volume of the stereoscopic window. The most common violations are the close-up shots, the medium close-up and over the shoulder shots [21, p.97]. The example of a close-up can be seen in figure 3.10(a). This scenario works in a 2D movie and is very often used to give the viewer a feeling of the characters state of mind. In 3D it causes incoherence in the left and right image and the character is projected behind the screen plane instead of in front of the screen. This can be avoided by leaving space around the characters head.

Over the shoulder shots are also common in 2D movies. This is used a lot when two characters are communicating with each other. The viewer sees one person from the front and another in the corner of the screen closer to the camera with his back towards the viewer. An example of this scenario can be seen in figure 3.11. In a 2D movie the character with his back towards the viewer is blurred a little so the viewer focuses on the person seen from the front. Also this character often has the head and parts of the shoulder cut off. If this same framing would take place in a 3D movie it could be seen as the character is decapitated and give the absolute wrong impression. Especially if this person is projected

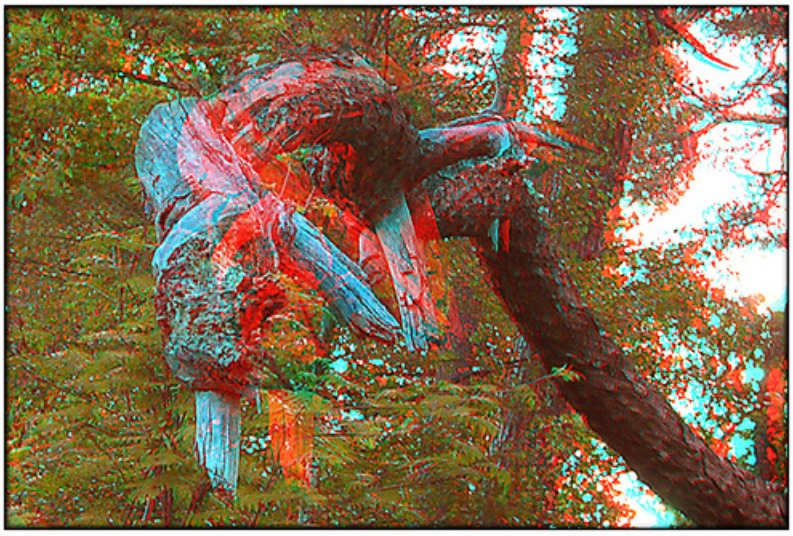
with the sense of sticking out of the screen this impression will be achieved. Therefore placing characters or objects too close to or beyond the frame should be avoided[21, p.97]. An example of good 3D framing can be seen in figure 3.11(b), displaying a screenshot from the award winning 3D movie Avatar (2009). The reason for why this shot works so well is due to that the characters are not cut off. As well none of the character are blurred and therefore allows you to focus on what you choose to focus on. The depth of focus needs to be kept quite large in a 3D production. As depth is introduced in the movie there is more for the viewer to explore in the scene. As we see 3D naturally around us we decide and focus ourself on what we find interesting in our environment. If this focus is done for us in the movie on some objects which we might have found interest in are blurred out the experience can become very annoying.

(a)

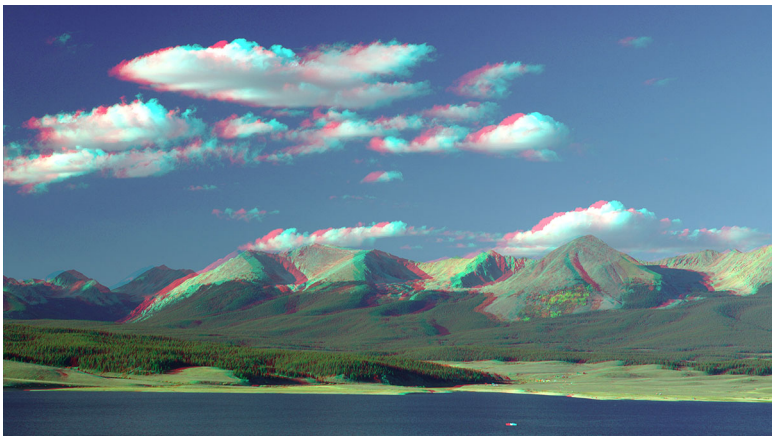
(b)

Figure 3.11: *Over the shoulder in 2D movie 3.11(a)* [32] *Over the shoulder in 3D movie which is here seen in 2D 3.11(b)* [33]

Jump cuts should be at all time avoided. A jump cut is when there is a big variation between the depth perceived from shot to another shot. An example of this can be seen in figure 3.10(c) and figure 3.12(b). This forces the viewer to switch between various depth dimensions, which leads to double vision and can disturb the viewing experience[21, p.88]. To avoid this the shots have to be appropriately selected and by using cross fades or other effects between shots can minimize the disturbance.



(a)



(b)

Figure 3.12: *Jump cut from different depth to another. Figure 3.12(a)* [34] *shows a negative parallax and figure3.12(b)* [35] *shows a positive parallax.* ⋘□□⋙

3.5.3 Lighting

In any movie production, one of the essential parts is the lighting. Lighting a scene can be a very difficult and a time consuming task, especially when used to create and reduce shadows and give a specific mood to a scene. When working with 3D the clearness of the images is very important. This is where the focus comes in to the picture. The main element for a sharp focus is to have lights that can minimize shadows in an image. When minimizing flat strong shadows the depth perception becomes greater. Therefore in a 3D movie production the amount of light required is enormous [21, p.112]. Using much light can also be a difficult task, specially when shooting nearby reflected surfaces, such as water. The light can create a flare that will not mach in the left and right images and therefore create unsymmetrical images. Lighting for 3D movies is not much different except more lights are required for the same result as for 2D movies. When designing the light for a 3D movie it is important to place them according to the viewers comfort zone[21, pp.112-113]. To avoid a double image, known as ghosting the shadows in the 3D image should be very softly lit. Especially objects that are reaching far out and far behind the screen needs to be well lit because the 3D display system does not decipher well high contrast images. Pay also attention to if an object that is strongly lit is placed close to the left or right edges of the screen, where only one of the eyes can see it, the object can draw to much attention to itself. In this case the viewer is unable to fuse it into a 3D image and becomes irritating to watch.

3.6 Experiment Specification

Through our research from both the pre-analysis and analysis we have formed the specifications set forth for the experiment in order to answer the final problem statement. In the following will be listed our specifications for the experiment. These will be taken into consideration while designing the experiment.

- The experiment will consist of a short scene portraying both vertical and horizontal depth.
- Two versions will be made, one in 2D and one in 3D in order to make a comparative study of the two.
- Both versions are to contain their respective depth cues.

- The experiment should consist of a simple storyline so that the viewer can make sense of what is happening.
- The scene is to contain a character that the viewer can connect to and simulate his/hers action. The character is not to perform any verbal action or other gestures in order to remain as neutral as possible.
- The scene needs to be very simple over all to be able to test and understand what elements may affect the perception in different ways.

Chapter 4

Experiment Design

The following section will describe the decisions made for designing the experiment.

4.1 Approaching The Experiment

In the problem statement the question on how the existence of stereoscopic depth can influence the audience perception of a scene was addressed. 3D can perhaps influence numerous things and therefore it is needed to decide on focusing on one particular area. As 3D is related to depth it would be reasonable to investigate a scene where space plays a big role. As introduced in the *Analysis*, Torben Grodal states that you can connect emotionally to an on-screen character. Therefore we found it prudent to choose a scene where the space affects the character, to then investigate if this could lead to affecting the audience as well.

There are at least two scenarios where space can have an explicit great effect on a character, a horizontal or vertical scenario. If there is great horizontal depth there might be a great distance to the other end. An example of this could for example be crossing a desert with no water. There the distance and space plays a big part. Another example could be a tunnel where it can become very claustrophobic if the opening is far away. Examples of great vertical depth could be standing on a high platform with a long way down to the ground. In both horizontal and vertical scenarios the sensation of depth might intensify the experience for both the character and the viewer. Depth could also be introduced more implicit like it has been done in the movie Avatar. There the world of Pandora where the Navi's live was, when viewed in 3D, displayed with much greater depth than on earth. This was to create the sensation of more beauty and more to explore than what we humans have on earth. To make such an implicit scenario would be much more difficult to create as

there can be so many different elements that plays a role in it. There are not either any studies suggesting that this implicit sensation was achieved.

Distance poses less immediate danger than height. Therefore a scenario with great vertical depth will be used for testing purpose. There will also be displayed horizontal depth but the emphasis will lie in creating a vertical distance induced scenario. In the following will be discussed how the design of this vertical stimulus will be made and the created story around it for the participant to emotionally engage with it.

4.2 Stimulus Design

4.2.1 Script

Making a movie or a short, the first thing to do is to build up a story. When the story is established it is written as a script. The script is one of the essential parts along with the storyboard, that the producer uses for the actors and film crew to understand what should happen in the different scenes. The different theories from the *Pre-analysis* and *Analysis*, helped us to a great extent to construct the script for the scene. Theories such as *Depth Perception* and *Element of Movie Making* presented in the *Pre-analysis* are used to help create an overall appearance and depth understanding for the scene. The final script is based on the decision taken in the *Delimitations*, section (2.12). To be able to use the 3D effect to its greatest extent, both vertical and horizontal depth will be used. Therefor a scene with a character on the top of a high building could be a good way of showing both vertical and horizontal depth. We mentioned in *Delimitations* the vertical depth could be used to give the viewer the perception of height, either from below looking upwards or from above looking downwards. The horizontal depth could be used to give the viewer the perception of the surrounding.

The scene will start up by seeing a man sitting, followed by showing what he is focusing on. At this point the viewer does not know in what situation the character is in. It is important to keep the first part of the scene neutral, to give the viewer a chance to establish his or hers own judgment about the situation the character is in. After he is presented it will be revealed that he is sitting on the edge of an high building. The man stands up and looks at the letter in his hand. The letter gets blown out of his hands. This leads to him trying to reach after the letter, but trips and falls. The next shot shows the man holding on to the edge that he initially was sitting on. This will illustrate the great vertical depth

he is in. The character can not hold on to the wall and falls down. He lands on the ground with the letter in his hand and walks away. What we want to achieve by this is to get the viewer to feel the uncomfortable feeling when standing on an edge of a high building. As mentioned in the *Analysis* on misperceiving distances, when presenting a scene like this in 3D the scene becomes more realistic and triggers instincts of keeping away from the edge.

The length of the scene will be about 30 seconds to one minute. The duration should be long enough for the viewer to grasp what is going on in the scene and establish a connection with the on-screen character. The final script can be found in the enclosed appendix.

4.2.2 Storyboard

Creating a storyboard is very vital for any production. It can radically cut down the cost of any production and be very time saving. A lot of the biggest design decisions are made in the storyboard. As we mentioned in the *Cinematography* section, it is very different designing a 3D movie from a 2D movie. This is due to for example different framing approaches and the use of different techniques such blurring elements to direct the viewer. There can be more harm done when filming a 3D movie with a 2D designed storyboard than the other way around. Creating a 3D designed film is overall much more time-consuming and there are more things to be cautious about. As mentioned in the *Experiment Specification* two versions are to be made of the short clip, one in 2D and one in 3D. In order to avoid as much bad cinematography as possible all shots are designed for 3D screening.

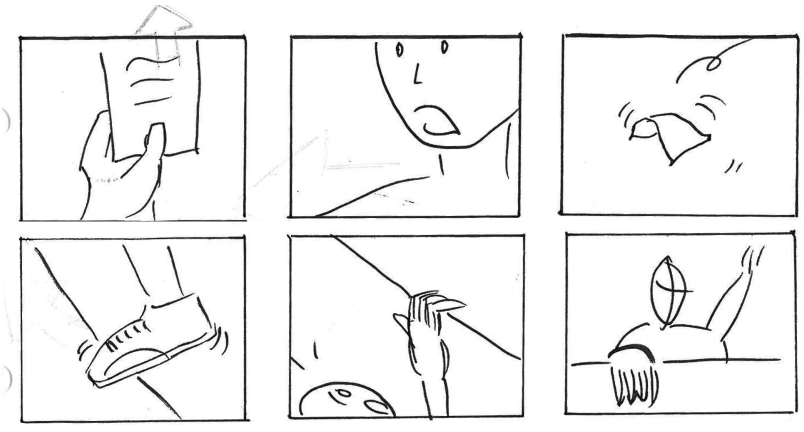


Figure 4.1: *A few frames from the storyboard*

The full storyboard can be found in the enclosed appendix.

4.2.3 Location

The scene will be filmed in three different locations. Even though the whole short seems to take place in one location, due to safety reasons we need to film in various places. It is not safe to film on top of a roof-top if we are not working together with a professional crew who knows how to handle such a situation. Instead we will use some visual effect techniques to "cheat the eye".

The shots located at an edge where the character is present a green screen will be used. The only thing which will be filmed on high altitude is the scene extension. By scene extension is meant the skyline which will show in the distance indicating the event taking place up in a roof-top and its vertical drop. The exact same angles will then be filmed with the character as if he was actually participating in the final composited shots.

