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Abstract:
The following project was finished at Aalborg University Copenhagen during the 10th semester of Medialogy. Although VFX Studios work with limited production budgets their clients' expectations of quality and appearance keeps rising. This thesis researches workflow optimisation possibilities within the VFX production pipeline. By utilising how human perceive and store information in memory to achieve acceptance of hyperrealistic VFX, the Expectation & Belief Model was synthesized. An advertisement was selected as the foundation for the testing. The results were based upon the conduction of two preliminary tests as proof of content and six main tests to determine how people perceive and accept hyperrealistic and non-hyperrealistic VFX. The main tests showed that people are less critical towards hyperrealistic simulations and consequently accept the representations despite a low definition. However, the exposure of non-hyperrealistic simulations resulted in a far more critical response. The conclusion suggests the optimisation of VFX productions by using 200 voxel definition for the creation of hyperrealistic simulations, which reduces the turnaround time 22minutes each iteration, compared to a voxel definition of 300.

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Preface

This report was written at Aalborg University Copenhagen Denmark as a result of the work done by a group attending the 10th semester of Medialogy.

Readers Guide

While considering the content of this project the need to guide the reader through the process is essential. To enhance the understanding of the presented, three improvements were implemented throughout this report. Firstly, all major key terms are styled with a dark grey box and white text. i.e.

> **Thesis Definition: Example**
>
> This is an example definition.

These boxes should not be considered a general terms, but terms defined within this thesis. Therefore some definitions may differentiate from the general understanding of that particular term. This was created to highlight the most important terms and consequently their correspondent decisions.

Secondly, a road map including all the major decisions throughout this project is available at the back of the report. This is designed to create an overview for the reader. The road map can be used to follow the process of the thesis through all the stages of the report.

Finally, the very first chapter of this thesis will not be the traditional motivation, but a summary of a previous research created by the authors. This project called *Zero Detection* is much related and will be presented as foregoing analysis and thereby suits a proper introduction within the current research.

Citation

This report uses ISO 690 with numerical references when citing works, as this is the standard in bibliographic referencing. The square brackets following a citation or written text i.e. [64] refers to a source used for that particular chapter. The number denotes its place in the report and also its location in the Bibliography chart.

The Bibliography chart also follows the design and rules laid forth in the ISO 690 standard, namely the layout referencing of published material in both its print and non print-form. The following is an example of the layout of a book reference:

Numerical Reference]. [**Author's Last Name**]**,** [**Author's First Name**]. [Title]. [Translator] [Editor]. [Edition]. [City] : [Publisher], [Year]. [Volume] [ISBN/ISSN Number].

Example:

[28]. **Bridson, Robert.** *Fluid Simulation.* 1st. Wellesley : A K Peters, 2008. 978-1568813264.

DVD

Following this report is a DVD located at the back of the report containing the digital equivalent of the references except books and this report. Lastly five versions of the advertisement with VFX implementations and a sixth version being the advertisement in its original form are included.

Recognition

The authors would like to extend their recognition to the work of Stefania Serafin, both as supervisor in this thesis, but also as representatives of the Medialogy study.

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1 Zero Detection Summary

The following chapter will recap a project completed in spring 2010 which serves both as inspiration and foundation of the following research. In the 8th semester a group of four members conducted a research which focused on the change of resolution of Computer Generated Imagery (CGI) added to a short film. The outcome of the research confirmed that it is possible to save budget when considering the resolution of CGI in film. It opened up the potential for future research by proving a low detection rate of low resolution CGI in moving images. The current investigation will attempt to build on the acquired knowledge by determining how the VFX industry can profit from the fact that people have difficulties in perceiving quality differences of certain CGI.

The following paragraphs will summarise the essential findings of the previous project. The idea of research in 2010 was to test, if render time and budgets can be saved on background CGI elements by lowering the level of resolution. The final problem statement was:

- At what point will decreasing the resolution of CGI, implemented in a short film, no longer remain unnoticed caused by change blindness, thus breaking the immersion?

The idea was to add CGI elements in different resolution levels to the environment of a short film and test at in which condition the viewer notices that CGI was used. None of the CGI elements were actively part of the story or were needed to understand the plot. However, the assumption was that when a spectator would notice that CGI was used in the scene he would get distracted from the movie.

The theoretical background used for this project was on first if all psychological immersion. Psychological immersion was defined as the state of being absorbed and surrounded by the consistent content of a medium which fulfils the user's expectations [1] [2] [3] [4]. A spectator who would be psychologically immersed the presented short film would be curious what will happen next. To lose track of time and focus only on what happens inside of the medium rather than around it are two further characteristics or psychological immersion; the spectator follows the narrative and relates to it. As immersive movies can direct the attention, the spectator might not notice irregularities in which are placed not in the centre of attention.

The second theoretical basement for the research was the perception process. It has been suggested that perception is a limited process [5] [6] and that hence the elements in the perceptive field need to compete for visual processing resources [6]. The resource competition is always biased towards current relevant behaviours, which means that some elements are selectively enhanced while others are suppressed [6]. In other words not everything in our perceptive field gets processed which conclusively leads to a difference between what humans see and what humans perceive.

In order to hide CGI in the short film this report intended to use this difference by aiming for *Change Blindess* [7].Change Blindess has the effect that humans fail to notice substantial and clearly visible changes to objects that are right in front their eyes [7]. It occurs when reoccurring scenes are manipulated. In order to experience change blindness a previous exposure to the stimulus must have happened which the current stimuli can be compared to [7]. Furthermore, the test subjects do not know the nature of change, the location of change must be unknown (otherwise change blindness would not occur), and lastly subjects should be confronted with novel scenes for each new trial [7].

Overall, psychological immersion was used to draw the viewer in to the story and thus make him more oblivious to changes in the short film. By using the theory of *Change Blindness* it was suspected that the viewer would not detect the loss of resolution, if the first exposure was on a high enough resolution level.

A 3,5 minute long short film was chosen which was presumed to be suspenseful and thrilling but at the same time offered the possibility to add CGI elements to scenes which had a long enough exposure time. The CGI was positioned close to the main characters (one even on top) but otherwise matched the overall look and feel of the film. The chosen CGI elements were smoke and a wooden window frame. The resolution of the CGI elements was degraded after the first exposure, either beginning on a high level or on a lower level. In all, three levels of resolution were introduced: high, medium and low. The three levels of resolution were established according to their render time.

It was suspected that the first exposure of the CGI had a crucial influence on the detection rate of the CGI. Hence, the assumption was that viewers would not notice the decay of resolution if the first exposure was on a high level. On the other hand, an initial exposure with a low level of resolution would increase the detection rate. Eye tracking was used to find out if the participants focused on the

CGI in the different scenes, whereas questionnaires helped to test if the participants noticed and remembered the CGI, implicit and explicit memory were tested.

Although the low resolution CGI was clearly identified as being of a low resolution on a still frame, participants did not detect the two CGI elements in the movie. Several focused on it but only view remembered having seen either the smoke or the wooden frame. Hence a fourth condition was introduced: an extreme low level CGI.

Yet again the detection rate was lower than expected, thought the extreme low level CGI was of a very low resolution. The conclusion was that the detection of CGI elements was unexpectedly low. Especially when the actors were talking or acting throughout the scenes, the focus of the viewers was set on the action instead of the CGI. So the final conclusion was that if the first exposure is of a high enough quality then it is possible to save budget by lowering the resolution and thereby render time of background elements in immersive short films.

Based in the findings gathered in this 8th semester project the current study would like to pursue the overall idea of manipulating CGI on a film plate to save production costs.

2 Motivation

The use of Visual Effects (VFX) in film and advertisement is on the rise and has been for several years. Comparing the film *Gladiator* [8](released in 2000) which used around 100 VFX shots [9] to the film *Hellboy II – The golden Army* [10] (released in 2008) used over ten times as many VFX shot, around 1100 in total, [11] shows the dramatic increase of VFX in film.

Anything is possible if you have the budget [9]. The *Hellboy II* crew started more than two years before the film was released with the creation of the VFX shots [11]. A total of 250 digital artists [11] were involved in the creation of the movie striving for perfection. In film VFX are created with finesse and detail in order to impress the viewer and create a *wow-effect*. But in order to be able to realise high-end film two factors are fundamental: time and budget. Based on this bottleneck, this research aims to suggest a way to save budget for companies with limited resources which are not able to afford picture-perfect visual effects and therefore have to compromise at some point in the production process.

Recently TV series dared to base their storyline on the use of VFX. Series such has *Fringe* [12] or *Heroes* [13] would not be realisable without the extensive use of VFX. Due to the fact that the VFX elements are a required element of their storyline the producers were forced to find a balance between acceptable VFX and the budgetary limits. Creating cost-effective CGI is essential for these series to be profitable because timings are short and the budgets are limited [14].

The need for cost-effective production is amplified in the advertisement industry. When planning the production of advertising content, it is always a challenge to create an adequate result within the given budget limitations. In order to be able to realise an advertisement with VFX shots the challenge is to save resources during the creation of the VFX without decreasing the overall level of appearance. If an advertisement is scripted to feature a hurricane the task is to create this concept within the client's expectations and resources. Creating this hurricane as visual effect might turn out to be a very cost intensive element in the relation to the rest of the video clip. As clients generally have an optimistic set of expectation the final look of the VFX needs to live up to these expectations. Hence, a solution must be found to lower the production costs of the VFX without severely degrading the image.

The aim of this thesis is to give analytical suggestions on how limited production budgets can have successful VFX shots. To achieve this it is interesting how and where to limit the production process. The quality, appearance or number of re-exposure is fairly straightforward suggestions to limitations. Given the task of cutting down on VFX placed in the background would sound reasonable, but what if the VFX itself was crucial to the overall advertisement message. How to create acceptable VFX with the production cost at a minimum?

In order to determine how the challenge of creating limited-budget VFX can be solved the first step is to evaluate what good VFX are.

> *The best VFX are invisible and simply enhance the story.*
>
> *Shane Warden [15]*

This means that a well made VFX is invisible to the viewer. This thought is supported by Jeffery Okun:

> *Visual Effects, if they are done well, are not obvious. At their best, they work to further the story being told, becoming an integral part of what makes us willing to suspend disbelief.*
>
> *Jeffery Okun [16]*

Instead of aiming for intrusive VFX, well made VFX should simply be accepted as a part of the story. Consequently, the tasks would be to find a way to create VFX in the given limitations of time and money which are at the same time invisible to the viewer.

Creating VFX can be driven by the wish of creating the perfect effect and making it look just like in reality. For companies who have the required resources to strive for perfection the current research might be uninteresting as they rather want to impress than to cut down on quality. The motivation is to show companies with limited resources at which elements they can cut costs in the most effective way but still have an adequate looking end result. Consequently, this thesis is written for the European VFX industry, primarily the Nordic. The analytical emphasis is focussed on the advertisement productions, since their resource of time and money are mostly limited compared with TV and films.

2.1 Initial Problem Statement

- How to integrate limited budget VFX into a commercial video and still create a result that is believed and accepted by the audience?

3 Preliminary Analysis

The purpose of the preliminary analysis is to gain a deeper knowledge of keywords used in the initial problem statement. It will be specified which areas shall be covered to narrow down the initial formulation. With this purpose in mind, the preliminary analysis is divided into the following parts: current work, VFX, simulation, perceiving and recognising, schemata and perceptual realism is the. At the end of the preliminary analysis a final problem statement will be formulated from these areas of research, determining the scope and final aim of this project.

3.1 Current Work

The advertisement industry has fast production workflows, which is the time span from concept pitch to final delivery. Unsurprisingly, the advertisement industry is dealing with lower budgets compared to the film industry. In the last decade VFX has had its intro into advertisement, especially due to the fact that the computer technology is getting cheaper and has faster performance as commonly known. Making the production capable of utilising VFX, but the need for optimisation is inevitable because a 3D production pipeline is expensive. This chapter looks into how current advertisements deal with the challenges.