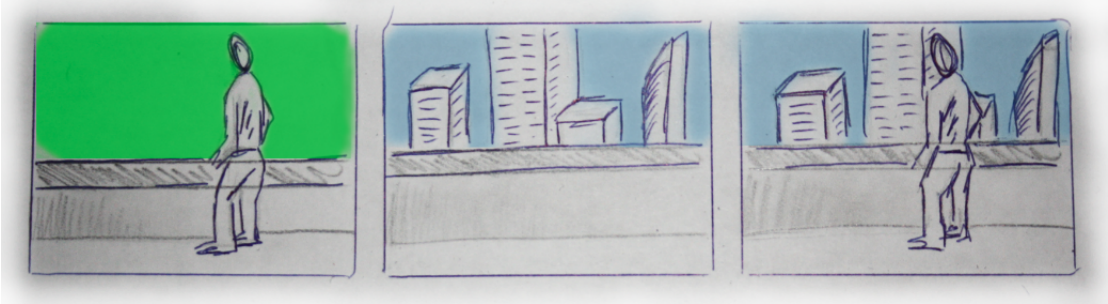


Figure 4.2: *This figure illustrates how a green screen can contribute to a scene extension.*

Figure 4.2 illustrates an example of how a scene extension can be made. A shot is taken with the character standing in front of a green-screen. The exact same angle is then shot from a high building or alike. These two shots are then composited together by removing the green screen and adding the skyline in the back. The result is a shot where the character seems to be standing on a roof high above the ground.

Some of the shots on the roof top will be filmed on top of a low building with no surrounding fence on the edges. This way nice establishing shots of the roof top can be filmed with no major rotoscoping or green screening needed to be done. As well the character can stand fairly close to the edge without fearing a fatal fall.

The shots where the character is falling off the edge and hanging will be shot from ground level. The actor will hang from a fence or alike with a green screen laying on the ground. The green screen will afterwards be replaced with imagery filmed from the tall

building. This will create the illusion of that the character is hanging on the edge of a very tall building and if falling it will be fatal.

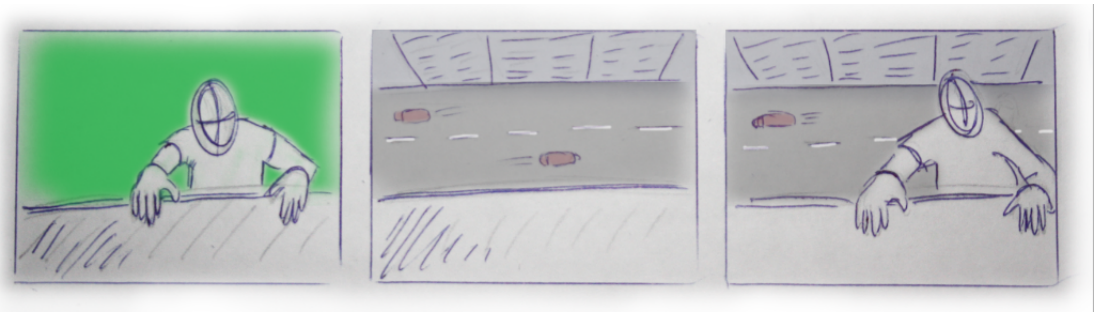


Figure 4.3: *This figure illustrates how a green screen can create the illusion of hanging from an edge.*

4.2.4 Framing

Since framing is such an important part for the production it is crucial for us to design the framing before shooting. This is often done with the use of a storyboard. According to the *Analysis* section (3.5.2) the framing of the shots have to be planned according to 3D cinematography. In a 2D production close-up are used to a great extent, particularly when portraying emotions from the actors. But in 3D these can create an uncomfortable depth perception. Since the character in the short should not show any emotional feelings or facial expressions, the close-up framing will be used to a minimum extent. A example of a movie that has well designed framing is Avatar (2009) and will serve as a good inspiration for this experiment. When working with a clip that needs work in post-production, such as filming with a green screen, it is necessary for us to have an understanding what the scene contains and frame the scene accordingly. The framing of scenes have to match with angles, position and action when compositing scenes together. This can cause many complications when working with 3D since the two images creating the 3D effect have to be identical.

4.2.5 Depth Cues

Since the independent variable is the changes in depth it is crucial that the designing of the depth in the scene is given great importance. In both of the two versions tested there will be illustrated depth. The difference between the two is that in the two dimensional version, only monoscopic depth cues can be seen. While in the three dimensional version

both monoscopic and stereoscopic depth cues can be seen. Stereoscopic depth cues is what most of us see in real life. To test the difference in perception between the two it is of utter importance that there is a lot of varieties of depth in the scene to be perceived. Otherwise it is quite meaningless that it is shown in 3D. To achieve this there has to be different distances between objects when filmed.

Figure 4.4: *Simple illustration of various distances of depth*

As shown in figure 4.4 is an example where the objects being filmed are located in different distances from the camera. This creates a variety of depth in the scene. When viewed in 2D, monoscopic depth cues such as *relatice size* and *occlusion* can be perceived. When viewed in 3D additional depth cues such as *parallax* can be perceived which should give an even better depth understanding. The aim is to use as much of the space in the pleasant area of the comfort zone as possible in the 3D version, see figure 3.6 on comfort zone.

When the two cameras are perfectly parallel all objects appear to be in front of the screen except those that are at infinite distance which will be located on the screen. To achieve objects appearing behind the screen the cameras need to converged towards each other so the convergence point will be in front of the screen. Unfortunately it is very hard to converge cameras and get a usable result out of it. The two cameras have to have a perfectly replicated angle or the 3D illusion will be destroyed.

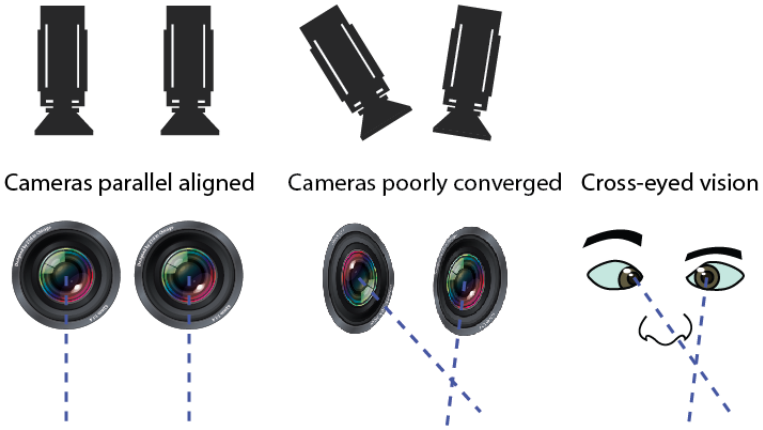


Figure 4.5: *Illustration of parallel and bad convergence*

4.2.6 Filming

To achieve stereoscopic imagery two identical cameras will be used. The two cameras distance will be replicated as a persons eyes, one for the left eye and one for the right eye. As we mentioned in section (3.4) in the *Analysis* the distance between the cameras are one of the most important parameter defining the depth within a scene. The decision was made to keep the depth within the comfort zone, meaning the range of depth should be kept neutral, with no out of the frame motions. Therefore the positive parallax between the two images should not exceed 6,5 cm and the usage of negative parallax should be by no means used when filming. Converging the camera should be avoided. As mentioned in section on convergence in the *Analysis* this has the effect changing the variety of depth perceived. Hence a great chance of the depth being located in the dark gray and black areas of the comfort zone might occur, see figure 3.6. Hunting time is uncomfortable for the viewer therefor a tripod will be used for most of the filming to avoid too shaky movements and fast pace movement. To avoid hunting time a tripod will be used. To achieve the very short distance (6,5cm) between the two camera lenses, pocket video cameras will be used due to their small dimensions, see figure 4.6

Figure 4.6: *An example of an camera that could be used.* [36]

4.3 Stimulus Implementation

This section on implementation of the stimulus will describe how the different design aspects were implemented for the final short. The final version of both the 2D and 3D versions can be found on the appended disc.

4.3.1 Camera Setup

As mentioned in the *Design* two cameras are to be used for achieving the stereoscopic movie. Our initial hope was to film with a 3D camera. Unfortunately there are very few of them out on the market and there was not the possibility to get the chance to borrow one for the implementation of the experiment. Instead a custom built setup was made to use two cameras side-by-side, see figure 4.7(a).

(a) (b)

Figure 4.7: *3D camera setup 4.7(a) The two Kodak Zx1 cameras 4.7(b)*

The setup consisted of two identical cameras and a tripod with a quick release shoe. A quick release shoe is a plate on the top of the tripod which gets screwed on to the cameras to gain easy control of attaching and detaching the camera to the tripod. As this shoe is made for only attaching one camera, a custom one had to be made in order to attach both cameras to the same tripod. It is crucial to mount both cameras on the same tripod to get identical movement on both cameras. The quick release shoe consisted of an

aluminum plate which was cut out to replace the original shoe. A screw was extended out of it to attach a second aluminum plate where the cameras were fitted on side-by-side. The secondary plate had various distances between the holes so different interocular distances could be used if we wanted to try out the different effects.

(a)

(b)

Figure 4.8: *Cutting out the plate 4.8(a) Drilling holes in the plate 4.8(b)*

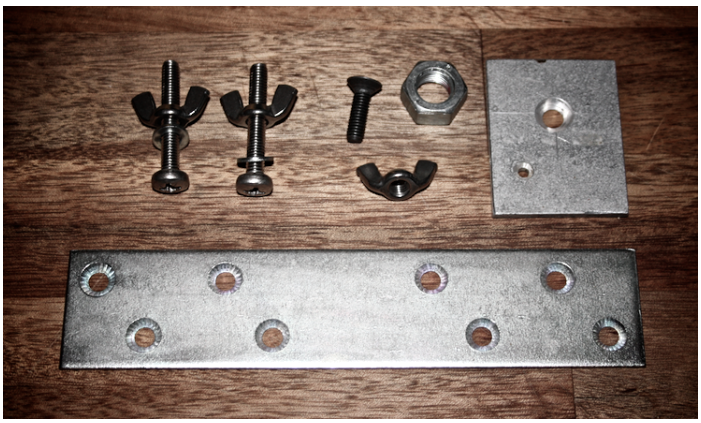


Figure 4.9: *The different parts needed for the custom built quick release shoe.*

Two Kodak Zx1 HD pocket video cameras where purchased for this project. The cameras are five centimeters wide, two centimeters deep and about ten centimeters high. Due to their small size it is possible to place the two cameras very close to each other. The cameras were placed exactly parallel to each other, hence no convergent was used. As mentioned in the *Analysis* convergence has the effect of controlling of how much objects appear to come out and in of the screen. As this technique can be hard to master we decided to it was entirely avoided it to ensure that the 3D effect would be kept within the comfort zone. The final decision was to use a distance of 6,5 cm which corresponds to the average distance between the human eye.

4.3.2 Filming

The camera setting on the Kodak Zx1 is minimal. When filming stereography the two images have to be identical with just a slight difference in position in order to create the 3D effect. In order to do that the settings were the same for both cameras. The scene was shot in HD 60fps. The majority of the scenes where shot outside since the daylight is one of the strongest light sources that can be used, hence no additional lighting was used during the production. In order to make the process of syncing the two shots together in editing, a clap was made in front of the camera before each take. A clap produces an instances of a sound which makes matching the two clips in post production very accurate.

To accomplish the green screen required scenes, a 5m long green fabric was purchased. While filming outside the wind poses a lot of problems for the green screen which we did not take in to account while storyboarding. But as many scenes required outdoor settings with its natural light and there was little time to make any major changes the decision fell on doing it as originally planned with the knowledge of having to work a bit extra in post production.

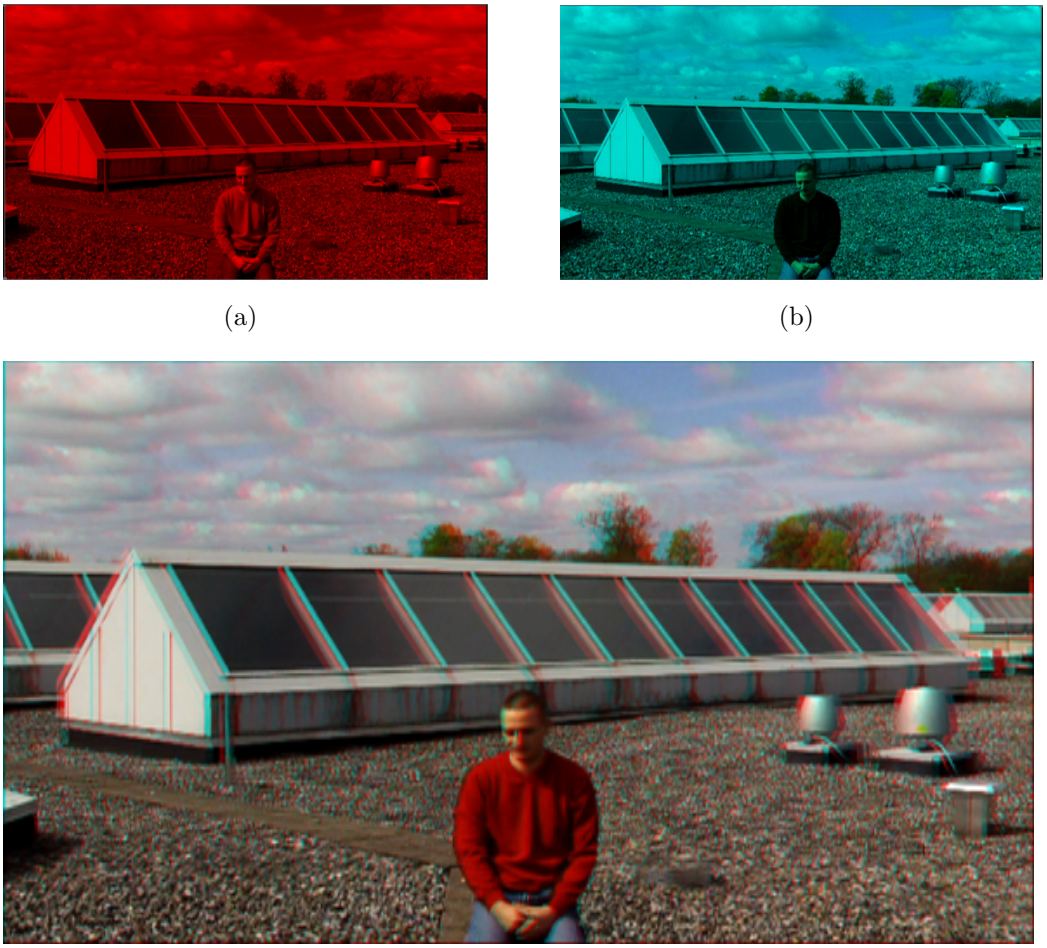
4.3.3 Editing

The syncing of the shots was achieved fairly quickly with the help of the clap method before each take. Many of the shots had to be taken in to Adobe After Effects to apply some of the required effects. They were namely all the shots containing the green screen. As mentioned in the previous section *Filming* the green screen shots needed a lot of extra work in post production. Due to the wind the green fabric moved a lot which created a lot off different shades which needed to be removed. This became a tedious process with a lot of frame by frame work in order to get an acceptable result.

The initial idea was to view this stereoscopic short with the use of shutter glasses but due to this not being possible we had to make it in anaglyph. This issue will be discussed more in section *Stereoscopic Projection* (4.3.5). If the short would have been viewed by use of shutter glasses a separate file would have been rendered out for the left eye and one for the right eye. But when viewed in anaglyph both the respective eyes images are superimposed on top of each other, see figure 4.10(c).

As the scenes which were done in After Affects were ready they were exported to Final

Cut Pro for final editing. Here both the left side and right side shot where placed above each other on the timeline ready to be superimposed. The left eye's image green and blue output values were taken down from the default 255 to zero leaving a red image, see figure 4.10(a). The opposite was done for the right eye's image, taking down the red output value down to zero leaving a cyan image, see figure 4.10(b). The left image was then screened on top of the right image creating a superimposed shot which can be viewed in 3D with red-cyan glasses, see figure 4.10(c).



(a) (b)

(c)

Figure 4.10: *Left image 4.10(a), right image 4.10(b) and the combined anaglyph shot 4.10(c)*
⋘□□⋙

The disparity between the two images can be seen in figure 4.10(c). When viewing the superimposed image without red-cyan glasses parts of the image can be seen in red and cyan which represents the disparity. The glasses have a red filter in front of the left eye

and a cyan filter in front of the right eye. Viewing figure 4.10(a) through the anaglyph glasses with the left eye will make the red color appear bright. If closing the left and and viewing it only through the right eye will on the other hand dim the image. The opposite will occur if viewing figure 4.10(b). This phenomena leads to each eye seeing a separate image when viewing anaglyph images. Note that cyan and red are opposite colors in the color wheel, see figure 4.11. Due to this their combined color is the very center of the color wheel - white. Therefore when viewing an anaglyph image without the glasses most of the image looks fairly normal with not that much discoloration.

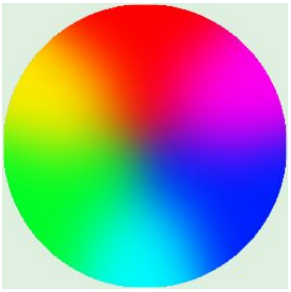


Figure 4.11: *The color wheel* [37]

For the experiment we needed to make a version in 3D for the short but as well one in 2D. For this only the left image was rendered out, due to better framing, as a clip without changes to the output levels. This created an identical clip in 2D.

4.3.4 Issues

There arose many issues with the first attempt of the short. This was due to many faulty framings while filming. Even though we knew that there are many differences when filming 3D comparing to when filming in 2D which had to be kept in mind, this knowledge somehow went forgotten during filming. We came across this issue after making all the green screen shots while composing the shots into 3D. Many shots were framed wrongly with cutting off parts of objects in the screen which made viewing it in 3D strange. If it had only been meant for 2D viewing they would have been working more than well. An example of such a shot can be seen in figure 4.12. Both the framing is bad and the composition of elements leading to the anaglyph picture not being able to interpret in 3D.

Figure 4.12: *Failed framing attempt* ⋘□□⋙

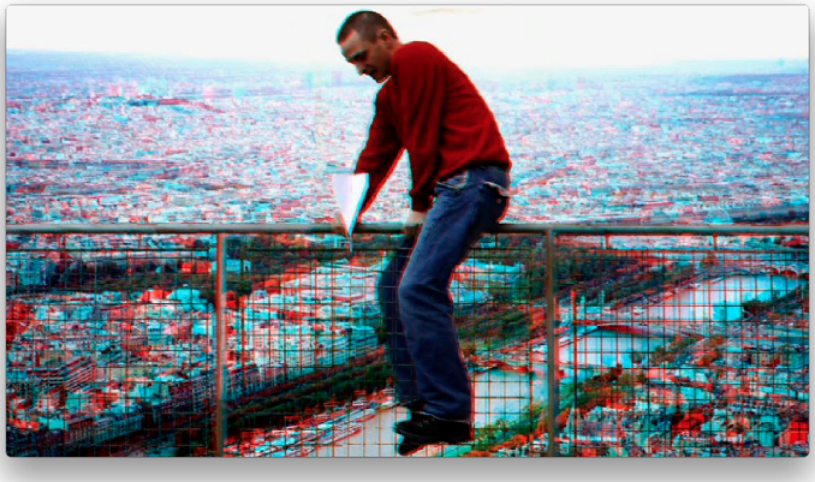
To solve this problem a new storyboard was created where framings were taken more in to consideration with 3D cinematography. The story was kept quite similar with the changes of instead of having the character writing a letter he was making a paper plane. This helped with not needing to have as tight framing of what he was doing. When writing a letter this often creates a curiosity in the viewer wanting to see what goes on. To satisfy the curiosity tight shots are made of the activity. Many of us has on the other hand made paper planes numerous times and this activity does not require close attention.

Another issue we had was that on the days which was intended for filming the scene extensions were very gray and rainy days. This meant that the matching of the shots were insufficient and the lighting conditions very bad. There was as well much uncertainty with if we would have been able to gain access to a high building and filming from an edge. Due to the time constraints another solution had to be found. Instead the scenario where the character stands on the edge was changed to on top of the Eiffel Tower. There was no particular reason for the Eiffel Tower other than it features a place high above ground level. Using images of the Eiffel Tower instead allowed for us to use images with matching color schemes. These images were distorted and made as if they had actually been filmed with a 3D camera setup. This was not the optimal solution but with the result it achieved it felt like it was the right decision rather then waiting for the weather conditions to change.

A third issue we accounted was something which would not have been a problem had the 3D short been viewed with shutter glasses. As mentioned in the previous section *Editing* when wearing red-cyan anaglyph glasses each of the filters eliminates the opposite color.

This became a problem for us when viewed in anaglyph as the main character is wearing a bright red sweater. Both cyan and red should be used to a minimum when viewing in anaglyph. It becomes hard for the brain to understand the object if one of these colors are used to a great extent. One eye tries to eliminate the object from its sight while the other eye sees it perfectly. Unfortunately it was too late for us to start from the beginning and film all the shots again with the main character wearing another sweater by the time we realized that it had to be viewed in anaglyph.

(a)



(b)

Figure 4.13: *Screenshots of the 2D 4.13(a) and 3D versions 4.13(b)* ⋘□□⋙

The final duration of the short is 1min 32s. It is rendered out in widescreen, has accompanied sound and contains color. These three elements were stated in the *Pre Analysis* as other elements which affects movies. Due to these three elements being completely identical in both the 2D and 3D version they will have the same effect in each condition. Above can be seen a figure showing a screenshot at the exact same duration from the 2D and respectively the 3D short (figure 4.13).

4.3.5 Stereoscopic Projection

The initial idea was to project the 3D short by the use of shutter glasses and a CRT computer screen. We were informed that our university had shutter glasses which we would have gained access to. Unfortunately by the time they were eventually found it came to our knowledge that they were not working properly and could not be fixed by time for the experiment testing. We therefore had to resolve to the use of anaglyph glasses. This is not an optimal solution for any kind of 3D viewing as much of the colors get lost and ghosting appearing.

If we had had the possibility to use the shutter glasses we would have used Stereoscopic Player offered by 3dtv.at. This player achieved really good results when testing out free demo clips in anaglyph which then could have been by the touch of a button changed to view with shutter glasses. Unfortunately the time spent on learning the program was not needed in the end.

The final setup for viewing the stereoscopic short is a laptop, or any other screen which can be fed with a movie file, with anaglyph glasses. When viewing in anaglyph there are no minimum requirements on update rates of the screen as an anaglyph can even be viewed on printed paper as a still image. The only requirement we had was that it was viewed as moving imagery which has the standard requirement of 24fps on a screen for the eyes to perceive it as a continuous image.

4.4 Testing

The following section will describe how we intend to test the experiment and what approaches will be utilized to gain test results.

4.4.1 Testing Methodology

Given the problem statement

> *How does the existence of stereoscopic depth in a scene including both great horizontal and vertical depth influence the audience's perception of the scene?*

the objective of the test is to find if there are any differences when viewing a scene in 2D or 3D. Therefore the intention is to unveil any difference at all in the test participants perception by means of evoking an emotional response.

As presented in the *Analysis* Plutchik considered there being eight primary emotions, namely; *anger, fear, sadness, disgust, surprise, anticipation, acceptance* and *joy.* [10, p.86]. Given the height induced scenario created as stimuli we are interested in finding if there is a emotional response connected to fear. The following table has been formed by inspiration from figure 3.2 on page 30. This is to represent what we believe will be the cognition of the stimulus created for the experiment.

Stimulus event	**Cognition**	**Feeling**	**Behavior**	**Function**
Threat by height ➔	Danger ➔	Fear ➔	Away from edge ➔	Protection

In the *Analysis* it was stated that our belief is that by introducing 3D in movies, making the scene more realistic, that a depicted height would be perceived larger and more dangerous than when viewed in 2D. From this statement and the above presented table the following hypothesis has been formed:

> *If stereoscopic depth is included in a scene of a movie where vertical space plays an important role, then the intended evoke of emotion, danger and fear, for that particular scene will be further induced than when viewing it in monoscopic. This will also trigger a protective instinct of wanting to stay away from the edge.*

4.4.2 Sampling Technique

3D in movies targets all regular movie goers. This target group is unfortunately a very wide variety of people for means of research. To narrow down a bit who this research will focus its experiment on is a target group with the age around 20-35. This population might have seen a wider variety of films than for example a child whose main interest may be animated movies. Younger people are also more adaptive to try different techniques and therefore older generations will be avoided to some extent.

Due to the target group containing a wide group of people, convenience sampling, also referred to as haphazard sampling, will be used. This means that participants will be obtained randomly where convenient [6, p.92]. In other words participants will be selected as they pass by instead of for example contacting specific participants from a list asking them to show up for the experiment. By doing this it has to be noted that no clear generalization can be made out of the answers but indications can be drawn. The advantage of this on a tight schedule is that there will not need to be decided a specific amount of participants on before hand, rather collect as many as possible until running out of time or it feels sufficient enough to analyze the data and acquire results.

4.4.3 Assignment Of Participants

There are two approaches to how the assignment of participants can be done. Either that the participants views only one of our conditions, independent group design, or that they view both of the conditions, which is called repeated measures design [6, p.114]. As the hope is to find if there are some changes in the perception when viewing one or the other condition, the repeated measure design approach will be taken on. When doing so the participant will first view one of the conditions, be measured and afterwards see the other condition. The participants will be measured twice on the dependent variable. By doing it this way it has to be noted that there will be a learning experience when showing both. When the participants view the second condition it has to be taken in account that they have already experienced it once on another condition and that they have that experience with them while undergoing the second one. The advantage of repeated measures are on the other hand that fewer experiment participants are needed as each participant undergoes both conditions [6, p.117]. This will come in good need when undergoing such an experiment like ours under time pressure.

To make up for the fact as the participants undergoes both conditions and gains an

experience in between counterbalancing will be taken in to account. Half the participants will see the 2D condition first while the second half will see the 3D condition first. By doing this it is also possible to determine to what extent the order of seeing them influence the results if needed [6, p.118].

To assign which condition a participant will see first it will be randomly chosen by flipping a coin or alike.

4.4.4 Instructions For Participants

The decision was made to have a written instructions for the participants in the beginning of the test. By this we make sure that the test participants get the same amount of information before participating in the experiment. As mentioned in the *Assignment Of Participants* half of the test participants will start up by viewing the 2D version and the other half the 3D version. The information given to the test participants should be kept minimal. Meaning that if the test participant is viewing the 3D version first, the only information he/she will be provided with are that they will be watching a clip in 3D by the use of anaglyph glasses. Before seeing the 3D short a small additional clip will be shown, for them to get accommodate to the viewing experiment. After the viewing of the 3D short a small questionnaire will be waiting for them to answer before watching the next short. If viewing the 2D version first the test participant will be informed that he/she is about to see a short clip, after seeing the clip a short questionnaire will be waiting for them to answer before seeing the next clip. So to summarize, the participants will not be aware of that the second clip to be viewed will not be the same but viewed with or without glasses. Making two different versions of the instruction and keeping the information minimal as possible will oblige the participant to focus on the given task and not think about the following task. The complete instruction sets can be found on the enclosed appendix.