DR Podcast Airport

The Danish Radio has a children television channel named *Ramasjang*, which is a playful channel solely for children. DR created a simple television commercial to market its podcast which involved a girl with 3D generated ears. It was a small budget production that worked very well, due to the fact that the 3D visuals should not replicate reality but show a surreal atmosphere. This left the audience with the impression that magic happens while listening to *Ramasjang*.

Figure 3.1 DR Rammasjang commercial - by Gimmick VFX [17]

Coca Cola Zero

Coca Cola is known for its big marketing budgets in the United States. When it comes to the European market the budgets are considerably lower, but far bigger than the average. For the Coca Cola Zero commercial series launched in Europe, the company chose Danish Ghost VFX as the main VFX partner. The commercial illustrated in Figure 3.2 was filmed in Brazil with a big production budget [18], but the VFX production was downgraded and kept at a minimum.

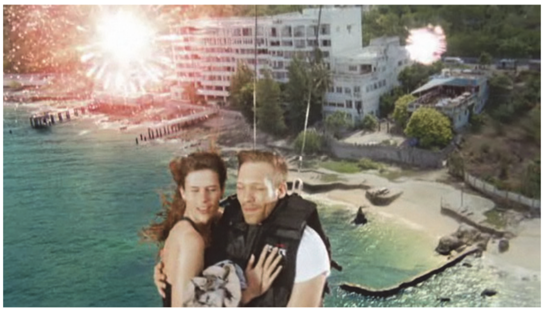


Figure 3.2 Coca Cola Zero Commercial - by Ghost VFX [18]

The image shows a film plate with a green screen recording composited on top. The keying and colour correction is slightly off, leaving the impression that this was a low budget VFX commercial. But due to the fast editing and the rapid humorous storytelling it is very doubtful that the audience will notice this example of low budget VFX.

Council for Traffic Safety

The Danish council for traffic safety created a campaign to avoid speeding in general. They produced a commercial showing a speeding car and how it ended up in an accident. The audience follows the accident in slow motion while a traffic expert, working as a narrator, is describing the accident. By portraying the car as a 3D see through model a surreal setting is created. The audience accepts the car as part of the scene since it has a cartoonish appearance. The real car is shown in the end of the commercial when it crashes into a nearby tree and the real accident occurs. This gives the terrifying impression that speeding is dangerous.

Figure 3.3 Council for Traffic safety - by Ghost VFX [19]

The surreal appearance creates a setting that makes the audience believe the visuals despite the fact that they looked painted. The simple surrealistic effect and the slow motion accident footage work well together and enhance the message of the advertisement. This is a great solution to a low budget effect.

Canal Digital

Canal Digital is one of the largest television providers in Denmark. A humorous commercial was created to improve the knowledge of their products. The intension was to replicate the Indiana Jones concept, where a person removes a stone from an old ruin and suddenly a giant rock charges downhill and eventually rolls over the person. In this low budget VFX production they chose to solve this effect by projecting an image of the person as a texture on top of the 3D generated stone. A very cheap and fast solution, but the end result looks disappointing. This led to a cheesy advertisement rather than a great outcome of the original idea.

Figure 3.4 Canal Digital - by Gimmick VFX [20]

The Outcome

These four examples of current work showcase how some of the low budget productions were solved. The use of rapid editing and surreal settings can aid the audience to accept the imperfect VFX effect. The question that arises from these examples is how well do the VFX studios know to tackle the low budgets and limited timeframes. Secondly, do studios tend to suggest more expensive VFX effects to avoid the low budget work, when it might not be necessary?

The above examples of current work are both successful and unsuccessful solutions to this challenge. The motivating factor of this thesis remains the belief that alternative methods to solve these challenges would be very beneficial and valuable for the VFX industry. The necessity to balance the detailed work with a limited budget production has to work jointly with a perfectionist VFX industry.

3.2 Visual Effects in General

VFX has many purposes such as colour grading or wire removal and can thereby be helpful when cutting production costs [21]. An alternative usage of VFX is to change the film plate by removing elements that should not appear on screen, masking out unwanted elements or changing the weather for instance [22]. But what is the difference between Visual and Special Effects. The public at large has a tendency to speak of *Visual Effect* (VFX) as *Special Effects (SFX) as the same thing*, which is nevertheless not completely the truth.

Visual Effects and Special Effects

The need of effects in films increased throughout the history of film making [16]. In the early days of effects in films, the effects were performed in camera or on a custom build stage. This was named Special Effects. The use of cranes, wires, rigs, chemicals for blood splash and other equipment was a necessity to create the illusion of an effect. Furthermore big in-house systems were created to simulate weather conditions such as rain and wind. Special Effects were also known as practical effects. All these effects were created while shooting the film. Although many effects were possible given the complex setup of stages, Special Effects still had certain boundaries [16].

Visual Effects (VFX) on the other hand, is a computer generated effect. The imagery is created, altered or enhanced to accomplish a required effect. This is not intended to be accomplished during the shooting of the live action, but in post-production. The effect is afterwards added to the recorded material to gain the desired look. VFX was introduced in the film industry much later than Special Effects because of the technology needed. It came to assist the Special Effects and in some areas take over and update the current methodology. The rapid release of software packages enabled artists to create stunning effects and have turned VFX into common use in even the smallest production houses, and not just as part of Hollywood. The technology is getting cheaper, better and faster making the advertisement industry capable of utilizing VFX in commercials [16]. Yet, at least one problem remains: how to create a great looking effect with a limited budget? Creating an effect is a time consuming process and even though the technology is evolving fast, the need for an optimised workflow has not been greater [16].

Figure 3.5 Visual and special effects combined. The Crain and stage is special effect, whereas use of green screen is computer generated, being a visual effect

The general definition of Visual Effects (VFX) is the following:

> **Thesis Definition: VFX**
>
> Visual effects is the term used to describe any imagery created, altered, or enhanced for a film or other moving media that cannot be accomplished during live-action shooting.
>
> Jeffery Okun [16]

3.2.1 VFX Categories

VFX is a common term in the advertisement industry. It covers a great amount of techniques which spans a huge area within computer generated imagery. In general VFX is categorised into intentionally visible and invisible effects. An explosion or a CGI character is supposed to be noticed (visible), whereas a sky replacement, a green screen shot or a wire removal should remain unseen (invisible). Many different techniques are used in the industry to deal with complex 3D scenes, such as *3D Match Moving*, *Rotoscoping*, and *Green Screen Keying* etc. This thesis will delve into visible effects and how these are perceived. It is not the interest of this thesis to work with invisible effect. As the focus will be on peoples' perception and acceptance of VFX this would be hard to test on invisible effects.

Recently the development of VFX has changed from a manual into a procedural workflow. A vast part of procedural VFX consists of simulations, which are currently is the fastest growing VFX category used in the industry [16]. This thesis finds this growing tendency very interesting. Consequently, the following chapter will establish how these simulations function.

3.3 VFX Simulations

Previously a general overview of VFX has been given. This chapter will delve into a more specific topic: simulation. It will give a broad description of simulation and take a look into fluids.

Simulations have bee an expanding part of the VFX industry in the last couple of years [23]. Very realistic looking animations, such as blowing up a house, can be complicated even for the advanced animators, while computer simulated based animations of the same explosion would be considered relatively straightforward.

Definition: Simulation

A very important and rapidly expanding aspect of CGI for creating animation. A simulation is a computer simulation of some natural phenomena, such as weight and gravity

Steve Wright [23]

3.3.1 The Arise of Computer Driven Simulations

Once upon a time, people believed that CGI could not be used for the film and advertisement industry. It was believed that CGI did not encompass the quality to make it into that industry. One movie that was released in 1993 changed the entire perspective on computer graphics: *Jurassic Park* [24]. This movie that gave life to 3D animated dinosaurs, but also showed the world how these creatures interacted with their surroundings. Suddenly it was possible to create a 3D character that destroyed buildings and trees. It even allowed rainy weather to pour down the back of the big tyrannosaurs. All this was possible due to the computer generated simulations which marked new era [25].

3.3.2 The Foundation of Simulation

Simulations can be performed in multiple ways, but the most commonly used is particles. Particles are small points in 3D space. They are the simplest form of simulation and have no intelligence. The calculations of particles happen with no understanding of the world they live in and they tend to stay permanently motion. This is way they are referred to as the most basic form of simulation. With the use of mathematical algorithms, expressions and rules, i.e. Newton's laws of motion, it is possible to control particles and thereby achieve the desired effect. The greatest advantage of particles is the low CPU computation they require, which made it possible back in 1993 to utilise this technology in a great scale production. Particle emitters are used to control the spread, speed, direction and amount of emitted particle. 3D geometry can function as an emitter [23].

Simulations are divided into two stages: simulation and rendering [26]. The simulation stage calculates the particles, emits according to the behavioural properties of the emitter, kills particles whose lifespan has ended and in some scenarios controls collection detection between particles and external geometry in the scene. Particles can be assigned additional properties, which are all calculated at a preset update rate, normally by each frame in the simulation. At the rendering stage, the simulation stage is typically cached into computer memory to avoid redoing the same particle calculations. During this stage the simulation gets rendered by giving each particle point a colour, shader or geometry [25]. In Figure 3.6 the visual difference in-between the images is big. The smoke shader in the right image tries to mimic a truthful appearance of the comet.

Figure 3.6 Particle rendering - Left: coloured particles, Right: Smoke shader assigned to the particles [25]

Fluid Dynamics

Particles were considered the primary solution to VFX simulations for many years, even though particles lack a realistic behaviour pattern. In those years, more effective solvers were created.

Solvers are operator-based mathematical algorithm solvers. These solvers got faster and more precise to calculate the particles collection, movement etc. The search for a mechanic or technology that encompasses the phenomena of our world was initiated. From theories of physics the fluid dynamics became an interesting approach to use in VFX simulations [25]. Although fluids algorithms required far more computational power, its equations of how substance flows were beneficial and even more important, they had a realistic movement pattern.

Even though fluid systems are also emitting they are nothing like particles. Basic particle systems have no boundaries because the emission releases them into free air, which makes them hard to control. Fluids live only inside of containers and can be affected by parameters in sections of the container. This container creates a controlled environment which enables small adjustments of the parameters to create a precise effect.

> *As an analogy, think of a clear glass of water. Left untouched, it appears to be empty. Squeeze red food coloring into it, and sections of the water turn red. As the food coloring dissipates, the water takes on a pinkish hue. It shouldn't come as a surprise that 3D fluids operate in the same way.*
>
> *Todd Palamar [25]*

Figure 3.7 How red food colouring affects a container filled with water [25]

Todd Palamer's point in the quote is to explain the differences of a particle system and a fluid system. The particle system would not consider the red colouring, although it is mixed with the water in the glass. This kind of system would only consider the collision of the two liquids and try to mimic that. A fluid system would immediately react to the red colouring liquid and start mixing them from a flow based algorithm which calculates how the water and red colouring material properties mix. Making the fluid effect a realistic representation of what will happen in reality.

Both gases and liquids are classified as fluids, meaning that fire, smoke, water, blood, wind and other substance are all part of fluid dynamics [27]. Fluid differentiates from particles on many levels. Forces, pressure, viscosity (the resistance of a fluid being deformed), velocity, density and compressibility are fundamental parts of fluids, and capable of simulating nature's phenomena [28].

Fluid simulation has great potential and is often the choice of simulation type when designing and implementing VFX in advertisement. The obvious advantage is how precise and realistic the simulation gets calculated and displayed. The downside is the time spent on such an effect because of its many parameters, such as forces and viscosity it has to compute. The following problem statement will focus on working with fluid simulation due to its great potential. Meaning, how the VFX industry in general uses fluid based simulations to recreate natural phenomena with movement, such as oceans, waterfalls, explosions etc. [25]. Furthermore, fluids are computational heavy which is of a natural interest for this thesis, due to its agenda to optimise the VFX workflow.