4.4.5 Experiment Setup

A decision was made to not test on Mediaologist at Aalborg University in Copenhagen. Therefore the setup for the test experiment had to be well planned in order for the equipment used to be easily transportable. A laptop computer is to be used for displaying the clips and headphones to accompany the sound and minimize the distractions in the sense of sound. To obtain the stereoscopic effect a pair of red-cyan anaglyph glasses are to be used. Since the experiment has to be shown on a computer screen the parallax of the images

had to be designed accordingly. As we mentioned in section (3.3) the disparity between the two images and the screen size has the effect on how far the participants need to sit from the screen to be able to have a comfortable viewing experience. Due to the disparity in the stereoscopic short the optimal viewing distance when viewing the clip in full screen on a laptop screen is approximately 120 centimeters. The experiment setup can be seen in figure 4.14. This should be kept to an extent so the participants will undergo the same test conditions.

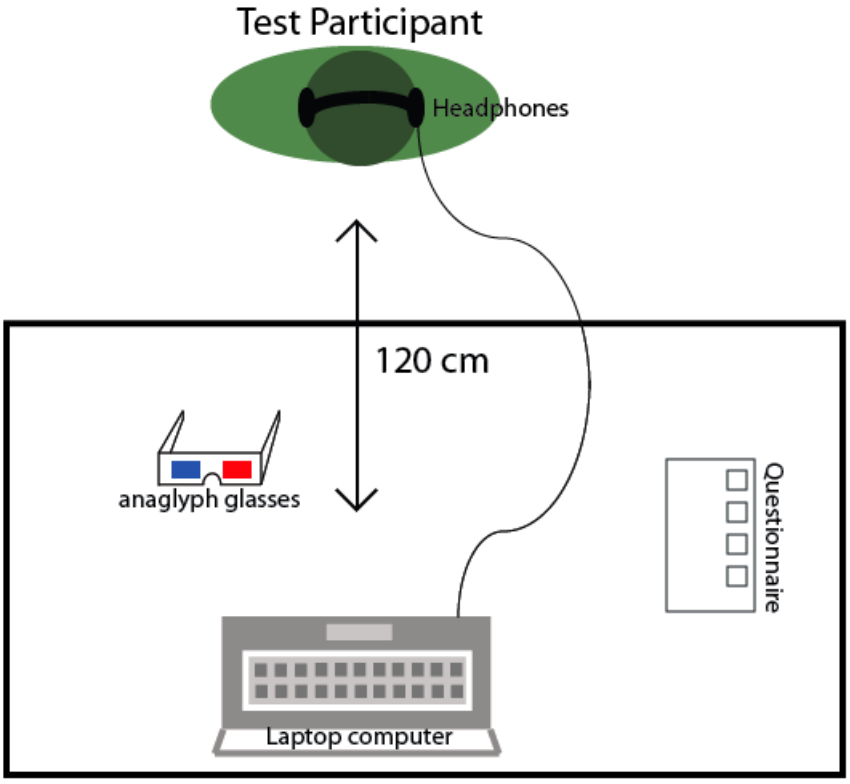


Figure 4.14: *The experiment setup*

4.4.6 Data Gathering

When gathering data it is important to keep in mind what the goal is for the testing, so when looking trough the data we can focus on what are the important informations to collect in order to answer our hypotheses. Before executing the actual experiment a pilot test is conducted. The reason for conducting a pilot test is to make sure that when the actual test is performed no complications that could have been avoided on before hand would occur. For example making sure that the equipment used is functioning and asking

the questions to a pilot test participants to clarify if the comprehension is right.

A consent form is made for the participants to sign, stating that they confirm that they understand the conditions of the experiment and they have accepted to participate in the experiment. This is done to make it clear for the participant the essential of the experiment.

In order to obtain data that is usable, it is important that the test participants has no knowledge about the goal of the experiment. The test participant is to shape their own opinions about the experiment and not be influenced by any informations. As mentioned in the section (4.4.2) by randomly obtaining test participants, we hope to gain a greater amount of test participants.

We have decided that a quantitative approach is needed in order to provide an answer for the posed hypothesis. A qualitative data could provide us with a better insight to how the participant perceived the depth. But due to the time it takes to analyze interviews with a phenomenological approach and creating transcripts we have decided that this information will be substantiated with qualitative data in a bigger sample instead. Some theorist even discuss that it can be hard to obtain someones subjective experience as it can be very hard for people to express what they feel [10, p.30]. Keeping this in mind an interview session was not used for the participants to give their subjective opinion about the experiment. Therefore the final decision lies on a quantitative approach containing a questionnaire which is designed according to the Likert scale to enable the participants to report their subjective feeling. We believe that this type of data gathering will be the most beneficial way of getting the response that we are seeking. The aim is to have a minimum of 20 participants for each condition.

Likert scales are generally used to measure a positive or a negative answer to a statement. The test participant is to choose from various options that correspond to his/hers opinion about a specific product [29, pp.113-116]. The likert scale is generally presented with 4-7 options which can vary for example from strongly agree to strongly disagree [5]. The figure 4.15 shows how the questions are to be presented in a five options likert scale.

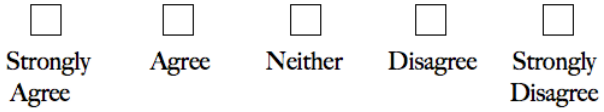


Figure 4.15: *Five point likert scale*

While the test participants conduct the experiment observations will be noted of how participants react throughout the experiment. This is mainly done for us to see if there is any verbal response from the test participants while viewing the shorts. Also any additional comments they state will be noted.

As described in the *Analysis*, we simulate an activity performed by someone else, either in real life or on screen, but do not actually activate the motor cortex. This could for example be someone grasping hold of a mug and drinking from it. We simulate this grasping to understand the action, but if we would activate the motor cortex as well it would imply that we actually would perform a grasping with our hand. But due to not activating the motor cortex when simulating a scenario, it is not possible to rely on bodily responses on a test participants when viewing a film. Therefore measurements like for example muscle activity will not be observed on the test participant.

In order to answer the hypothesis presented in *Testing Methodology* (4.4.1) four categories have been formed. These categories are based on topics touched upon in the *Analysis*. The aim is to seek findings within each category which could substantiate or falsify the hypothesis.

The first category formed is *Emotional Stimuli*. The aim of this category is to seek if an emotional response was evoked in the participants. It is important to seek an answer for this in both conditions as they can thereafter be compared to each other. In section (3.1.3) which can be found in the *Analysis* the hypothesis is that there will be a greater emotional response when viewing the 3D condition as the depth is depicted more realistically then in 2D. The following question for the questionnaire has been formed to seek this answer;

I felt a sensation of fear of height when I saw the edge

The second category formed is *Emotional Engagement*. This category is to help find if the story is concrete and the viewer is able to connect with the main character. If the story is to abstract it can be hard for the character to grasp the content and evoke an emotion with in the participant. The following question has been formed to investigate if there is any engagement between the participant and the on-screen character.

I felt scared for the character when he was hanging on the edge

The third category formed is *Simulation*. When watching movies we engage with it and become part of it. Not as an observer but simulating the same emotions as the character

on-screen. We need to understand if the test participant has simulated himself as standing on the edge and as such perceiving the depth cues given. To obtain this knowledge the following question will be asked.

I felt like it was very far down when he was standing on the edge

The last category formed is *Direct Comparison*. An answer for this category aims to give the test participant the task to intensionally make a direct subjective comparison between the two different measurement. The following question has been formed to get the comparison.

I felt it was a lot further down to the ground the second time I saw the clip

This question will only be asked after both conditions has been viewed to eliminate the participants of knowing that a comparison will take place.

In order to enable to categories different participants and look at explicit findings additional questions will be included in the questionnaire. The additional questions are;

- Age
- Gender
- Any visual impairments
- If the participant has seen a 3D movie in the theaters in the recent year
- Do they enjoy watching movies in 3D

All questions are phrased with the intention to minimize the test participants awareness of the objective of the experiment. The final questionnaire and its layout can be found in the enclosed appendix.

Initial testing

An initial test was conducted to make sure that the questions asked would be easily understandable. The exact same procedure that was planned for the actual experiment testing was used. The test was conducted on three participants. All of the participants understood the questions asked and had no complications during the initial testing. One thing was noted during the testing. The participants were asked to answer the general questions

before conducting the actual test. They started looking at the questions that were to be answered after viewing the clips. It was decided that during the actual experiment that the paper with the questions is to be folded so the general questions are the only questions see to the participant in the beginning of the experiment.

4.4.7 Data Analysis

The data obtained from the questionnaires will be gathered in to spreadsheets and represented both numerically and graphically. Viewing results which are graphically represented provides a quick overview of the collected data. Therefore two types of diagrams will be made; one displaying the frequency of answers in each question, and another displaying the mean values with their respective standard deviation. Results indicating a clear distinction between the two conditions will be further analyzed to find if they are statistically significant.

Chapter 5

Results

5.1 Test Procedure

The testing took place in two locations. The first location was The Black Diamond - The Royal Library and the second Tycho Brahe Planetariet, both located in central Copenhagen. The participant which took part in the experiment were comprised of 40 volunteers with a mean age of 26 years (26 males and 14 females). Before each participant started the actual experiment a brief introduction was given that they were partaking voluntarily in an anonymous experiment containing two shorts with their respective questions. A consent form was also asked to be signed before participating.

The two versions were both displayed on the same computer, a Macbook Pro 13',' in full screen with their native resolution of 1280x720, using Sennheiser HD 205 headphones for the sounds accompanying the clips. In order to view the anaglyph clip red-cyan anaglyph glasses were used. To eliminate reflections on the screen, as this can disturb the 3D effect, two poster-walls were placed around the test participant, see figure 5.1. The whole experiment took approximately 5 minutes per participant. All of the participants answered the questionnaire successfully.

It can be argued that this setup is not entirely optimal as it does not reflect a real life scenario of how a movie would be viewed. But due to this only being a short experiment it was deemed sufficient enough the obtain the results needed. The setup was placed in both locations away from the general activity and noise. The walls around the participant also gave more privacy during the testing.

Figure 5.1: *Experiment setup*

5.2 Results

In the following the results obtained from the experiment will be presented which was conducted in accordance with the methodology described in the previous chapter. The responses obtained is given as ordinal data but in order to calculate means it needs to be made in to a continuos scale. The following values has been given to the different levels of the Linkert scale; Strongly Agree (5), Agree (4), Neither (3), Disagree (2) and Strongly Disagree (1).

The complete data sets can be found in the appendix.

5.2.1 Emotional Stimuli

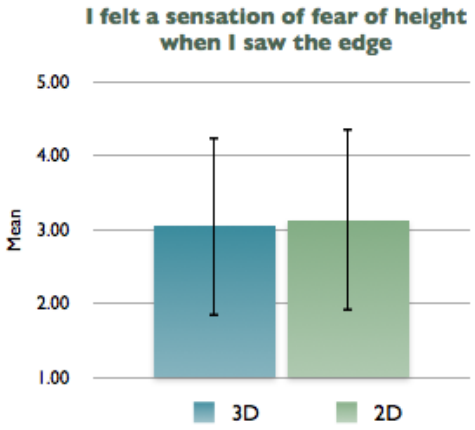
I felt a sensation of fear of height when I saw the edge

The results related to if the participant gained any emotional stimuli when viewing either of the two conditions, 2D or 3D, can be seen in figure 5.2.

Calculated Statistics

	3D	2D
Count (n)	40	40
Mean	3.05	3.13
Median	3.50	3.50
Standard deviation	1.22	1.24
Variance	1.48462	1.54808
Mode	4	4

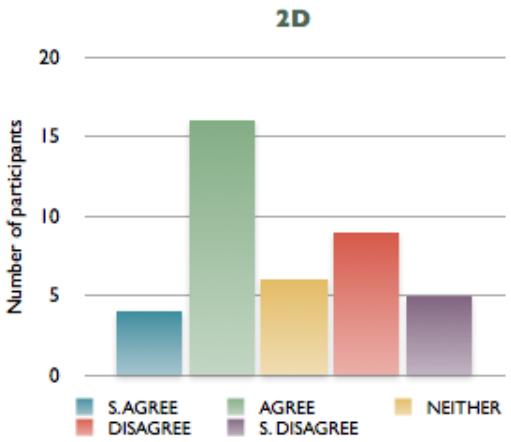
(a)



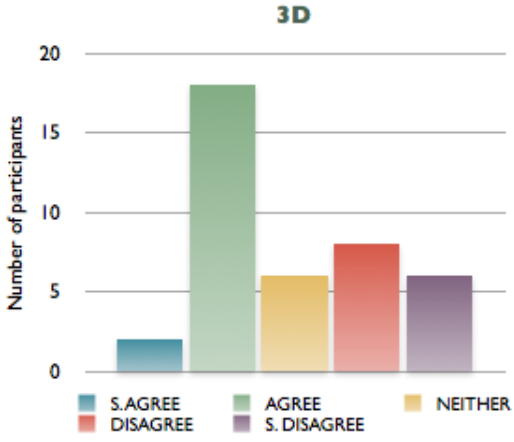
(b)

Figure 5.2: *Statistics obtained from the emotional stimuli question 5.2(a) and the mean for each condition 5.2(b). Error bars indicate ±1 standard deviation from the mean.*

The two group averages were almost identical as the mean for when watching the 3D condition was 3.05±1.22 and for when watching the 2D condition was 3.13±1.24.



(a)



(b)

Figure 5.3: *Emotional stimuli frequency for when viewing in 2D 5.3(a) and frequency for when viewing in 3D 5.3(b).*

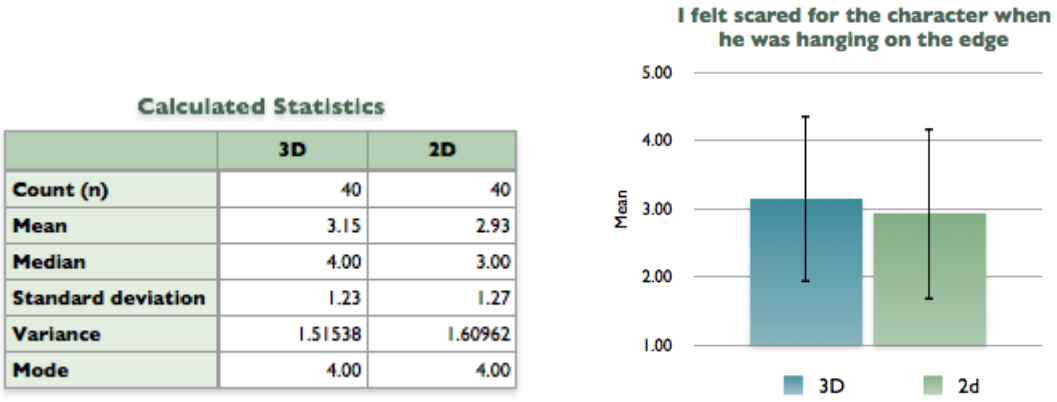
As shown in figure 5.3 the answers were very scattered along the Linkert scale but with the median for both conditions being 4.

5.2.2 Emotional Engagement

To determine if there was any emotional engagement between the participant and the character the following question was asked:

I felt scared for the character when he was hanging on the edge

The results obtained for the two conditions, 2D or 3D, can be seen in figure 5.4.



Calculated Statistics

	3D	2D
Count (n)	40	40
Mean	3.15	2.93
Median	4.00	3.00
Standard deviation	1.23	1.27
Variance	1.51538	1.60962
Mode	4.00	4.00

(a) (b)

Figure 5.4: *Emotional engagement statistics 5.4(a) and means 5.4(b). Error bars indicate ±1 standard deviation from the mean.*

The averages for both conditions were very similar with the mean for the 3D condition being 3.15±1.23 and for the 2D being 2.93±1.27. As can be seen on the standard deviation the answers were very scattered around but with both their mode being 4.

5.2.3 Simulation

I felt like it was very far down when he was standing on the edge

The results related to if the participant was able to simulate the scenario when viewing either of the two conditions, 2D or 3D, can be seen in figure 5.5 and figure 5.6. This question was only asked in the questionnaire after watching the first condition, therefore each condition has only got 20 participants each instead of a full set of 40.

Calculated Statistics

	2D
Count (n)	20
Mean	3.55
Median	4.00
Standard deviation	1.23
Variance	1.51538
Mode	4.00

(a)

Calculated Statistics

	3D
Count (n)	20
Mean	3.80
Median	4.00
Standard deviation	0.83
Variance	0.69474
Mode	4.00

(b)

Figure 5.5: *Simulation statistics for when viewing in 2D 5.5(a) and viewing in 3D 5.5(b).*

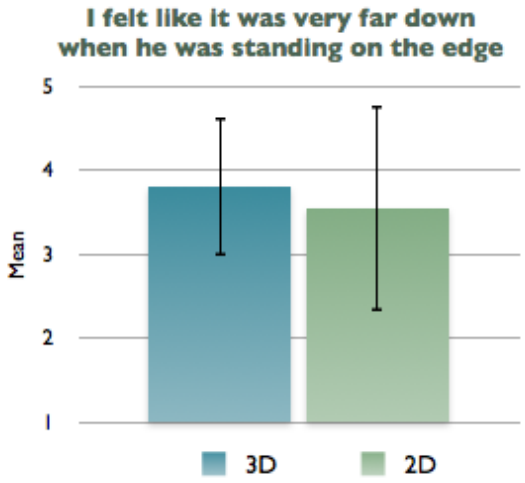
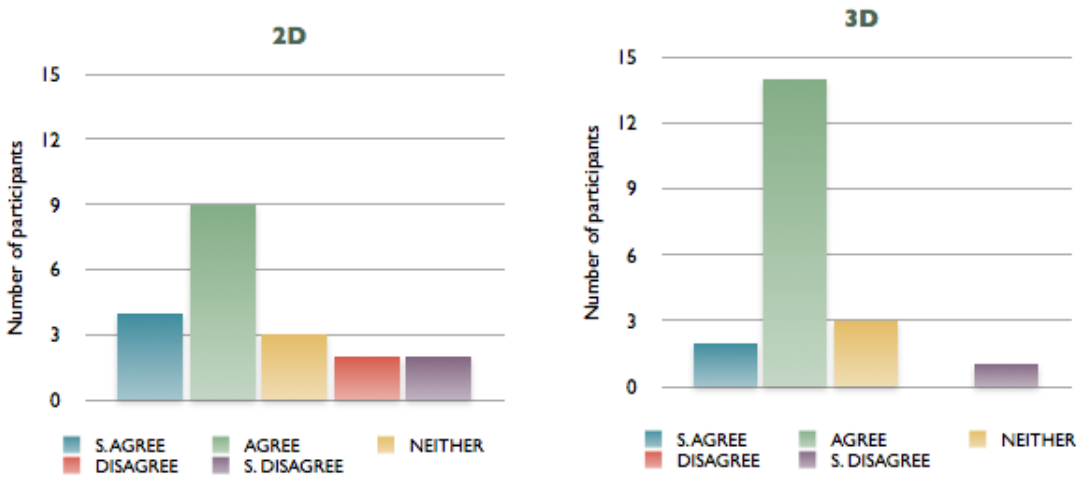


Figure 5.6: *Simulation mean. Error bars indicate ±1 standard deviation from the mean.*

The averages for both conditions were again very similar with the mean for the 2D condition being 3.55±1.23 and for the 3D being 3.80±0.83. Both conditions mode is 4.



(a) (b)

Figure 5.7: *Simulation frequencies for when viewing in 2D 5.7(a) and frequency for when viewing in 3D 5.7(b).*

5.2.4 Direct Comparison

I felt it was a lot further down to the ground the second time I saw the clip

The results related to a direct comparison between the to clips by the participant can be seen in figure 5.8 and figure 5.9. This question was only asked in the questionnaire after the participant had watched both conditions, therefore each condition has only got 20 participants each.

Calculated Statistics

	2D
Count (n)	20
Mean	2.75
Median	3.00
Standard deviation	1.21
Variance	1.46053
Mode	3.00

Calculated Statistics

	3D
Count (n)	20
Mean	3.35
Median	3.50
Standard deviation	1.39
Variance	1.92368
Mode	3.00

(a) (b)

Figure 5.8: *Direct comparison statistics for when viewing in 2D 5.8(a) and viewing in 3D 5.8(b).*

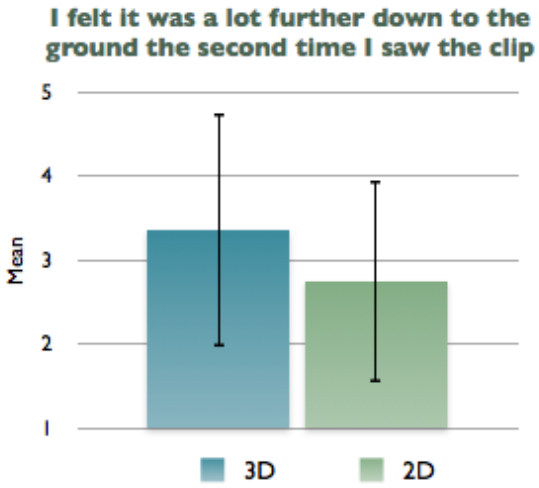


Figure 5.9: *Direct Comparison mean. Error bars indicate ±1 standard deviation from the mean.*

Again, both averages were relatively similar with the mean for the 2D condition being 2.75±1.21 and for the 3D being 3.35±1.39. Both conditions mode is 3.

5.2.5 Results Grouped - 3D Not A Distraction

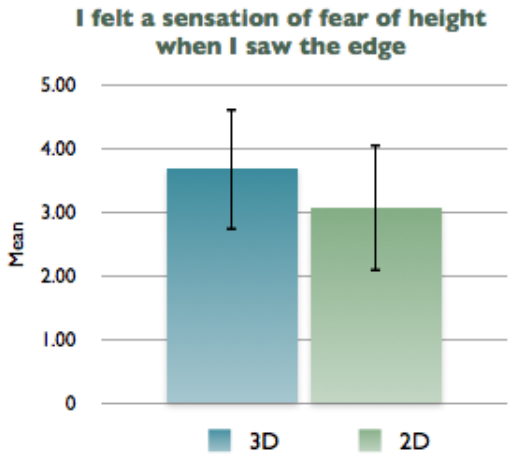
The question *I felt the 3D was distracting* was asked by each participant after viewing the 3D condition with the possibility of answering either *Yes*, *No* or *Don't know*. A large part of the participants felt that the 3D was distracting in one way or another. As the previous results presented did not yield any noticeable difference in averages it was decided to look exclusively at experiment participants who did not find 3D disturbing at all. It seemed reasonable to assume that those who found it distracting would not have been affected by the 3D in they way we intended.

Emotional Stimuli

Calculated Statistics

	3D	2D
Count (n)	18	18
Mean	3.67	3.06
Median	4.00	3.00
Standard deviation	0.97	1.00
Variance	0.94118	0.99673
Mode	4	4

(a)



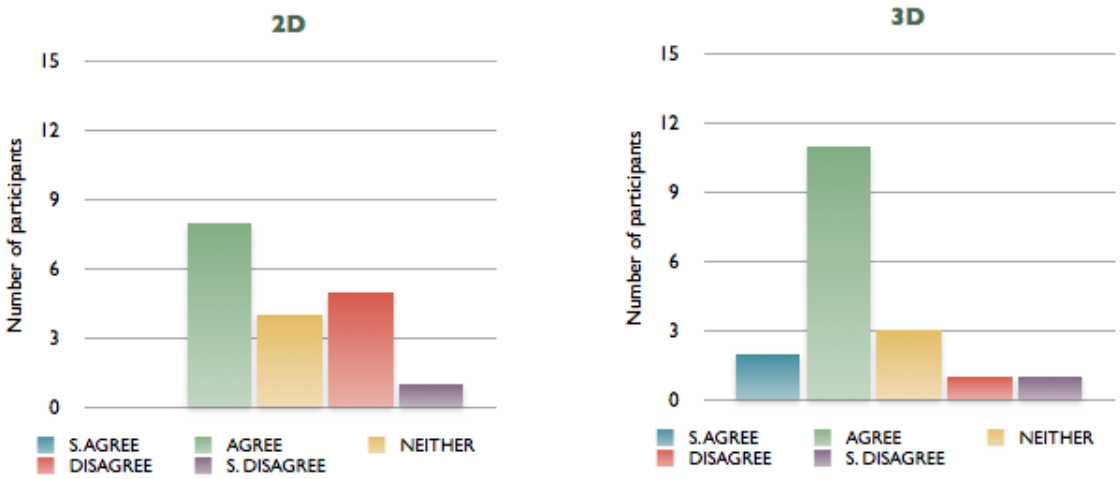
(b)

Figure 5.10: *Emotional stimuli statistics 5.10(a) and the mean for each condition 5.10(b). Error bars indicate ±1 standard deviation from the mean.*

The two group averages for those participants who did not feel the 3D was a distraction for when watching the 3D condition was 3.67±0.97 and for when watching the 2D condition was 3.06±1.00.

	3D	%	2D	%
S. AGREE	2	11	0	0
AGREE	11	61	8	44
NEITHER	3	17	4	22
DISAGREE	1	6	5	28
S. DISAGREE	1	6	1	5.6

(a)



(b) (c)

Figure 5.11: *Emotional stimuli frequency 5.11(a), when viewing in 2D 5.11(b) and frequency for when viewing in 3D 5.11(c).*

Those viewing the 3D condition 11 out of 20 agreed on feeling a sensation of fear of height, while those viewing the 2D condition had more variance in their answers.

Simulation

	3D	2D
Mean	3.90	3.63
Standard deviation	0.32	1.15

Figure 5.12: *Simulation mean when 3D was not distracting. Error bars indicate ±1 standard deviation from the mean.*

The mean for when watching the 3D condition was 3.90±0.32 and for when watching the 2D condition was 3.63±1.15.

Direct Comparison

Calculated Statistics

	2D
Count (n)	10
Mean	2.50
Median	2.50
Standard deviation	0.85
Variance	0.72222
Mode	3.00

(a)

Calculated Statistics

	3D
Count (n)	8
Mean	4.63
Median	5.00
Standard deviation	0.52
Variance	0.26786
Mode	5.00

(b)

Figure 5.13: *Direct comparison statistics for when viewing in 2D 5.13(a) and viewing in 3D 5.13(b).*

There is a clearer difference between the answers on the two conditions when only taken in to account those who did not find the 3D distracting. Those viewing the 3D conditions as the second measurement had a mean of 4.63±0.52 while those viewing the 2D conditions as second measurement having a mean of 2.50±0.85, see figure 5.14.