3.4 Perceiving and Recognizing Objects

As this research attempts to make VFX more cost-effective without the viewer realising, it is important to understand how viewers recognise the elements that are presented. The basic level is to have a look at how people recognize real objects. The following chapter gives an example on how we as human beings perceive and sometimes misperceive reality. Furthermore it will look at the difference between perceiving reality and perceiving representations of reality.

3.4.1 Perceiving the Real

In his research on *Perceptuals Systems and Reality* Raftopoulos [29] mentions that perceptions successfully guides our interactions with environments. In most cases people perceive the information around them, in their natural environment, correctly and can thus interact with the world. This means they are able to identify a chair or a table and thus know that it is no possible to walk through it but necessary to walk around it. In some cases however perceptions might lead to a false belief:

> *"Since the world causes in us perceptual states, which in their turn cause us to form beliefs, one might think plausible to argue from the truth of these beliefs back to the correctness of perceptual states".*
>
> *Raftopoulos [29]*

In other words, there are moments when beliefs in peoples' perceptions might mislead their expectations. For instance, when sitting down on a sofa you expect it to be soft, but it might end up being the opposite, by our experiences and beliefs people were shaped to think that what looks soft is soft. That is to say, when an object is perceived and information about its properties is retrieved, a belief is formed that this object has more or less these perceived properties [29].

This is an important point when transferring these believes to the realm of film. Just by looking at objects beliefs about their properties are formed, even if the object has previously been perceived in a different way. Although an object is unknown, people still form a belief about the surface of it (without having touched it). The question is, if this belief would have been different if not the original object was perceived, but a representation of it instead. Where is the border between perceiving reality or a depiction of it?

3.4.2 Perceiving Representations

In Gregory Currie's book on *Image and Mind* [30] it is discussed in what way the process of recognising an image differs (or equals) the recognition process of real life. Currie suggests that in order to recognise an image or depiction of an object, visual features are associated with the concept of the image, the same features that would also be used to recognise the object in the real world [30]. Some features or properties of the image, which are alike on the image and in the real world, trigger the object recognition capacity. It appears that the same recognition process is used to recognise an object, or the image of the object.

Next to that Currie suggests that this recognition process is personal.

> *The likeness might be quite insignificant or artificial when judged from any perspective other than that of someone who wants to recognize horses and pictures of them by looking. But for such a person, the likeness is a significant one.*
>
> *Currie [30]*

It appears to depend on the spectator if the likeness to another object is established or not. So the recognition process is not universally the same for everyone. This implies that one spectator perceives the represented images different than another one.

Supporting the idea of the personal recognition process of images, Stephen Prince mentions the prior recognition knowledge that the spectators have accumulated in their life.

> *"A perceptual realistic image is one which structurally corresponds to the viewer's audiovisual experience of three-dimensional space."*
>
> *Prince [31]*

Hence, depending on the experiences the spectators have had in their life the perception of an image, and thereby the perception of realism, will differ. Not only does this work for the recognition of objects or spaces, but also for the perception of people, as

> *"viewers draw from a common stock of moral constructs and interpersonal cues and percepts when evaluating both people in life and represented characters in media".*
>
> *Prince [31]*

So far it was argued that the recognition process of our real environment equals the process or images or film. Furthermore this recognition process for spaces, objects or people is a personal process which can differ depending on the spectator's experiences.

Overall this implies that human beings use their real life experiences and knowledge to make sense of the images and representations presented to them. Depending on their background and on what spectators wants (maybe even expects) to see, elements are recognised. Consequently, advertisements might be perceived and interpreted in different ways according the person watching it. Previous knowledge of the presented content appears to have an effect on the recognition process of objects; does that also entail the perception of VFX? Additionally, the question arises which factors can influence our recognition process, especially the recognition of images or moving images. How are the just mentioned expectations or the spectators' background formed?

3.5 Experience & Schemata

The following chapter will deal with the question how experience and memory can influence the interpretation of stimuli. As mentioned in the previous chapter, the interpretation of stimuli can vary depending on the prior experience of a person. Does that mean that watching an advertisement or movie has an effect on the spectator and will influence their future viewing behaviour?

In a research on *Evolutions's Pedagogy* [32]Steen and Owens state that

> *"even if we are only interested in being entertained, we end up being influenced ".*
>
> *Steen & Owens [32]*

This means that depending on the entertainment a person had in their life the same set of stimuli might be put it into different contexts. Steen and Owens go as far as to say that

> *"[…] the learning processes that are involved are largely unconscious and may be cognitively impenetrable. Even when we engage in activities simply because we find them entertaining, we are likely to be engaged in an evolved from of unconscious learning".*
>
> *Steen & Owens [32]*

Hence, depending on how intense people have been exposed to a certain form of entertainment the more they might have learned from it – even if they are not aware of that process. This indicates that prior experience with advertisements is important. Depending on how many advertisements spectators have perceived so far, maybe of the very brand or product this research ends up utilizing, might have an effect on the research. If the test subject has already seen the advertisement, associations or expectations can influence the perception and hence distort the evaluation of actual focus of this project: the VFX. If the spectator knows the advertisement he might have more capacity left to detect the low level VFX, as he does not need to focus anymore on story or pay-off.

3.5.1 Influence of Schemata

The idea that previous experiences influence how people perceive, comprehend and remember new information is a basic assumption of schema theories [33]. Schemata have been defined to structure how previously gathered information are stored and are used to speed up the recognition process

[33]. The central points of schemata were collected by Goodman in his article about picture memory [34]. He states the four main aspects of schemata:

> *"Schemata:*
> *(1) provide an internal structure for efficient perception and memory of events; (2) generate a set of interrelated expectations pertaining to a specific event; (3) selectively retain or alter the representation of events originally attended; (4) are constructed through experience with real- world events and change their organization, and perhaps their representational properties, with development."*
>
> *Goodman [34]*

When considering these four points, it appears that schemata are used to make the perception process more effective by structuring the elements and building up expectations accordingly – once an expectation is formed it is not static as it can be subject to change. Related to the research at hand this indicates that the advertisement presented to the viewer will also call up a schema. Depending on the content of it the spectator might know the schema very well or not. Depending on the elements revealed over time the schema can be changed, a more suitable schema gets called for. The last point indicates that in order to form a schemata people must gathered real-world experiences of that event or element. The question arising from this formulation is if schemata can also be created from elements or events which were previously only experienced as representations?

Up until this point no evidence has been found to establish a difference between the perception process of virtual images and the perception process of the real world [3.4 Perceiving and Recognizing Objects]. This leads to the assumption that schemata can potentially be formed based on the perception of representations. The crux to answer this seems to be the question if people can consciously differentiate between perceiving representations or real-world elements.

Thesis Definition: Schema

Schemata are an internal structure for efficient perception which generate expectations. They are created and adjusted over time depending on the individual experiences.

It has been argued that schemata are important when it comes to recognising perceived elements. Prior knowledge of the stimuli and expectations are core factors when determining how schemata influence the perception process. The important factor of schemata for the current research is if the created expectations influence the perceived detail of certain elements in the image. In previous researches [33] [34] two opposing hypotheses have been formulated and answered around this question: (1) people might spend more time on looking at schemata relevant information and ignore the irrelevant elements [33]. Hypothesis (2) suggests that people spend more time on looking at novel and unrelated information rather than on the expected elements [33]. So far proof was found for (2) that *nonschema* and unexpected information required more time and attention than expected information [33] [34].

Namely Goodman states that

> *"[…] atypical and unexpected events, those that do not conform to schema expectancies, are retained with greater discriminative accuracy than are typical or expected events ."*
>
> *Goodman [34]*

Not only events, also unexpected items get more attention and

> *"are represented in detail, while expected items are represented in terms of prototypical expectations."*
>
> *Goodman [34]*

It appears to highly important that the embedded VFX are not unexpected or nonschema elements. If people would perceive the VFX as unrelated they would use more attention and time on analysing it which would increase the chance that the spectator would notice that the VFX is of limited quality.

In the previous chapter it was derived that people are influenced by what they hear and see around them. All the information appears to be stored in schemata which are at the same time used to process the information available. If elements do not correspond to the appointed schemata they receive more attention and focus to be evaluated. The question that remains unanswered is if people can differentiate between perceiving fictional or real-world events. This research can use the schemata theories for the selection of the appropriate VFX and advertisement. It seems to be important that they belong in one schema. Furthermore, it might be important to select an advertisement that the participants potentially have the same amount of experience with in order to be able to compare the results.

3.6 Perceptual Realism

With the use of CGI and VFX it is possible to manipulate images in many ways. Elements and setups that would not be realisable in real life can be constructed on a picture in a believable manner. However, by doing that a paradox is created: CGI credible photographic images can be created that of things that cannot be photographed [31]. Is it possible for humans to judge CGI objects they have not seen before as realistic?

One assumption about realism in film that prevails is indexicality [31]. Tom Gunning names and index a:

> *"direct physical connection between the sign and its referent".*
>
> *Tom Gunning [35]*

Famous examples for this are the footprint or the bullet hole which are evidence for the respective impact of a foot or a bullet [35]. In film the index can refer to large amount of signs and indications, such as light reflections, skid marks just about any element can be an index and support the realism in an image. This approach to realism in film is based on photographs as photographic images

> *"correspond point by point to nature".*
>
> *Prince [31]*

Digital images and CGI can challenge the theory of indexicality as it is possible to manipulate in uncountable ways without having a real life referent [31].

When creating an image without a real life referent the law of realism is bent – but spectators might still accept the images of *perceptually real. Perceptual Realism* is a term coined by Stephen Prince who wrote that

> *"perceptual realism […] designates a relationship between the image or film and the spectator, and it can encompass both unreal images and those which are referentially realistic."*
>
> *Prince [31]*

He thus expands the field of realism, to everything that the spectator perceives as real, although it might now have a referent in real life,

> *"unreal images have never before seemed so real."*
>
> *Prince [31]*

However, in order to create perceptually real object certain guidelines that should to be respected.

> *"[…] representations are perceptually realistic when they share perceptually significant properties with the things they represent."*
>
> *Currie [30]*

That is to say, there needs to be a connection to a real-world element in order to be perceived as perceptually real. Another guideline might be: movement. Tom Gunning brings up a research from Christian Metz who suggests the photographic images are condemned to a perceptual past tense, as they show a snapshot of how it was. Moving images on the other hand can create a feeling of a scene that just happens [35]. By creating a moment that the spectator can get absorbed in a *participatory* effect is created. Participation is named to be an important element of realistic effects in cinema. Movements or motion are key elements in creating a participation in the film. As motion can trigger perceptual, cognitive and physiological effects it the spectator can be swept away with motion itself [35].

> *"Participation properly describes the increased sense of involvement with the cinematic image, a sense of presence that could be described as an impression of reality."*
>
> *Gunning [35]*

In his article Gunning mentions that watching a film is not simply looking at moving pictures but experiencing something truly moving. This implies that when watching moving images people are not only visually affects but also produce a psychological effect. Hence it appears that moving images can support the perceptual realism.

In order to replicate a participatory effect with VFX several rules need to be respected. Stephen Prince mentions important elements that virtually created images should entail in order to be perceived as real. The intersection of 3D objects, such as collisions and collision response, lighting and motion blur are some examples of important features that need to be taken in consideration, whereas generally the most important ones were mentioned to be light, texture and movement [31]. In order to connect the CGI to the photographic imagery reflections and other indexes should be added in order to fulfil the indexicalized condition [31].