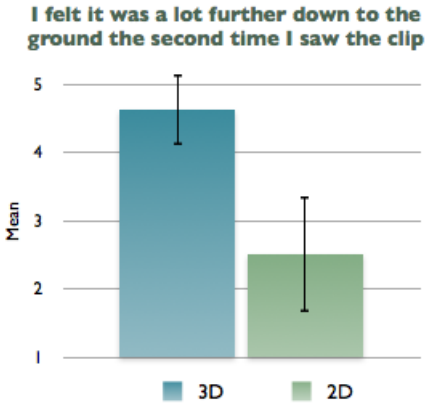
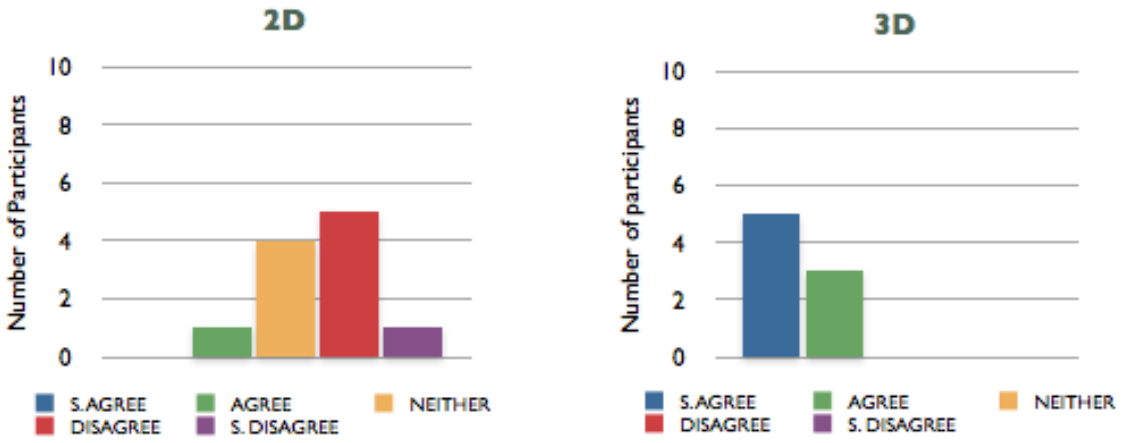


Figure 5.14: *Direct Comparison mean. Error bars indicate ±1 standard deviation from the mean.*



(a) (b)

Figure 5.15: *The direct comparison frequency for when viewing in 2D 5.15(a) and frequency for when viewing in 3D 5.15(b). while only explicitly looking at those participants who did not find 3D distracting.*

The frequencies are more divided between the two conditions with the 2D condition having a mode of 3 and the 3D condition a mode of 5.

Chapter 6

Discussion

This chapter will briefly start up discussing the over all project leading to the actual experiment. Thereafter the results gained from the experiment will be throughly gone through before concluded upon.

The entire aspiration for this project was based on investigating if there is a future for 3D in movies and if it can be used for more than just being a "wow-factor". Unfortunately there has been found no published previous research in this field and little knowledge on the topic was found. The *Analysis* therefore delved in to areas such as how we perceive movies and how they affect us. The hope was to get an understanding of how regular 2D movies affect the perception and find reasons for how the introduction of another dimension could affect the perception. A couple of beliefs arose like for example that a more realistic depiction would trigger stronger emotional responses. Cinematographic theories were also investigated as to help us how to design a good 3D short and what we need to be aware of not to create a distraction out of it. These thoughts and research was thereafter taken in to consideration when designing the experiment which would lead to answering our question. The hardest part during the design and implementation was to utilize the theoretical framework correctly presented in the analysis as we had never made a 3D movie before. Through some trial and error we finally achieved creating a short which was deemed sufficient enough for the experiment in question. This learning process proved to be both a revealing and rewarding experience.

Shifting focus to testing and what we gained out of the experiment. Four categories were created in order to answer the final problem statement. These were *Emotional Stimuli*, *Emotional Engagement*, *Simulation* and *Direct Comparison*. Each of these categories

will be discussed separately with their gained results.

The first category, *Emotional Stimuli*, aims to seek if there was an emotional response evoked within the participants. When only looking at the means of both groups they seem very identical, but due to the answers being broadly divided over the whole scale no conclusions can be made at all. In the analysis Grodal's argument was presented that emotions are directed outwards. There was not either any significant observations made that the participants would have felt an uncomfortable sensation of fear of height while watching either of the conditions. The reason for this could be that the story was too short to become entirely immersed in and therefore gave no great impact when the vertical space was introduced. The question "I felt a sensation of fear of height when I saw the edge" might also have been badly phrased. Perhaps asking the participant to compare their response to fear of height is a too far fetched reaction to be expected from them. The screen size might also have had an affected on the immersion. It is not a normal condition to watch a movie on a small screen while having someone observing you on the side. We feel that this might have had an impact on lack of immersion to the short presented to them.

In the category *Emotional Engagement* regarding if the participants was able to connect with the main character was again inconclusive. The answers were broadly divided spanning the whole range of levels on the Likert scale. This could again be due to what was discussed for the previous category, that the short did not allow the participant to become immersed enough to give the opportunity to emotionally connect with the main character. Though it is noteworthy to mention that none of the participants asked afterwards what actually happened in the story. It can be assumed that the story was not too abstract and each participant was able to make sense of the events.

The following category is *Simulation*. Again no conclusive results were given but it is interesting to see slight unanimous answers for the 3D condition. For the question "I felt like it was very far down when he was standing on the edge", out of 20 participant only one strongly disagreed and three answered neither. The remaining 16 participants either agreed or strongly agreed. This is nothing but a vague indication but it can be argued that those seeing the short with stereoscopic depth simulated the scenario better and therefore felt the vertical space better.

The last category, *Direct Comparison*, presented very vague indications that participants felt the 3D condition creating a bigger vertical depth. This question allowed partic-

ipants to directly compare the two conditions, but due to not everyone enjoying the 3D experience the answers might have been very affected by that. The reason for over half of the participants not enjoying the 3D could lie in the use of anaglyph. Anaglyph is not recommended for any type of projection as much of the color gets lost and ghosting occurring frequently. By using anaglyph it is also like jumping back half a century in technology. The fairly young target group is probably used to watching the recent 3D movies that are in theaters. These are namely Avatar, Monsters vs. Aliens, Up to name a few successful ones. These are viewed by the use of polarized glasses which ensure almost no ghosting, clean colors and a much more enjoyable experience. If one is used to this new technology it does not matter how good the anaglyph is made, it still will not meet the same standards. Therefore many chooses to rather watch a 2D movie than a 3D movie in anaglyph. If this argument is taken in to account it makes sense why so many did find the 3D distracting.

As half the participant found 3D distracting we chose to look at answers by those who did not find it distracting. There were clearer differences between the two conditions but still not enough to make anything conclusive.

For the Emotional Stimuli the means now vary in a larger degree. The ones watching the 3D condition are with 11 out of 18 stating they agree feeling a sensation of fear. For the 2D conditions 8 out of 18 agree while the rest answers are divided on neither, disagree or strongly disagree. The difference remains though so vague with still varying answers that no indications can be made.

For the Simulation even stronger results now show that those viewing the 3D condition agree on it feeling very far down as the character is standing on the edge. The results remain a bit more scattered for the 2D condition. The question “I felt it was a lot further down when he was standing on the edge” is though interpreted very subjectively by each participant. Some people that are generally scared of height can perceive a vertical drop very strongly when presented in a movie. While others who are more fearless to height do not get affected by such a scenario on screen. It is though interesting to see that almost everyone except one experienced it being far down in the 3D condition. This can be interpreted as a slight indication that better simulation occurs in a 3D scenario.

The most interesting results was found in the Direct Comparison when only those who did not find the 3D distracting was taken in account. There was a clear difference in the means between the two conditions. Those who saw the 3D conditions first and were asked

to compare it to the 2D answered with a mean of 2.50±0.85 which translates to their opinion lying somewhere between either and disagreeing. On the other hand those first seeing the 2D and then comparing it to the 3D condition answered with a mean of 4.63±0.52. This translates to them almost unanimously agreeing that it felt further to the ground when watching the short with stereoscopic depth. But is this difference enough to argue that 3D can be used as a storytelling element?

The reason for the results being so inconclusive overall can be as a result of many reasons. As already mentioned the anaglyph might have played a big role in the perception of the 3D short. As was presented in the issues of the implementation the short was not intended to be shown through anaglyph projection, rather by the use of the shutter glasses. The sweater of the main character is bright red which poses problems when viewed through red-cyan glasses. Be believe that this caused much of the distraction perceived in the participants. If this could have been avoided more consistent results might have been gained.

The choice for a quantitative approach might also have been the wrong choice. As emotions are very subjective it might have been better to perform a qualitative approach with interviews to get a better understanding of the participants perception in each of the conditions. As well when using a Likert scale with two adjacent levels one can never be sure that all participants perceive the difference between the two in the same way. This could have been one of the reason with so different answers.

Also through observation notes we got some noteworthy responses from participants. One participant proudly said that "I'm not scared in real life of heights so why should I be now?" This can be either that he simply does not get emotionally affected by content on screen due to him not fearing heights or that he perhaps did not want to admit getting an emotional response. Another participant said that "I got really scared when I saw him climbing over the fence". Movies are build up on suspense and it could be that the notion of him being at the top standing on the edge of a high vertical drop was enough to induce a fear response. The horizontal space already gave away that he was in a dangerous situation. The fact the character lands safely from such a normally fatal fall, might have led the participants believe to feel that the vertical distance was less than initially perceived. But due to findings from the direct comparison in the group of participants who did not feel 3D being a distraction feeling fairly unanimously that the distance was felt more, this can be argued against.

From the research made in the *Pre-analysis* and *Analysis* the following hypothesis was formed:

> *If stereoscopic depth is included in a scene of a movie where vertical space plays an important role, then the intended evoke of emotion, danger and fear, for that particular scene will be further induced that when viewing it in monoscopic. This will also trigger a protective instinct of wanting to stay away from the edge*

The experiment gave vague indications of the 3D condition being able to induce a protective instinct. Many of the participants got surprised over that the main character chose to walk over the fence. This shows that the participant simulated the scenario and triggered a protective instinct of not wanting to go over the fence themselves.

Furthermore there might be a difference in the overall results and we did not detect it, or there might not simply be a difference between the two conditions.

Chapter 7

Conclusion

A problem statement was formulated in the end of the *Pre-analysis*. The problem statement is the following:

> *How does the existence of stereoscopic depth in a scene including both great horizontal and vertical depth influence the audience's perception of the scene?*

Grodal's theories proved to be an invaluable source of information in the understanding of the perception of participants in the experiment. Unfortunately even though we had a brief understanding on how movies are perceived it is evident that sufficient results were not gained in order to draw conclusions.

A large part of the participants felt the 3D was distracting. We believe that therefore the overall results did not yield any noticeable difference. While looking at those participants who did not find 3D distracting we found a vague noticeable difference. There is a slight indication of change in perception of the perceived depth in the 2D compared to the 3D version.

We can not though conclude on if this change in perception is on a positive note as for future use as a storytelling element without causing distraction. In order to conclude this a less distracting projection than anaglyph would be needed.

We feel that over all the experiment we conducted was successful. But by the use of more participants or a qualitative approach some more clear indications might have arose.

As stated in the discussion the cinematographic theories were investigated to help us create the 3D short. During the development of the 3D short many complications occured. As Phil McNally said:

> *"One can teach the whole theory of stereoscopy in two hours. You can learn all about 3D moviemaking in two months. That will never give you the 10 years of experience needed to master it [...]"* [21, p.35]

We found this statement to be very true. If we have had some previous experience with creating 3D movies some of the complications of the experiment development could have been avoided. We believe that many of the participant felt that the 3D conditions was a distraction due to the usage of anaglyph. But on a personal level all the trial and error was a good learning experience which we hope to be able to use in our future adventures.

Chapter 8

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Chapter 9

Glossary

Acrophobia A person that has an extreme fear of height [15].

Anaglyph Procedure where complementary-colored filters are used over left and right lenses of the projectors to superimpose both images on one screen. The audience thereafter wears glasses with the same complementary colors to separate the superimposed image for each eye [33].

Convergence The action performed when a person adjusts his/hers eyes on a horizontal plane. This can be tested by placing a finger in front of your face and moving it back and forward [33].

Disparity The distance between a point's position on the two eye's retina [33].

Eclipse system Also referred to as a shutter system. As the left projectors shutter is opened so is the left shutter of the glasses opened, and continues to alternate between left and right [33].

Fusion The action happening when the eye combines the two 2D images into one 3D image [21, p.22].

Interocular distance This is referred to as the distance measured between center of the two cameras lenses in a 3D camera setup [33].

Interpupillary distance The distance between peoples right and left eye [33].

Median The midpoint of a range of values or frequencies [15].

Mode The value that occurs most frequently [15].

Monoscopic Depth Only one eye is required to obtain the depth [19, p.164].

Occlusion When an object covers another. The object being occluded seems to be further away [19, p.165].

Orthostereoscopy When a 3D image is said to be orthostereoscopic it is perfectly replicated by the human vision [21, p.78].

Parallax The distance between the right and left image on the screen [21, p.15].

Polarized light Neutral grey filters placed in front of the projector lens. These filters orient the light waveforms from the projector [21, p.172].

Rotoscoping The effect of cutting out parts of an image [15].

Short A name used for a short movie [15].

Silver screen A highly reflective screen used for the passive stereoscopic projection [33].

Stereoscopic Depth Binocular vision with which we perceive the world around us three dimensionally [21, p.17].

Stereoscopic comfort zone The range of parallax that is sufficient enough for the viewer to have an comfortable viewing experience [14].

Stereoscopic window This is the space that defines the area 3D is displayed in [21, p.97].

Stereoscopic window violation When items are placed wrongly within the volume of the stereoscopic window [21, p.97].

Technicolor A technique combines two colors to create other hues, which results in green-blueish and pink tones [2, pp.458-459].

Talkies Short for movies with synchronized dialogue [15].

2D, Two dimensional 2D is an object that has no depth, meaning that it only has two dimensions, which are width and height [33].

3D, Three dimensional 3D is an object that has a total of three dimensions, which are width, height and depth [33].

Chapter 10

Additional Appendix

10.1 Script

1. Character sitting on the edge of a building. 5-6 sec.
   Front view, close-up shot of his face. Character showing NO emotions.

2. Character sitting on the edge of a building. 5-6 sec.
   Front view. Medium close-up, from face to his lap. Showing that the character is writing a letter.

3. Character sitting on the edge of a building. 3-4 sec.
   Back view. Wide shot, revealing that the character is sitting on the top of a building.

4. Character standing up. 5-6 sec.
   Back view. Wide shot, showing the character standing up by the edge of the building.

5. Character standing. 3-4 sec.
   Side view. Wide shot, showing character looking at the letter, holding it in his hands.

6. Letter in hand. 3-4 sec.
   Side view/ Front view. Close-up. Showing the letter in the characters hand.

7. Letter in hand. 2-3 sec.
   Side view/ Front view. Close-up. Letter being blown out of the characters hand by the wind.

8. Reaching. 3-4 sec.
   Side view/ Front view. Medium close-up. The character reaching for the letter.

9. Feet. 1/2 sec.
   Side view / Front view. close-up. The characters foot slip from the edge.

10. Wall. 1-2 sec.
    Side view / Front view. close-up. The wall that the character slips from.

11. Hands. 1/2 sec.
    Side view / Front view. Medium close-up. The character grabs on to the wall falling down.

12. Letter. 3-4 sec.
    Back view. Wide shot. The letter flying in the air.

13. Letter. 2-3 sec.
    Front view. Close-up. The character falling and grabbing the letter, seeing only the hand.

14. Falling. 2-3 sec.
    Front view. Wide shot. Character falling down.

15. Landing. 4-5 sec.
    Front view. Wide shot. Character lands on the ground and walks away. Maybe panning up.

10.2 Second Script

1. Character sitting on the top of a building. 5-6 sec.
   Front view. Wide shot. Panning. Character showing NO emotions.

2. Character sitting on the top of a building. 5-6 sec.
   Front view. Medium close-up, from face to his lap. Showing that the character is looking down.

3. Character sitting making a paper plain. 4-5 sec.
   Top view. Wide shot, revealing what the character is doing.

4. Character standing up. 1-2 sec.
   Top view. Wide shot, showing the character standing and walking away.

5. Character walking. 3-4 sec.
   Back view. Wide shot, showing character walking away.

6. Stares. 2-3 sec.
   Back view. Medium close-up to Wide shot. Showing the character walking down stares.

7. Tower leg. 1-2 sec.
   Front view. Close-up. Walking towards the entrance.

8. Elevator. 3-4 sec.
   Front view. Medium close-up. The character getting in to the elevator.

9. Elevator. 2-3 sec.
   Front view. Medium close-up. The characters coming out of the elevator.

10. Fence. 5-6 sec.
    Back view. Wide shot. The character climbing over a fence.

11. Feed. 1-2 sec.
    Down view. Medium close-up. The character feed standing on the edge.

12. paper plain. 3-4 sec.
    Back view. Wide shot. The character trowing the paper plain.

13. Slip. 1/2 sec.
    Down view. medium close-up. The character feed slip from the edge.

14. Hanging. 2-3 sec.
    Down view. Wide shot. Character hanging on the edge.

15. paper plain. 4-5 sec.
    Front view. Wide shot. Paper plain flying in the air.

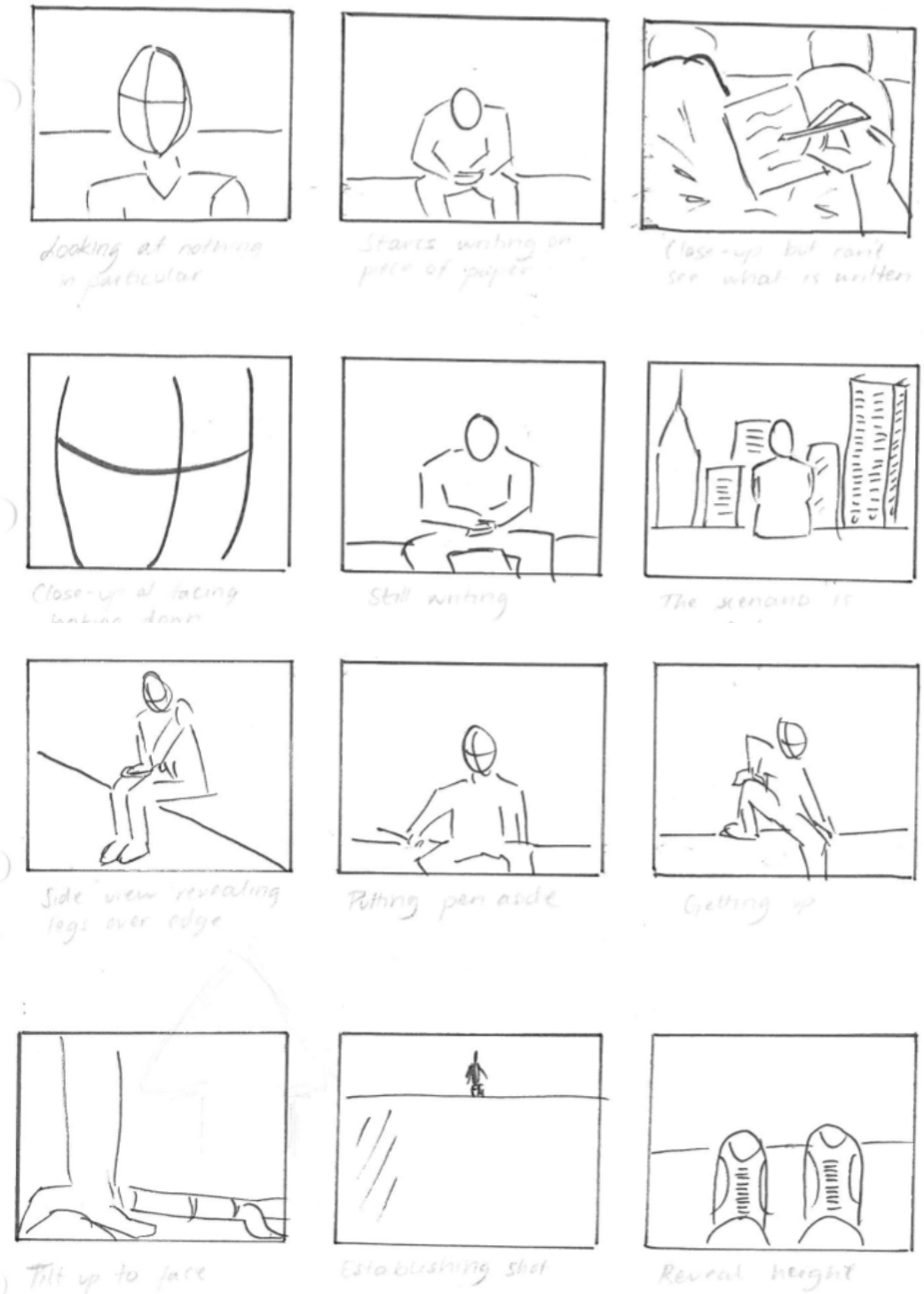
16. Falling. 1/2 - 1 sec.
    Down view. Wide shot. Character falling down.

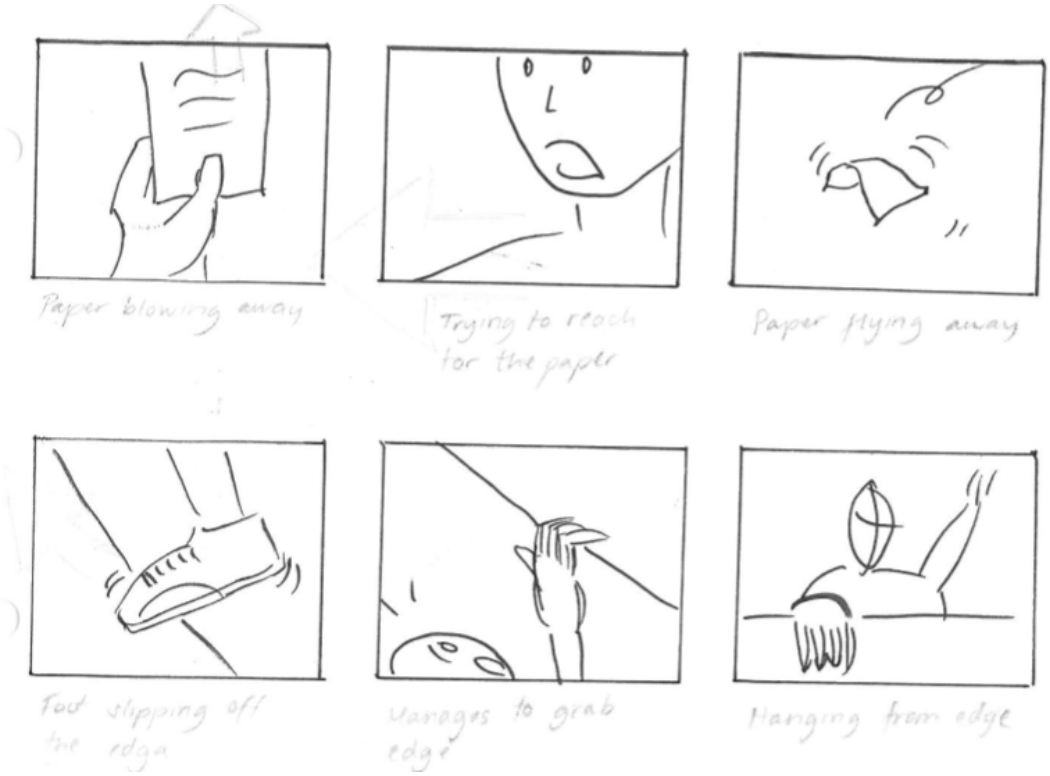
17. Plain landing. 2-3 sec.
    Front view. Wide shot. Paper plain lands on the ground.

18. Landing. 3-4 sec.
    Front view. Close-up. Character lands on the ground after falling.

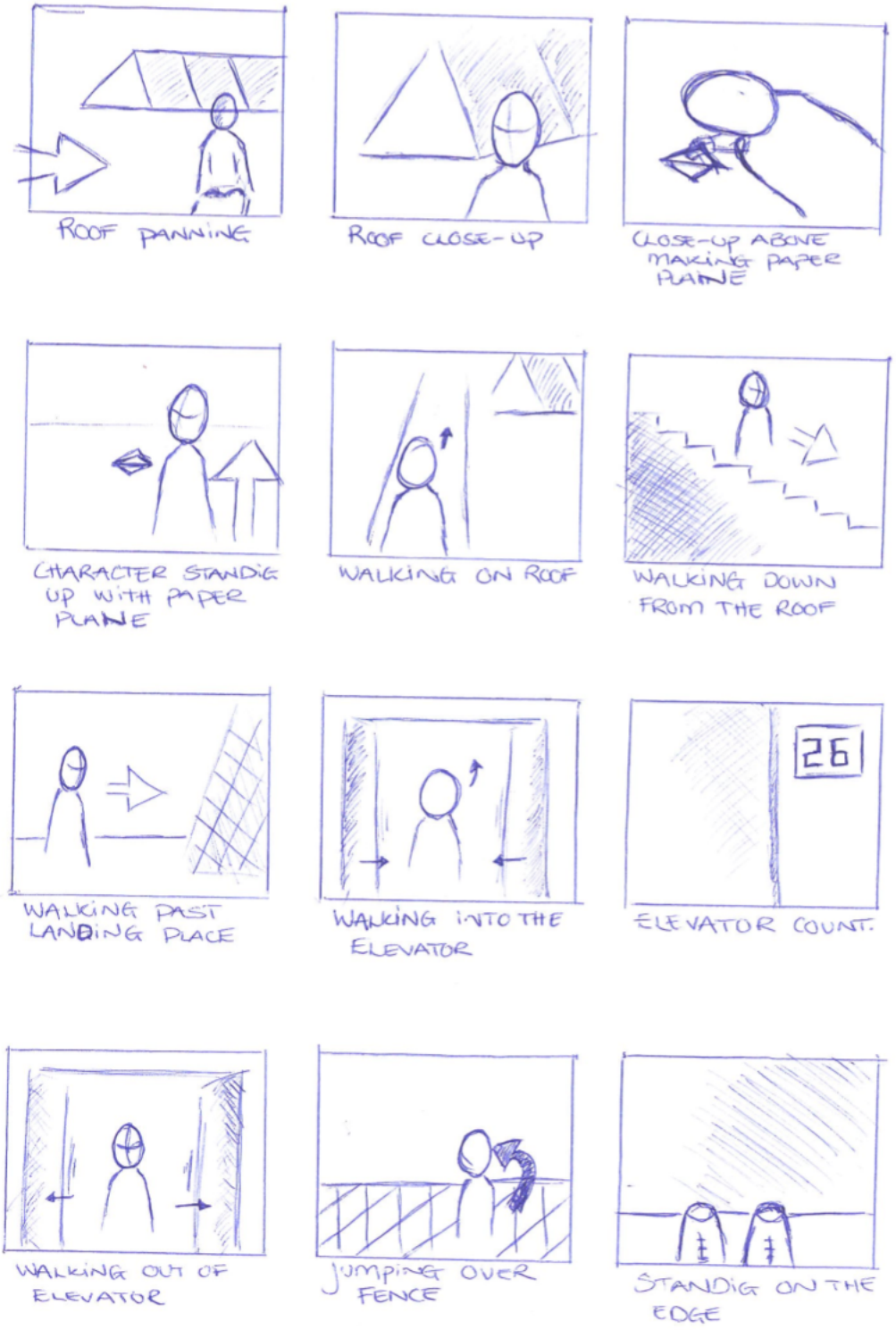
19. Walk. 2-3 sec.
    Front view. Close-up. Character picks up the paper plain and walks away.