Perceptual realism allows CGI to bend the laws of reality in the moving image but still convince the audience that what they see is real. Based on Princes' theory it can be argued that even elements without a real life referent can be perceived as real. The perception of reality can be especially effective in moving images as it create a participatory effect. However, as the line between not real will become more and more blurred [31] it is important to remember that, at the end of the day the film is an illusion,

> *"in cinema we are dealing with realism not reality".*
>
> *Gunning [35].*

What it is important about the previous paragraphs is that it is possible to virtually create images that people accept as perceptually real. Hereby it appears to be important, that there is some connection to a real life element, just for instance take a dinosaur representation. Everyone knows that dinosaurs in a movie cannot be real, however their representations are bound by gravity just as everyone else and they move their legs or wings just as any animal that we know. By having these elements that we can refer to it might be easier to perceive them as perceptually real.

Thesis Definition: Perceptual Realism

Perceptual realism designates a relationship between the image or film and the spectator, and it can encompass both unreal images and those which are referentially realistic. *Prince* [31]

As described in a previous chapter [3.5 Experience & Schemata] every film that was watched might have a learning effect on the spectator and thereby adjust the corresponding schemata. Looking at the film Jurassic Park which was made in 1993, back then it was a famous example of perceptual realism [31]. When watching the movie again today the VFX are rather easy to detect. The technological possibilities advanced immensely over the past 20 years and with it the schemata (and expectations) seem to have adapted to that.

In 1993 spectators were impressed by the perceptually real dinosaurs. But when re-watching the movie today the VFX does not have the same effect anymore. Although people were just as critical towards new representations as they are today, their expectations were on e different level. The standard of VFX has increased immensely over the past years [9] [11]. Nevertheless, back in 1993 people accepted the imperfect VFX as perceptually real because it was inspiring VFX at that point of time. This is a proof that perceptual realism does not correspond to photorealism but to the border of acceptance in that point of time.

This border has certainly been heightened in the last 20 years, as has technology has evolved and the peoples experience with VFX grew. Still, the principle remains that in order to achieve acceptance by the spectators the VFX must suit the expectations of that time. For limited-budget VFX this implies that instead of aiming for perfectionist VFX it might be enough to aim for acceptable quality. Based on this assumption there is a good chance that people will still accept imperfect or limited quality images as perceptually real.

3.7 Final Problem Statement

By the motivation, the initial problem statement and this preliminary analysis, a final problem statement has been formulated.

- How to define the border zone of audience acceptance for limited budget fluid simulation effect in a advertisement video based on the Expectation & Belief Model?

3.7.1 Final Problem Delimitation

Fluid Simulation

Fluid simulation was chosen as the VFX category due to its expanding popularity in the advertisement industry. It offers massive potential but has a tendency to be very extensive in production. Furthermore, fluid simulation contains an interesting, reasonably new and time consuming approach to creating VFX. Yet, it still lacks the knowledge how big a production budget should be to achieve a given effect.

The further progress of this project encompass analysis and testing on how the furthermost significant parameters within the simulation stage of fluid dynamics alter the effect itself and how it influences the perception of the effect - a workflow optimisation analysis. The rendering stage of a simulation will not be the main focus of this project.

Acceptance

The moment of acceptance determines if the spectator perceives the image as one coherent representation or if the spectator notices the usage of distracting VFX and is consequently reminded that the image is virtual.

Expectation & Belief Model

This model will be synthesised by the end of the analysis chapter. It is meant to summarise the essence of the findings of the analysis and it will form the foundation for the choice of the test methods. It will hypothesise how a schema built on hyperrealistic representations benefits the processing of hyperrealistic VFX.

Visible/invisible

It is not this thesis scope to work with invisible VFX, such as covering up a microphone, remove a wire or changing the weather, colour and setting. This project will only focus on visible VFX that has a purpose in the scene.

Advertisements

This thesis is directed to advertisement companies who work with limited budgets but are still keen on achieving the best possible result. Characteristics of advertisement are repetitions and short exposure durations. Due to the shortage of time and budget in the advertisements industry this thesis will focus on giving recommendations respectively.

4 Analysis

The analysis is divided into four parts. The first part synthesises the knowledge from the preliminary analysis with the intension of building the foundation for the Expectation & Belief Model. Featuring an analysis of the perception process, the theories of suspension of belief and an insight to the term hyperrealism. The second part focuses on the workflow of fluid simulation and which type of fluid to choose for future testing. Subsequently the third part will encounter the EBM and how it should be understood. The fourth and final part will state the hypotheses of this thesis. Once this analysis is complete, the knowledge gained will be used to commence the advertisement selection, design phase and test methods.

4.1 The Perception Process

The following chapter will introduce a model of the perceptual process to respond to questions raised in the preliminary analysis. Is there a difference between perceiving reality or representations? Could it be that spectators accept perceptual realism although the images are not perfect?

The answer the question how people recognise virtual elements might be found when examining the perception process more thoroughly.

> *"Perception is, on an everyday basis, understood as something that has to do with the senses or derives from the experience of having sensations".*
> *Meldgaard [36]*

Senses and experiences seem to be the tow keywords when discussing perception. Betty Li Meldgaard gives a basic definition of perception in general as a choice of directing attention to certain features in the imagery [36]. This specific part of perception was investigated in *Zero Detection* [1 Zero Detection Summary]. The theoretical focus was set on the question how the cognitive capacity is allocated across the visual filed and how the saliency of visual elements is determined. But what happens once the stimuli in perceptive field have been attended?

In order to identify the next step in the perception process a more extensive approach is required. With the focus on film viewing and how these images are processed after the perception a model suggested by Torben Grodal might bring the answer: the *PECMA Flow* model (perception, emotion, cognition and motor action).

> *"In the PECMA flow model it is anticipated that humans makes use of the same general biological system [...] used in order to make sense of and survive in the actual world, in order to understand audiovisual representations."*
>
> *Hansen [37]*

In his research Ole Ertloev Hansen [37] explains that PECMA flow model is based on the general theory of the film experience and encompasses how the film viewing experience is cognitively processed. As the task at hand is to find a border of acceptance when being exposed to moving images the PECMA flow model seems to be the right choice. For the realm of game experience Meldgaard [36] criticises that Grodals model oversees that experiences might not follow each other sequentially as

> *"his idea is fit for a schema, not for a process of experience."*
>
> *Meldgaard [36]*

But as this research focuses on the exposure of an advertisement, which can be equalized to film viewing, and is interested in the effect of experience schemata this model seem to be appropriate.

In 1997 Torben Grodal suggested the *PECMA Flow* model (perception, emotion, cognition and motor action) for the first time [38]. It is based on fundamental brain architecture and focuses especially on the experience of film viewing. The model tries to enhance the understanding of how different parts of the film experience draw on different aspects of the human mind. Grodal suggests that the PECMA model takes a direct approach to film viewing as it starts by the light waves reaching the eye. He argues that humans use the same mechanism to makes sense of the stimuli from a moving image and from the world, they both are connected to the same brain system [38]. Grodal states that people do not see representations objects, but simply see the object itself. Furthermore Grodal argues that the experiences in film run in the same circuits as our real life experiences,

> *"only mental 'reality-status-markers' indicate the difference between visual fiction and online facts."*
>
> *Grodal [38]*

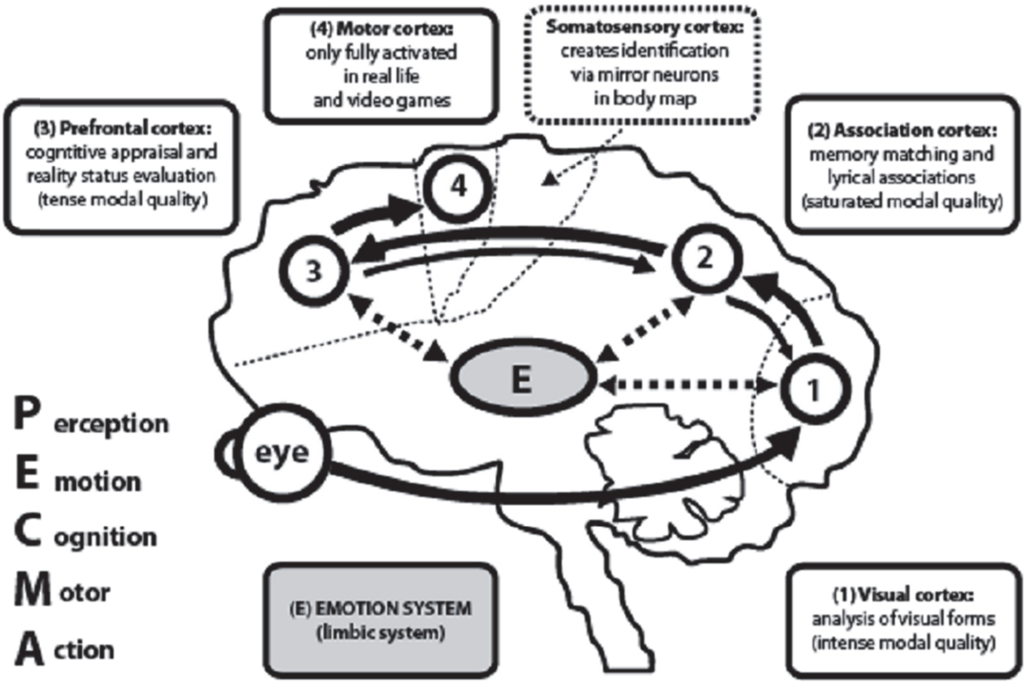


Figure 4.1 1 PECMA Model [38]

He divides the PECMA flow model into four steps.

1. Input devices: Sensory organs transducer the information available in sight and sound and send it to the internal brain system.
2. Associative networks: The information gets matched with schematic representations stored in memory. The identified objects or events are labelled with an emotional tag – thus these emotional cues can motivate action.
3. Cognitive centres. The input is analysed in a more sophisticated manner which allows to generate hypotheses or to simulate consequences before the output.
4. The motor system controls the muscle actions while planning alternative reactions.

Grodal calls stage 1 and 2:

"perception and association, emotional activation and emotional labelling."
Grodal [38]

First the huge amount of visual information is transmitted to the visual cortex. A series of brain modules have the enormous task of breaking the information down into identifiable forms [38]. At the same time emotional experience cues are processed. In the second stage the identified forms are matched to representations in memory as well as an emotional tag. The third stage deals with cognition, narrative and identification. In this stage the film is cognitively assessed, for example the identification process with characters. Herby the chronological order of events can have an effect on the emotional saturation (as Grodal calls it). Emotional saturation happens when the spectator cannot release the emotional tension [38]. Grodal argues that a certain set of neurons, called mirror neurons, is not only activated when a person performs a certain action but also that person observes another person performing the action. In the fourth and final stage, the action tendencies which are the result of the previous emotional processing are vicariously implemented [38].

Grodal states that throughout the stages from *emotion* to *action* the films reality status gets evaluated. This comes back to the question if people can differentiate between seeing reality or representations. In this context Grodal brings up the act of *suspension of disbelief* which is considered to be a precondition to accept the presented moving images as real. Grodal writes that

> *"the viewer primarily experiences the film as simulation of real life events that come into existence as the film progresses, although they know it is pre-recorded and told by some sort of narrator ."*
>
> *Grodal [38]*

As this is a fundamental element of the current research the next chapter will elaborate on the suspension of disbelief and on Grodal opposing views on it.

When considering Grodals model a whole it is a comprehensive theory from the moment of perception to motor action. Yet, this study will only focus on the second stage associative networks and the third stage cognitive centres. The first stage has been dealt with in the research *Zero Detection* [1 Zero Detection Summary]. As mentioned earlier, in order to define the border of acceptance it is mainly important to figure out what happens to the stimuli once they have been attended. Likewise the last stage, which focuses on the motor action will be out of the scope if this project. Motor actions, in other words physical reactions, are not of primary interest for the evaluation of the border of acceptance.

The important aspect of Grodals model is the reality evaluation process. The present research aims to determine the border of *acceptance* for the spectator when being exposed to VFX. Evaluating what has been discussed so far it might be that the suspension of (dis)belief is the moment in which the spectator either accepts or rejects the images.

4.2 Suspension of Belief

The following chapter focuses evaluation of the reality status of perceived images. Can people distinguish between representations and reality right away? In order to react to a work of fiction on a personal level a precondition is required: the individual needs to *suspend disbelief* [39] [40], or as the PECMA model argues to *suspend belief* [38]. Although people who go to the cinema are aware that they will be watching a work of fiction and it is clear, that all scenes in the movie are staged, they are likely to experience emotional responses. This could be due to the fact that the

> *"willing suspense of disbelief has become as natural an act to most contemporary folk as breathing air."*
>
> *Martin [41]*

Following, it will determine what happens when a person engages with fiction and if it is disbelief or belief that needs to be suspended.

Suspension of Disbelief

In their article on *Enjoyment* Vorderer, Klimmt and Ritterfeld [40] state that in order to enjoy a work of fiction the suspense of disbelief is a precondition. Suspending disbelief is defined as perceiving the fictional content as *real* or *natural* [40]. They state that suspending disbelief would be the only way for a person to develop empathy for the characters and their actions in the work of fiction. A further interesting point they are making is that any doubts about the realism would ruin the experience. Hence, the basis to fully experience a work of fiction is that the individual accepts it as real for the moment and is thereby able to develop a connection the presented imagery.

Lombard and Ditton [39] mention the suspense of disbelief in the context of *Presence*. They consider the suspension of disbelief as part of the trial to *get into* the experience stage in which inconsistencies are ignored and cues that the experience would be artificial are blended out [39] . Moreover, they mention that

> *"the willingness to suspend disbelief probably varies both across individuals and within the same individuals across time".*
>
> *Lombard & Ditton [39]*

In other words, the suspension of disbelief is not just one stage which is universal for everyone in order to experience fiction but it is a concept that varies from person to person and can be more or less intense depending on circumstances that person stands in.

Although the definitions mentioned by Vorderer, Klimmt and Ritterfeld [40] and Lombard and Ditton [39] do not match completely, both of them have the same approximate understanding that the suspension of disbelief. Spectators watching moving images are aware of the fact that whatever they see is fictive and virtual. The images show representations of objects or characters and not their original referents, thus by seeing these representations instead of their referents a state of disbelief arises which has to be suspended in order to belief the images [38]. More precisely, in order to be able to connect with the content they need to suspend this disbelief in the fictional representation, as a precondition. Only by suppressing this disbelief they are able to make a connection to the fictional content and thus either accept it as *real* or ignore the elements in the medium that appear artificial.

Suspension of Belief

As previously mentioned, Torben Grodal has a different approach to the suspension of disbelief. He criticises the theory that film viewing involves seeing images and consequently does not agree with this derivation of the suspension of disbelief. In his opinions people do not see images but perceive light waves which cause neural actions.

> *"The humble neurons in the rear of the brain cannot distinguish representations from the real thing".*
>
> *Grodal [38]*

Consequently individuals cannot differentiate between an image of an object or the real object. When following Grodals argument spectators of a film are not able to distinguish between the fictive images and reality. Therefore, instead of suspending disbelief they have to suspend belief when watching a movie to avoid fleeing the cinema in when watching a scary movie [38].

Not only Grodal takes a critical opinion on the idea of suspending disbelief. Already in 1978 Eva Shaper discusses the topic of *Fiction and the Suspension of Disbelief* [42]. She brings up the same problem as Grodal:

> *"If […] the disbelief entailed by our knowing that we are dealing with fiction and that the characters and events are not real, then we do have a problem: only if I suspend the disbelief in their reality can I reasonably be moved by what happens and only if I hold on to my knowledge of their non-reality can I avoid becoming the naïve backwoodsman who jumps onto the stage trying to stop the characters […]."*
>
> *Shaper [42]*

Shaper offers an interesting approach to solve the dilemma. She suggests that:

> *"knowing entails believing and an emotional response presupposes some beliefs about that to which one responds."*
>
> *Shaper [42]*

In other words in order to emotionally respond to a situation people need to have formed beliefs about the situation the character is in, which they then can respond to. This emotional response can also happen in case of a fictive character, as knowing that this character is not real does not alter the beliefs in the situation the character is in. Holding on to the beliefs on how these characters might feel in their fictional situation does not mean that people have to believe there characters exist [42]. In short, in order to emotionally respond to fiction it is required to belief and not disbelief.

Steen and Owens [32] bring up an example of a four-year old boy who jumped from a seventh floor building. The boy miraculously survived the fall and stated in the hospital that he thought he was a Pokémon and would be able to fly like one [32]. This suggests that he actually confused the virtual character with himself [32] which could lead us to the conclusion, that he truly believed in the fictional content, to an extend that he did not distinguish between reality and fiction anymore. This indicates that he did not need to suspend a disbelief in the movies, as he did not see the movie as fictional content but as part of his reality.

Greg Martina comes to a similar conclusion is his thoughts about the willing to suspense disbelief [41], he suggests that

> *"[…] we have become so accustomed to living so much of life in other states of reality that real-life events sometimes seem fictional. We experience the sense that an event in real life feels like a scene from a movie."*
>
> *Martin [41]*

Again, this is an example of blending the fictional events with reality. The border where the fictive experience ends and reality begins appears to blur. The effect of intermixing reality with fiction could imply that people use the same mechanisms to recognise reality and representations. This would indicate that we need to suspense belief in order to remind us of our surroundings.

In his book on *Image and Mind* Gregory Currie suggests that

> *"viewing the cinema screen is […] in important ways rather like viewing the real world; it is not at all like viewing someone's subjective visual experience of the real world (a notion that barely makes sense anyway)."*
>
> *Currie [30]*

That is to say that the spectator does not take an indirect approach to the presented imagery by thinking that the movie is someone else, the experience appears to be more direct. He also brings up the question if the spectators imagine themselves to be observers of the fictional events by being placed within the world of fiction [30]. He doubts that spectators identify their visual systems with the camera and hence imagine being placed where the camera is [30].

> *"When I say "film watching is similar to ordinary perceptual experience of the world", I mean that film watching is similar to our ordinary perceptual experience of the world. "*
>
> *Currie [30]*

Currie's arguments appear to support the idea that the experience of fictional content is processed in the same way as reality. This supports the idea that viewers have to suspend belief, rather than disbelief when watching a film.

Thesis Definition: Acceptance

Acceptance is achieved when the presented stimuli meet previously formed expectations and thereby let the spectator get into the experience. Acceptance requires the spectator to belief in the imagery and is in danger when fictive elements on screen look unreal. With the acceptance of the imagery the need for suspension of belief arises.

Summary

Summing up, all presented theories agree that it is possible to *let go* of the real environment and build up a relation with the characters or objects represented on screen. This could be due to fact that people suspend their disbelief of watching images or by believing in the images right from the start. Important is that (distinguishing between reality and representation) people use the same recognition process to identify the objects for reality and representation. Both the belief in reality and the suspended belief would be in danger when fictive elements on screen would look unreal and thus would remind the spectator that it is indeed a representation they are seeing. A final important point that theories stated so far all appear to agree with is that the spectators refers to previously formed beliefs, as well as to their very personal and individual experiences or circumstances.

In relation to the problem statement of this thesis it is highly important that the people are willing to belief when watching the advertisement. Only when the presented content (especially the VFX) can meet their expectations they would allow suspending their disbelief or would be forced to suspend belief. If however the VFX distracts the spectator it is a reminder of the virtuality of the presented imagery and hence ruins the desired effect.

4.3 Concerning Hyperrealism

So far it was argued that people recognise the presented imagery by matching their shapes to elements they have seen before [3.5 Experience & Schemata]. Although all chairs look different everyone can still identify a chair when seeing one (no matter if on film or in real life). The reason why humans are so good at identifying chairs is because people have been interacting with them in real life. Based on the knowledge acquired during these chair-interaction-sessions people cannot only identify a chair but also give a very detailed description of one.

But what about things or elements that people have not seen in real life but somehow still know how they look like?

The dinosaurs in the film *Jurassic Park* [24] combine the actual with something possible and thus create a non referential but still believable image [43]. By building on the knowledge that science has from dinosaurs they created a possible world which made the inconceivable conceivable [43]. In other words, based on the archaeological findings from scientists a probable reconstruction of dinosaurs was attempted, by using all the available information and filling the gaps with possible setups the dinosaurs came to life. If their skin or movements looked the way presented in the film Jurassic Park cannot be proved or disproved. Although no one currently living actually saw a dinosaur in reality the majority of people around us would be able to give at least a rough visual description of one.

For instance, Buckland considers the dinosaurs in Jurrasic Park as a combination of both, visible and invisible effects: "the crucial aesthetic point in relation to the digital special effects […] is that, while clearly visible these effects attempt to hide behind an iconic appearance, […] they are visible special effects masquerading as invisible effects. [43] .184-185"

The idea that fictive characters can be considered iconic is supported by Currie who mentions that

> *"at the movies, we do not see, nor do we imagine that we see, fictional characters or events. Rather, we see signs: pictorial or "iconic" signs which tell us what it is appropriate to imagine [30] p.195."*

This is an important point when considering it in the context of the current research. When visual effects are created in a way that spectators are not able to differentiate between the visible and the invisible effects it implies that they accept presented effects as part of the image. It does not mean that they necessarily think that the image is real or photorealistic, as Buckland pointed out, the effects might hide behind an iconic appearance.

> *"The special effect in films […] attempt to combine the aesthetics of both visible and invisible digital special effects – […] they have the potential to replicate the realism and illusionism of the photographic image by conferring a perfect photographic credibility upon objects that do not exist in the actual world [43] p.190. "*

With this Buckland states that it is possible to create a credible illusion of something that does not have real life referent. When considering this from a philosophical point of view it relates to an idea formulated by Jean Baudrillard [44]. Baudrillad talks about an *"area of simulation which is inaugurated by a liquidation of all referentials* [44]*"*.

When signs of the real get substituted by the real a hyperreal is created [44].

> *"A hyperreal henceforth sheltered from the imaginary, and from any distinction between the real and the imaginary, leaving room only for the orbital recurrence of models and for the simulated generation of differences."*
>
> *Baudrillard [44]*

In other words, if something is more real than real it becomes hyperreal. When reasoning about Baudrillard, Coulter quotes that

> *"the strong lesson of contemporary simulation is that the old relationship between sign and referent have become reversed ."*
>
> *Coulter [45]*

In other words people accept the simulated imagery as a sample of the real. For instance, when someone watches a historical movie which is based on a true event, he might assume that the movie shows how the events were. However, a movie only reveals one perspective on the events that happened and might be distorted by the vision of director. Hence,

> *"today so much of our so called 'reality' is filtered through the media, including tragic events of the past ".*
>
> *Coulter [45]*

The effect that represented imagery might influence peoples' views or believes on occurrences in the world or past could be adapted to a variety of situations. The effects might just as well happen for events or incidents that everybody knows can happen, but have no idea how they would look like. Natural catastrophes, war scenes, expeditions to far places in the world – as most of the viewers have never experienced a situation like that, they might more easily accept the imagery presented. They might know that the story itself could be true but if the images illustrating it are closer to what one thinks it would like than to how it does? In such a case a hyperreality is established, which is accepted by the spectator nonetheless.

The existence of this hyperreality can be very useful for the creation of VFX. It means that VFX studios do not need to simulate photorealism anymore – but hyperrealism. This can of course only be applied to elements, objects or incidents that the majority of the population has not yet seen in reality. For instance, any setting or element out in space, a plunger deep down in the ocean or simply a hurricane and an explosion – everyone could identify it on an image but only few people saw them in reality. In other words, in order to represent these elements the VFX creators are not competing with reality which can be used as an advantage.