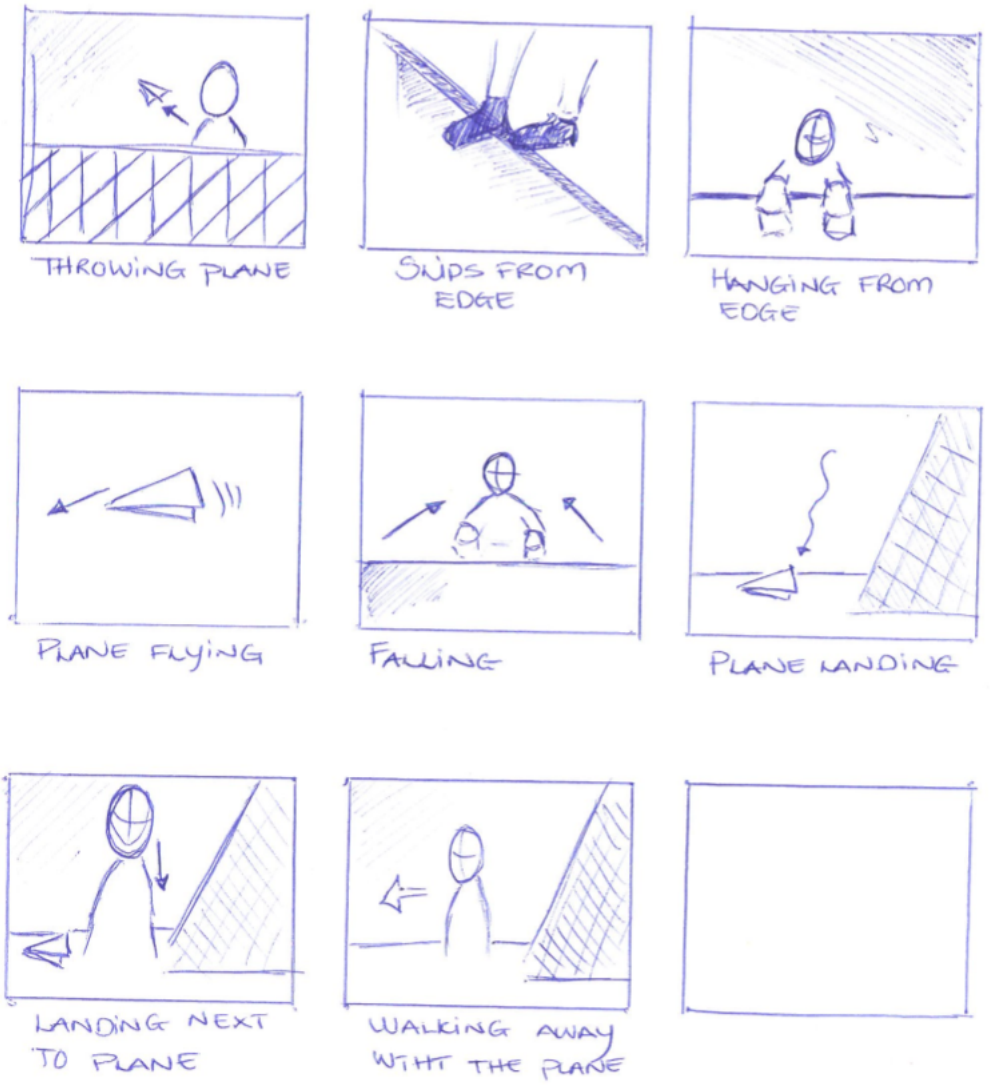
10.3 First Storyboard




Paper blowing away
Trying to reach for the paper
Paper flying away
Foot slipping off the edge
Manages to grab edge
Hanging from edge

10.4 Second Storyboard




THROWING PLANE
SLIPS FROM EDGE
HANGING FROM EDGE
PLANE FLYING
FALLING
PLANE LANDING
LANDING NEXT TO PLANE
WALKING AWAY WITH THE PLANE

10.5 Questionnaires

Instructions Here is the information that was handed to the participants to read before conduction the experiment.

Thank you for taking time participating in this experiment.

We will ask you to watch two separate clips. After each clip there will be a few questions for you to answer. The experiment will not take more than 10 min all together.

If viewing 3D clip first:

You will be watching a clip in 3D by the use of anaglyph glasses. We will ask you to first watch a clip which has got nothing to do with the actual experiment. This clip is for you to get comfortable with wearing the anaglyph glasses. When you feel comfortable viewing the clip we will show you the actual experiment clip. Afterwards you will be asked to answer a few questions before watching the second clip.

You will now watch a clip which will take around 1 min as well. Thereafter you will be asked to answer a few more questions before the experiment is finished. There will be no need to wear glasses for this clip.

Thank you for your participation!

If viewing 2D clip first:

You will firstly watch a clip which will take around 1 min. Thereafter you will be asked to answer a few questions before watching the second clip.

You will be now watching a clip in 3D by the use of anaglyph glasses. We will ask you to first watch a clip which has got nothing to do with the actual experiment. This clip is for you to get comfortable with wearing the anaglyph glasses. When you feel comfortable viewing the clip we will show you the actual experiment clip. Afterwards you will be asked to answer a few questions before the experiment is finished.

Thank you for your participation!

Questionnaire Here are the general questions participants where asked to answer before conduction the experiment.

Experiment Questionnaire

2 ☐ 3 ☐

Age: **Gender:** **Male** ☐ **Female** ☐

Do you have any visual impairments? If yes, please answer the following:

I need to wear glasses ☐ I am colorblind ☐

Other _____

Have you seen a 3D movie in the theaters in the last year?

Yes ☐ No ☐

If yes, do you enjoy watching movies in 3D?

Yes ☐ No ☐ Don't know ☐

Circle around the number that closes represents how you feel right now

Stressed 1 2 3 4 5 Relaxed

Questionnaire Here is the questionnaire for the test participants that saw the 2D condition first. The first part is the question after seeing the 2D version.

Experiment Questions

Please check the box you feel represents your opinion the best:

I felt a sensation of fear of height when I saw the edge

☐	☐	☐	☐	☐
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

I felt scared for the character when he was hanging on the edge

☐	☐	☐	☐	☐
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

I felt like it was very far down when he was standing on the edge

☐	☐	☐	☐	☐
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

Additional comments:

Questionnaire The second part is the question after seeing the 3D version.

Experiment Questionnaire

2 ☐ 3 ☐

Additional Experiment Questions

Please check the box you feel represents your opinion the best:

I felt a sensation of fear of height when I saw the edge

☐ Strongly Agree ☐ Agree ☐ Neither ☐ Disagree ☐ Strongly Disagree

I felt scared for the character when he was hanging on the edge

☐ Strongly Agree ☐ Agree ☐ Neither ☐ Disagree ☐ Strongly Disagree

I felt it was a lot further down to the ground the second time I saw the clip

☐ Strongly Agree ☐ Agree ☐ Neither ☐ Disagree ☐ Strongly Disagree

I felt that the 3D was a distraction

Yes ☐ No ☐ Don't know ☐

Additional comments:

QuestionnaireHere is the questionnaire for the test participants that saw the 3D condition first. The first part is the question after seeing the 3D version.

Experiment Questions

Please check the box you feel represents your opinion the best:

Additional comments:

I felt a sensation of fear of height when I saw the edge

☐ Strongly Agree ☐ Agree ☐ Neither ☐ Disagree ☐ Strongly Disagree

I felt scared for the character when he was hanging on the edge

☐ Strongly Agree ☐ Agree ☐ Neither ☐ Disagree ☐ Strongly Disagree

I felt like it was very far down when he was standing on the edge

☐ Strongly Agree ☐ Agree ☐ Neither ☐ Disagree ☐ Strongly Disagree

I felt that the 3D was a distraction

Yes ☐ No ☐ Don't know ☐

Questionnaire The second part is the question after seeing the 2D version.

Experiment Questionnaire

2 ☐ 3 ☐

Additional Experiment Questions

Please check the box you feel represents your opinion the best:

I felt a sensation of fear of height when I saw the edge

☐	☐	☐	☐	☐
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

I felt scared for the character when he was hanging on the edge

☐	☐	☐	☐	☐
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

I felt it was a lot further down to the ground the second time I saw the clip

☐	☐	☐	☐	☐
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

Additional comments:

10.6 Test Results

Question: I felt a sensation of fear of height when I saw the edge

I felt sensation of fear of height when I saw the edge

PARTICIPANT #	3D	2D	GENDER	AGE	3D A DISTRACTION	COMMENTS
1	1	1	M	27	N	
2	3	2	M	21	?	
3	1	1	M		Y	
4	4	4	F		N	
5	4	4	F	25	N	
6	4	2	F	22	N	
7	2	4	M	32	Y	
8	4	2	F	26	N	
9	4	3	M	27	?	
10	4	4	M	39	N	Hard time seeing the 3D second half
11	2	4	M	26	?	Felt it when he crawled over the fence. Easier to focus on the ind. elements
12	4	4	F	27	N	
13	4	4	F	25	N	
14	3	4	M	28	Y	
15	2	2	M	25	?	My answer perhaps affected by seeing it twice
16	4	4	M	22	Y	
17	4	3	F		N	
18	1	4	F	22	?	
19	4	5	F	25	Y	Was a bit blurry the 3D
20	4	2	F	20	N	
21	4	4	M	31	?	A little distraction with 3D
22	4	3	F	27	N	
23	3	2	M	19	?	
24	3	3	M	27	N	
25	4	3			Y	
26	3	3	M	27	N	
27	5	4	F	26	N	
28	3	2	M	21	N	
29	1	5	M	20	?	
30	4	5	M	27	Y	
31	4	4	M	24	N	
32	2	1	M	23	?	
33	2	2	M	26	N	
34	1	1	M	26	Y	"I'm never scared of height so why should I have been now"
35	2	5	F	25	Y	Knew what was happening the second time so didn't feel gg fear then
36	2	2	M	30	Y	
37	5	4	F	21	N	
38	4	4	M	26	Y	
39	2	4	M	24	Y	Had a hard time viewing the 3D when the depth became extreme
40	1	1	M	32	?	
Average	**3.05**	**3.13**		**25.58**		**±**

Question: I felt scared for the character when he was standing on the edge

I felt scared for the character when he was hanging on the edge

PARTICIPANT #	3D	2D
1	1	1
2	3	2
3	1	1
4	5	3
5	4	4
6	2	4
7	4	3
8	3	4
9	3	3
10	4	4
11	2	2
12	4	3
13	2	2
14	4	4
15	4	2
16	4	3
17	4	2
18	4	4
19	3	5
20	2	2
21	4	2
22	4	4
23	1	1
24	4	2
25	4	4
26	5	4
27	5	4
28	4	3
29	1	1
30	4	4
31	3	3
32	2	1
33	3	2
34	1	1
35	3	5
36	4	5
37	4	4
38	4	4
39	2	4
40	1	1
Average	3.15	2.93

Question: I felt like it was very far down when he was standing on the edge

I felt like it was very far down when he was standing on the edge- I

PARTICIPANT #	2D
1	4
2	4
3	4
4	2
5	5
6	3
7	4
8	4
9	4
10	5
11	4
12	1
13	3
14	1
15	5
16	2
17	5
18	4
19	4
20	3
Average	3.55

Calculated Statistics

	2D
Count (n)	20
Mean	3.55
Median	4.00
Standard deviation	1.23
Variance	1.51538
Mode	4.00

(a)

I felt like it was very far down when he was standing on the edge

PARTICIPANT #	3D
1	4
2	4
3	1
4	4
5	4
6	4
7	4
8	4
9	4
10	4
11	4
12	4
13	4
14	4
15	5
16	3
17	4
18	3
19	5
20	3
Average	3.80

Calculated Statistics

	3D
Count (n)	20
Mean	3.80
Median	4.00
Standard deviation	0.83
Variance	0.69474
Mode	4.00

(b)

Question: I felt like it was a lot further down to the ground the second time I saw the clip

I felt it was a lot further down to the ground the second time a saw the clip, 2D

PARTICIPANT #	2D
1	1
2	1
3	1
4	3
5	3
6	3
7	3
8	3
9	3
10	2
11	5
12	2
13	2
14	4
15	2
16	2
17	2
18	4
19	5
20	4
Average	2.75

Calculated Statistics

	2D
Count (n)	20
Mean	2.75
Median	3.00
Standard deviation	1.21
Variance	1.46053
Mode	3.00

(c)

I felt it was a lot further down to the ground the second time a saw the clip, 3D

PARTICIPANT #	3D
1	3
2	5
3	3
4	5
5	3
6	5
7	5
8	4
9	1
10	2
11	4
12	4
13	4
14	1
15	3
16	1
17	5
18	3
19	2
20	4
Average	3.35

Calculated Statistics

	3D
Count (n)	20
Mean	3.35
Median	3.50
Standard deviation	1.39
Variance	1.92368
Mode	3.00

(d)

Overall quotes from test participants during experiment

"I'm not scared in real life of heights so why should I be now?"

"I couldn't see the extreme depths."

"Wow! Did you really make this? It was really cool."

"I got really scared when I saw him climbing over the fence."

"I wasn't able to connect with the character."

"The second half of the 3D was really blurry for me."

"The first clip with the birds was a lot harder to see than the real clip"