When considering hyperrealism in combination with VFX the question arises how detailed the representation it needs to be. Currie mentions that

> *"what appears on the screen always surpasses in detail and clarity the possible content of anyone's memory ,"*
>
> *Currie [30]*

which indicates that the stored knowledge is lower than the details represented on screen. Hence it depends on the level of resolution of the previous exposure of hyperrealistic elements if the quality is perceived as acceptable.

Merging visual effects with the image is the basic way of compositing in which the

> *"optically produced composite fabricates a spatio - temporal unity, giving the impression that the two separate events are taking place at the same diegetic time and place".*
>
> *Buckland [43]*

In order to make the visual effect even more convincing a seamless fusion of live action and computer generated imagery should be established [43]. This means that in order to integrate visual effects successfully into the film footage it is important to create a unity between them.

Thesis Definition: Hyperrealism

Spectators have not yet been exposed to hypererealistic phenomena in reality. Hyperrealistic simulations lack a real-life referent.

Summing up, with the use of VFX it has not only become possible to imitate the real world on a screen but also to create a credible illusion of it. Hence, hyperrealistic elements, which lack a real life referent, can be created. As people have no experience with the hyperrealsitc elements in real life they cannot evaluate them critically. Additionally, the memory of elements shown on screen is less detailed than the actual representation. This opens up the possibility of using the lack of detailed memory of hyperrealistic elements when simulating them.

4.4 Fluid Simulation & Workflow

This chapter will delve into how the workflow of creating fluid simulation is and which approaches and methods are available in such a process. Lastly, this chapter will chose which specific simulations this thesis should design, implement and test upon.

In the time of writing this report, fluid simulations are considered a very computational heavy task for the workstation computer to perform. A regular particle simulation can be simulated and displayed in real-time with thousands, even hundreds of thousands of particles, whereas a fluid simulation cannot.

Thesis Definition: Turnaround time

Turnaround time is the total time taken between task submission to the 3D software for execution and the return of the finished outcome to the end user [16].

Turnaround time is crucial in the VFX industry. The less iteration needed to accomplish the desired effect of a simulation the more optimised workflow and the less budget used. Fluid simulation is considered the hardest simulation type to work with due to its computational requirements. Different approaches have been used to optimise the workflow – usually the upscale method.

Upscale

Simple particle simulation has the ability to increase the resolution at any time during the creation process. The process in possible because particles are not complex systems and have minimal relationship with each other, thus can imitate same behaviour with fewer or higher amount of particles. Here upscale of resolution is considered a straightforward process [28]. The regular particle workflow starts by creating a low resolution simulation, which is based on a number of particles, to be able to preview the simulation in real-time in a 3D simulation software. When the desired effect is achieved the particle count can be increased by an infinite amount for the rendering stage.

However, this is not the case with fluid simulation. The structure of fluids is complex and an upscale of resolution is not a linear task. By increasing the amount of particles in a fluid simulation, the forces changes and thereby the relationship between fluid particles alters, which will lead to different behaviour [28]. This makes fluids hard to work with. Most commonly in computer graphics fluid simulation algorithm functions by dividing 3D space into units named *voxels*.

Thesis Definition: Voxel

A three dimensional volumetric uniform element with the purpose of dividing 3D space into this unit. A voxel is the three dimensional correspondent to a two dimensional pixel.

An area of the fluids is only limited to the number of voxels, which can be infinite. The density of the voxels is referred to as the resolution of the fluid simulation. The higher resolution yields clearer and better detailed representation of a given behaviour. This includes how the fluid interacts and the interaction with other objects in the scene. The fluid will look thick and sticky if the resolution is too low, even with a correct correspondent viscosity [46]. In addition to resolution, particles inside a voxel can be sampled and thereby create detail.

Figure 4.2 This is the same fluid simulation in both images, but the voxel definition is 5 times greater to the right [46].

> *The amount of memory needed goes up with the cubed value of the resolution, meaning that slightly higher resolution can take considerably more memory.*
>
> *Tony Mullen [46]*

The use of computer memory is extensive when increasing the voxel definition. The computer strives to preserve the simulation cached in memory in order to display the result real-time. This becomes a bottleneck for the VFX artist. On one hand the artist wants a fluid simulation that is possible to manipulate with different parameters in real-time. On the other hand the artist wants precision and fineness of the simulation to acquire the small details, e.g. a liquid splash.

Consider the water simulation in Figure 4.2 as an example of the difference in turnaround time. The simulation to the left has a low voxel definition. Let's imagine it consist 10.000 particles and the turnaround time for the simulation to finish a 10 second duration takes about two minutes. The simulation to the right has a voxel definition that is 5 times greater, generating a particle count of 1.000.000.000.000 particles because voxels are three dimensional, thus 10.000 to the power of three. While the particle count increases by the power of three the turnaround time has an even great escalation, due to the fact that the more particles a fluid system consist of the more collisions will occur. With collisions the system also needs to calculate all the forces, velocity and other material properties involved in such a simulation. The turnaround time is hard to predict but would definitely be at least 30 minutes. This indicates that a two minutes turnaround time increases to 30 minutes by a voxel definition rise of 5. Now consider an ocean, and how the turnaround time will be a problematic workflow.

Scenario One – low to high: If the artist begins with a low resolution simulation, the turnaround time is fast, almost real-time, but the need to higher the resolution arise when the basics of the simulation is accomplished. The artist will most likely end up altering the accomplished simulated by increasing the resolution. A scenario that was not part of the artists desired workflow. Now, the slower and more computational simulation needs to be modified to have the same behaviour as before and subsequently incorporate the fine details. The turnaround time has increased tremendously and the workflow has become tedious [46]. This upscale process will repeat itself until the artist is satisfied with the detail lever and the movement and behaviour of the simulation. It is considered very important to upscale the resolution in small step due to the major influence in change of behaviour, thus a larger increase will result in a great change and thereby loose the current desired behaviour. In this approach it is common to use several resolution steps before ending at the desired level.

Scenario Two – high: Alternatively, a high resolution simulation could be the starting point for the VFX artist. This process is tedious from the beginning. The turnaround time is slow and many iterations is needed to acquire the desired effect. This workflow could easily end up becoming a slower approach due to the extensive turnaround time. However, this is the preferred workflow in the industry. Some effect must start from a high resolution due to its design and effect, e.g. an ocean, would not be possible to simulate with a low resolution. Such a task could easily end up with days of simulation time because of its complex forces and structure [28].

If the VFX supervisor does not know where to keep the resolution, the production cost increases. When are details visible to the eye of the audience and is it necessary to reproduce the real world's phenomena in great detail to convince the audience? Both approaches will require lots of iterations, due to the complex nature of building a fluid simulation. These iterations functions as turnaround time. Consequently, it is essential to keep the turnaround time as low as possible to be productive, but without detail the time used in the lower resolutions can be wasted. The two scenarios described above is the core problematic workflow that needs optimisation.

The entire concept of upscale workflow and voxel definition will be the foundation for this thesis testing. Whether is it needed to upscale the resolution to create more detailed simulations versus the audience perception of these details. The lower the border of audience acceptance is the more efficient VFX workflow, due to faster turnaround time.

Solvers

This chapter has the purpose to determine which type of solver to use for the following choice of fluid simulation. Solvers are the basis of fluid simulations. To calculate a fluid simulation a solver is needed. A solver is the mechanism that calculates all the particles within a fluid simulation and thereby figures out how particles react and move according to each other. The solver uses the chosen algorithm and the given input (objects, fluid surface and all the parameter) to solve the equation and give a simulation output. These parameters vary from the type of solver and which 3D software chosen, but generally solvers have around 20-40 parameters from physics field, forces gravity, density, divergence, variational velocity etc., two important once are; sub-steps and voxel definition. Furthermore, solvers are often created for one purpose, making their pre-programmed algorithms specific for their task. Smoke, gas, liquid, fire solvers are common in larger 3D simulation packages.

In general a solver does the following in each frame: Start by applying forces to object, looks for collision, calculate the collection and repeat those step until it cannot find any collision.

A solver calculates the entire fluid simulation once per frame. However, if the need for more precision is necessary, *sub-steps* divide the frame into iterations of calculations. A sub-step of five will give five calculations between two frames, instead of only one. Often sub-steps used to insure that the majority of collisions are detected. These parameters are fundamental knowledge when deciding on which fluid simulation to focus on in the following chapter.

4.4.1 Choice of Fluid Simulation

Fluid simulation is a wide range of different effects that have a common bound, they move by the laws of flow as described earlier in this report. What differentiate them is how their respective solver functions and which algorithms are used in order to simulate the desired effect. Liquid solver such as water has a very different simulation structure than for instance a hurricane which would use a gas solver. It is essential to delimitate the field of fluids, and thereby produce specific and useful research for the VFX industry. There are several types of fluids that can be researched, but for the sake of a narrow and scrutinized report, only two types will be chosen. This choice will be made with the intension to simulate some of the most commonly used simulation effects in the industry. Smoke and fire are basis for lots of general effects and are thereby great to base this thesis upon. Furthermore both are simulated by the gas solver, which takes it interesting to compare. Hence, this project will investigate the simulation of smoke and fire, and thereby only work with the fluid solver of gas.

Smoke is fascinating due to its appearance and how humans relate to it. The exposure of a smoke grenade, cloud or other related smoke situation does not happen for people very often. Hence, the overall shape of a smoke cloud is considered common knowledge, but the specific details and exact movement patterns of smoke might be a more difficult task to explain in depth. This thesis assumes that smoke is a hyperrealistic element [4.3 Concerning Hyperrealism]. Consequently it is interesting to determine the border of audience acceptance in smoke simulations, as how they perceive details and have the capability to relate it to their expectations as their personal interpretation of real world smoke.

Fire on the other hand is a phenomenon people are exposed to more frequently. Candlelight, gas stove, fireplace or bonfire are common places to observe fire. Fire is therefore not considered a hyperrealistic element. These two simulation categories allow a test of whether the previous knowledge of a phenomenon has influence on the border of acceptance. The thesis strives to optimise the turnaround time and thereby the workflow of a VFX studio. Smoke and fire simulations with different voxel definitions would be tested upon to determine the desired border of acceptance.

Voxel definitions are relative to the type of simulation needed for a job. There are multiple ways to determine which end resolution is needed for the effect. One is to use the same resolution as the final output, meaning that a full HD (1920 x 1080) would have simulations of maximum 1080 voxels. This is however extremely high and are considered Hollywood workflow and not within the scope of this thesis. Low budget productions typically have a voxel definition from 100 to about 400. These definition settings are not related to the output resolution, but rather the production costs of such an effect. These voxel definitions will be used in the design of the upcoming preliminary tests as a reference for the industry. It is a precondition to have at least two different voxel definitions to determine the border of acceptance within this thesis.

4.5 Synthesising the Model

Recapping so far this research analysed how people recognise objects and elements in reality, as well as representations [3.4 Perceiving and Recognizing Objects]. The influence of media exposure was discussed and schema theories were presented [3.5 Experience & Schemata]. Furthermore, it was argued how the perception process works [4.1 The Perception Process] and that believing the imagery is a necessary step to achieve acceptance by the spectator [4.2 Suspension of Belief]. Finally the construct of hyperrealism and its effects on perception have been mentioned [4.3 Concerning Hyperrealism]. In order to use the presented theoretical background for the current research it is vital to apply these theories to the ambition to optimise the limited budget VFX creation process. Pursuing that aim the following model attempts to use previous knowledge of the spectator to achieve acceptance of imagery despite a low voxel definition of the fluid simulation.

4.5.1 The Expectation & Belief Model

The *Expectation & Belief Model* (EBM) is based on the assumption mentioned by Grodal [47], that spectators cannot distinguish between represented objects or real ones and hence have to remind themselves of watching a movie (rather than suppressing the thought of watching images). When assuming that people recognise representations as they do in reality then it can be assumed that they are able to form schemata based on what they perceive. The EBM was developed following the example of the PECMA model by Grodal [47] but focuses on the second and third stage, the associative networks and the cognitive centres. In these stages the reality status of the perceived stimuli is assesed and the visual elements are matched to previous knowledge. The fundamental assumption of the EMB is that hyperrealistic elements are stored with limited detail in the memory of the spectator [4.3 Concerning Hyperrealism]. By abusing this lack of detailed memory the spectator is expected to accept a VFX depsite a low definition. As derived in an earlier chapter, a difference can be made between conform and non conform elements in the visual field [3.5.1 Influence of Schemata]. If the hyperrealistic elements are conform to the rest of the presented imagery it is assumed that they would only be schmeatcially processed. Oppositional, non-conform elements would be analyised with greater discriminative accuracy. Detecting the hyperrealistic elements in the prestended imagery means that the spectator becomes aware of the fact that part what they perceive is gernerated. In case the VFX has an unreal appearance and distubres the viewing experience the spectator is will not be believe the imagery anymore. Yes it is also possible that spectators notice the usage of VFX but still accept the presented imagery. In some cases the logical analysis of the imagery can lead to the assumption that the VFX must have been used. However, due to a seamless integration into the image the spectator accept the imagery.

Joining the dots on how hyperrealistic represeantions are perceived results in the following model:

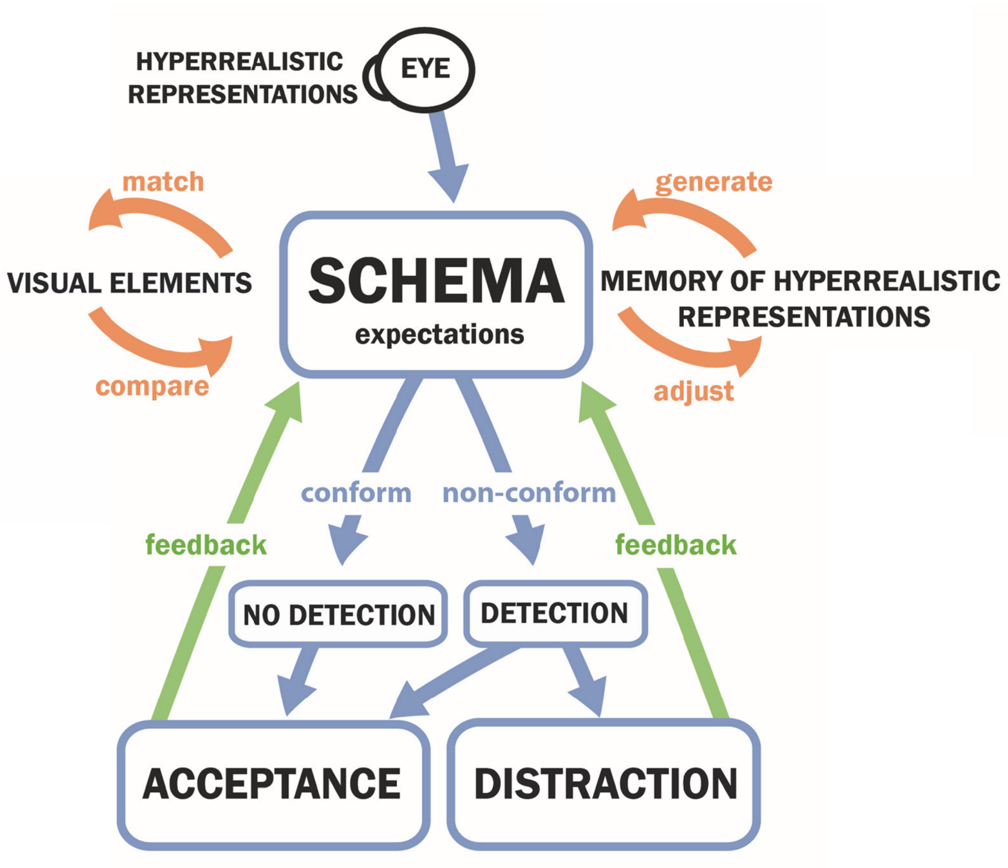


Figure 4.3 The Expectation & Belief Model

4.5.2 Stepwise Explanation of the Experience & Belief Model

The EBM maps out the process from the exposure to hyperrealistic representations of phenomena (that have previously only been perceived as representations [4.3 Concerning Hyperrealism]) until the moment of acceptance or distraction of the perceived visuals.

The PECMA flow model starts with the sensory input device, the eye [47]. Following Grodals example the EBM starts at the moment when the eye perceives the presented stimuli as shown in Figure 4.4. This first step of the EBM comprises the analysis of all elements in the visual field.

Figure 4.4 EBM: Perceiving Stimuli

The next step of the EBM refers to schema theories [3.5.1 Influence of Schemata]. While analysing all elements a schema is selected matching the stimuli. This selection can be updated over time if new elements appear in the visual field. The schema, which is called for, brings up a previously established set of expectations as depicted in Figure 4.5. As derived in [3.5 Experience & Schemata] depending on the previous experience with the context of the representation and the hyperrealistic phenomena the schemata is completely different from person to person [48].

Figure 4.5 EMB: Schema & Expectations

Based on the selection of the most suitable schema, the next step is to identify if the elements in the field of view (in this case in the representation) do or do not match the chosen schema. Hence, all the visual forms in the visual field are compared to the selected schema as shown in Figure 4.6.

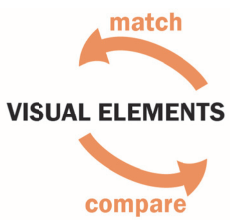


Figure 4.6 EBM: Matching visual forms

At the same time, the memories of the represented hyperrealistic element are accessed. The memories of hyperrealistic elements have previously generated a schema (otherwise it could not be called for). As mentioned earlier, schemas can be adjusted over time as depicted in Figure 4.7. If an element consistently appears in an unexpected context it might be added to that schema at some point and consequently turn into an anticipated element.

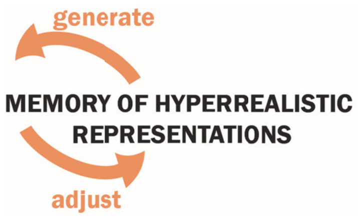


Figure 4.7 EBM: Calling for the memory

In the process of matching all the visual forms in the field to the schema it will be determined if an element in the visual field does not fit. As mentioned in [3.5.1 Influence of Schemata] a distinction is made between schema conform and non-conform elements.

In case all visual forms are matched to the schema and are judged to suit the context, the EBM depicts that the elements are perceived with less detail, in a rather schematic fashion. This lowers the chance that the hyperrealistic element gets detected as such by the spectator, as shown in Figure 4.8.

Figure 4.8 EBM: conform elements remain undetected

If the hyperrealistic element remains undetected the imagery will be accepted by the spectator, seen in Figure 4.9. As mentioned at the beginning, the EBM assumes that the spectator perceives the images as reality as the same recognition process is used [3.4.2 Perceiving Representations]. In case the perception of the imagery results in acceptance then the spectator believes the imagery and consequently needs to suspend belief [4.2 Suspension of Belief]. The PECMA flow model would consider this the evaluation of the reality status of the presented stimuli [47].

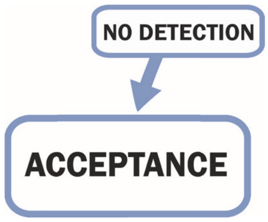


Figure 4.9 EBM: Acceptance of the imagery

In case elements in the visual filed to not suit the selected schema the EBM anticipates that these elements will be processed in more detail, which is depicted in Figure 4.10. Processing a visual form with greater discriminative accuracy would heighten the chance of detecting the hyperrealistic element as virtual. Identifying an element that is non-conform to the context could also lead to a reselection of the schema. Either way, at that point the non-conform element has already been evaluated with more care.

Figure 4.10 EBM: Non-conform elements lead to detection

The detection hyperrealistic elements can result in two different outcomes: either in distraction or acceptance of the imagery. If the hyperrealistic element is detected as VFX due to its unreal look it will remind the spectator of watching representations which results in distraction and thereby causes the state of disbelief [4.2 Suspension of Belief], as shown in Figure 4.11.

Figure 4.11 EBM Detection can result in distraction

But detecting the hyperrealism must not automatically distract the viewer. If the hyperrealistic element seamlessly integrated in the context and is only detected as VFX due to the logic evaluation of the imagery the detection of VFX can still result in acceptance, as depicted in Figure 4.12. A seamless integration of VFX can be achieved by using the theories of perceptual realism [3.6 Perceptual Realism].

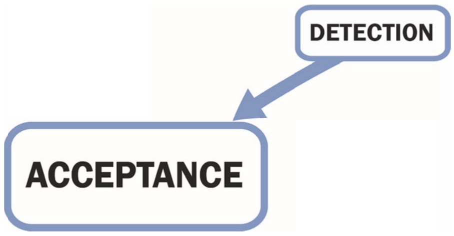


Figure 4.12 EBM: Detection can lead to acceptance

The insights gathered throughout the process are returned to the original schema as feedback, just as stated by Goodman schemas can change with development [49]. Feedback can be any information acquired during the perception process as depicted in Figure 4.13. Over time this feedback could adjust the schema or influence the level of expectations.

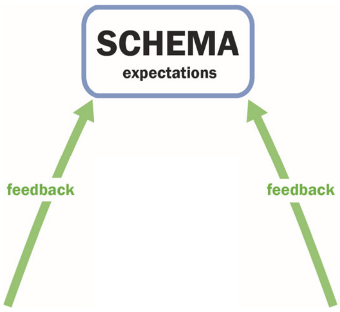


Figure 4.13 EBM: Schemas are improved by feedback

4.5.3 Using the Experience & Belief Model

In order to use the EBM solve the problem statement the implemented VFX needs to be a hyperrealistic element that should suit the schema of the advertising. If the VFX is successfully matched to the presented context it receives schematic processing and will consequently be likely to remain undetected. It would pass the moment of acceptance which implicates that the spectator (if the test setup is ideal) needs to suspense the belief that what spectator is seeing is real because it is a representation. Reversed this indicates that the acceptance or distraction is based on the expectations with the hyperrealistic elements in prior exposures. As hyperrealistic elements are suspected to be stored with limited detail in memory they are expected to be accepted despite a lower detail level.

In order to test the EBM it is going to be necessary to compare the perception of hyperrealistic representations to non-hyperrealistic representations, respectively smoke and fire. As the memory of non-hyperrealistic elements is presumed to be very detailed this enables the spectator to judge the fire more critically. Hence, if the smoke receives a higher acceptance rate than fire this model would be supported.

Important to note is that both elements need to fit the schema presented in the advertisement. Adding elements that appear out of place will almost certainly lead to higher detection rate due to the fact that they would attract attention.

In an advertisement more information can be revealed over time. If a new element is introduced that does not fit the current schema anymore this element will first of all receive more attention and might then induce a switch of schema. In case this element would receive more attention by the spectator and might affect the categorization of the entire presented material. This can be a turning point or a payoff line in the advertisement.

This chapter synthesised the theories introduced throughout the preliminary analysis and analysis to form the *Expectation and Belief Model*. This model will aid in answering the final problem statement.

4.6 Hypotheses

The most important findings of this analysis led to the creating of the EBM which has the purpose of answering the final problem statement. Four continuative hypotheses were formulated in order to thoroughly answer the problem statement. Each of them focuses on a specific part of the problem. By verifying these hypotheses the EBM and thereby the final problem statement will be answered.

1) Hyperrealistic representations are stored in memory with less detail than real life experiences.

2) People accept a less defined representation of smoke due to the vague smoke representation in memory.

3) The majority of people are distracted by high defined representations of fire due to their detailed memory of fire.

4) Low definition fire simulation triggers schema changes and results in disbelief.

Explanation

In the following analysis of the specific hypothesis the purpose of each will be clarified. Additionally, it will be stated how each of them will aid in answering the final problem statement. Lastly, the interconnection of the hypothesis will be described.

1) Hyperrealistic representations are stored in memory with less detail than real life experiences.

The first hypothesis covers the basic assumption of this research. As derived in the analysis it is expected that the memory of hyperrealistic elements depends on the quality of previous exposures [30]. On the other hand, real-world experiences with phenomena allow the spectator to perceive and store a very detailed version of it. This establishes the foundation for the manipulation of the VFX, as the idea is to utilise the gap of detailed memory to achieve acceptance of a low definition version. This hypothesis works as a proof of concept; hence if this is disproven there will be no reason for the further progress of this research.

2) People accept a less defined representation of smoke due to the vague smoke representation in memory.

Smoke was identified as a hyperrealistic element [4.4.1 Choice of Fluid Simulation]. The effect of this is that people do not have a detailed mental image to compare the smoke to and hence are expected to accept a low definition representation of smoke as derived in the EBM [4.5.1 The Expectation & Belief Model]. The answer will indicate where the border of acceptance for a hyperrealistic element would be defined. This hypothesis is required to be accepted by the future test in order to validate the EBM, as well as significant for defining the border of acceptance in the final problem statement.

3) The majority of people are distracted by high defined representations of fire due to their detailed memory of fire.

Fire is an element that people have a lot of experience with [4.4.1Choice of Fluid Simulation]. Based on that fact it can be suspected that they have a more detailed memory of fire and hence can identify it very well so that even a high version of fire will be detected. As soon as a doubt on the realness of the fire occurs [40] it will be processed in a more detailed manner [33] [34] and if identified as CG will ruin the acceptance in the image [42]. This hypothesis will work as an opposing argument for the second hypothesis. The idea is to prove that fire, which is a non-hyperrealistic element, would be less likely to be accepted, even at a high definition. If proven, this will strengthen the verification of the second hypothesis. Furthermore by proving this, an indication of differentiating the amount of definition needed for various effects, thus optimising the workflow of VFX.

4) Low definition fire simulation triggers schema changes and results in disbelief.

During the process of analysing the presented stimuli all the elements in the perceptive field not only compete with each other [5] [6] but are also matched to select a schema [33]. Once a schema is selected new information will trigger either an update the existing schema [34] or to select a completely new schema. Low definition fire is expected to induce a schema change, as people are assumed to be more critical to fire representations. The identification of the fire as a VFX will furthermore ruin the belief in the image. As the third hypothesis, this will with a verification result in a clear differentiation of acceptance between hyperrealistic and non-hyperrealistic VFX.

The further progress of this thesis will need to establish requirements and make a selection of the advertisement needed for testing. This is possible with the theoretical basis, the VFX simulation chosen and the hypotheses defined.

5 Advertisement Selection

The following chapter will delve into the requirements and the selection of the advertisement used for future testing of the problem statement. The advertisement selection is built upon the previously chosen fire and smoke simulation [4.4.1 Choice of Fluid Simulation]. The chosen simulations must be possible events in the selected advertisement. Several parameters need to be described in order to acquire the best advertisement for further testing of this project. These requirements will be discussed throughout the following chapter.

Suitable VFX

It is a requirement, that the smoke and fire added to the selected advertisement thematically suit the context. If the implemented VFX elements are not schemata conform they would receive more attention. Then, no matter what the detail level is, the chances of spotting the VFX are heightened. Furthermore, the VFX should not influence the story of the advertisement, as the advertisement must still make sense as whole. The implemented VFX may not change the message, nor the overall appearance of the advertisement.

Clear Message

A fundamental part of testing advertisement is how clear the message is delivered. A need for an easy understandable advertisement is the first and foremost requirement. The test subject would need to understand the content of the ad before it would be considered valid to question the subject in any related topics.

Minimal Dialog

Dialog was the biggest focus demanding area in the previous project [1 Zero Detection Summary]. It took all the focus from the effects which were the intension to test. Such a situation must not be redone. It is therefore very important that the chosen advertisement does not require the audience to follow dialog to understand the overall message.

No Visual Effects

The advertisement should only contain film footage and no visual effects, such as explosions, fire, etc. Colour corrected footage is of course allowed. This is important that the future implementation of smoke and fire simulations is the only simulated effect. Otherwise it could result in misleading test analysis from test subjects answering questions in relation to another simulation or effect in the advertisement.

Long & Steady Shots

The advertisement may not contain rapid editing, short shots and shaky camera movement. It is crucial to have long and steady shots for optimal audience perception of the content, as a continuation of the gained Zero Detection experiences. Furthermore, it is expected that the viewer perceives the VFX by these long shots which is fundamental because this thesis works with visible effects.

High Quality

As a baseline the advertisement quality must be at industry standard level. There is no point of this thesis research if the quality of the advertisement does not meet the minimal requirements of the VFX studios and their clients.

Duration

Advertisement comes in multiple durations. Some are only 10-15 seconds, a regular duration is about 30 seconds and it is possible to have advertisements in duration of minutes. The required duration for the future testing is 30 seconds. This is chosen due to the length of the exposure of the VFX and it will meet the standards of advertisement.

Foreign Advertisement

It is the optimal situation if the audience would be unfamiliar wills the advertisement. Therefore a foreign (non Danish) advertisement would be selected to minimise the possibility of the audience knowing the message and the advertisement brand. Furthermore, the language must be in English to enable a larger group of test subjects to participate in the testing.

This concludes the requirement involved in choosing the best advertisement for this thesis. The following sub chapter will delve into the selection of the advertisement.

5.1.1 Selection

A selection was made after a thorough search for an advertisement capable of encompassing every single requirement above. Allstate, an American insurance company created a campaign for promoting their motorcycle insurances with the payoff; "Bikes never crash alone" [50]. The campaign advertisement illustrates bikes crashing with no rider on them. Three motorcycle crashes are depicted as the main storyline. The entire shot is kept in extreme slow motion, and consist only of a couple of shots with long durations. The background music is subtle keeping the advertisement in a calm mood. Hence, it is not perceived as an action packed commercial, but rather a controlled review of accidents. The advertisement has a very clear message with no dialog at all, directing the focus on the visuals. The message is delivered throughout the advertisement, and shown in the payoff at the end, illustrated in Figure 5.1, followed by the company logo and contact information. It has great potential that no dialog is needed to deliver the message. The focus of the audience can be directed on the visuals which enables this project to test various fluid simulations.

Figure 5.1 Screenshots from the Allstate Bike advertisement

This slow motion advertisement delivers great detail at a pace that enables the human eye to capture great parts of it, which is a key element in the selection of the advertisement. This detail level will be used to test whether a test subject perceives the fluid simulation as part of the advertisement and its details. Hence, the requirements of high quality and long steady shot have been fulfilled.

In addition, the need for no VFX is crucial to the selection. It must not contain any simulation effect as described above. The advertisement is solely created by using Special Effects. The motorcycles are crashed using cars, cranes and other stage equipment, but no added effect. The effects are natural caused by the impact. The duration is 30 seconds and the American ad is in English.

Conclusively, the chosen advertisement fulfils all the requirements and has indeed great potential as a baseline for future testing. The slow motion, long duration shots combined with no dialog offers ideal opportunities to perceive the implemented fluid simulation.

6 Test Methodology

It is the aim of this chapter to outline how testing will occur in the later phase of the project, to thoroughly explain the considerations in planning the tests, how the strategies of the tests are and how the findings should be analysed and understood in order for the problem statement to be answered.

The test method prepares the testing phase in which the problem statement will be answered by using and evaluating the synthesised Expectation and Belief Model. The idea is to conduct a series of initial tests to create a proof of concept and confirm basic assumptions. Afterwards, two tests will have an iterative setup in order to determine the answer to the final problem statement. The test methodology is developed to create a testable foundation for the requirements of the design. Therefore it is essential to state the test strategies before the design of the fluid simulation can commerce.

6.1 Determining the Method

To answer the final problem statement and the hypotheses the most useful method for the current research will be determined in the following paragraphs. The aim is to find a method that provides insights to the question if the audience notices reduced detail levels of elements they have not interacted with in real life. Consequently, finding out at which detail level test subjects notice the implemented VFX is essential.

In the current study it is expected that all test subjects have time enough to focus on the VFX, as the advertisement is in slow motion, with very long steady shots and the only thing displayed is one motorcycle crash at the time [5 Advertisement Selection]. It is essential to determine if the VFX made an impact on the viewer which either led to the distraction in the presented advertisement or to acceptance. This cannot be done by solely observing the test subjects, as:

> *"one of the problems [...] is that the observer doesn't know what users are thinking, and can only guess from what she sees ".*
>
> *Rogers, Sharp & Preece [51]*

Consequently, this observational method will not be used in the current study.

This indicates that a form of feedback is required. To choose the most suiting approach Blaxter, Hughes and Malcom [52] divide the choice of method in three steps: research families, approaches and techniques.

Research families	Research approaches	Research techniques
• Quantitative or Qualitative	• Action Research	• Documents
• Deskwork or Fieldwork	• Case Studies	• Interviews
	• Experiments	• Observations
	• Surveys	• Questionnaires

Figure 6.1 Research Selection Structure

Based on this division [52] is can be stated that deskwork was used to explore the theoretical background and to synthesize the model. In order to test the assumptions made so far the next step is to proceed to fieldwork. An experimental setup is needed to test the problem statement and the synthesized model.

Qualitative vs. Quantitative

The first and probably most crucial decision is if a qualitative or quantitative strategy should be used. Qualitative research has been defined as "exploring in as much details as possible [52]" and "achieving 'depth' rather than 'breadth'" [52]. Considering the current research, it is highly important to acquire the information if the participant detected the VFX but without directly asking for it. Any question bringing up the topic of VFX might lead the participants to an answer. Consequently, a qualitative research is deemed to be most appropriate for the current study.

Apart from the fact that questionnaires are in most cases based to conduct quantitative research one problem was highlighted *Zero Detection*. During that past research some questions on the questionnaire were partly misunderstood by the test participants. To ensure that the test subjects provide the information needed to answer the problem statement an in-depth discussion with the test subjects was chosen as a suitable solution.

A one on one interview setup could have been an option; however,

> *"another solution is to have two people work together so that they talk to each other. Working with another person is often more natural and revealing because they talk in order to help each other along [51]."*

As it could be helpful for the current research to have test subjects discuss the presented advertisement the idea was to form focus groups as primary research technique. Focus groups offer the possibility to interview several test subjects at the same time and use the interaction among the group members as additional source [52]. The downside of focus groups is that the participants might influence each other; this has to be accounted for in the layout of the interview.

Use of Cover Story

The current research relies on the fact that the test subjects watch the advertisement with a neutral mindset. Once they would know that this research investigates VFX their focus might shift to the implemented elements and hence bias the results. In order to be able to conduct the focus groups without the test subjects knowing the actual goal of the research a cover story will need to be used. A cover story can be an ethical problem as it implies that not all the information on this project will be shared with the test participants. The public's right to know [52] would demand to give the participants a complete explanation. In this case it was judged to be ethically justifiable to lie to the test participants on the true purpose of the study. The tests will be anonymous and only the experiences during the exposure of the advertisement will be asked for, hence, these sessions will not take advantage of the participants' lack of knowledge to obtain fraud information. The cover story used will state that the project intends to investigate the effect of slow-motion scenes is film. This fits to the selected advertisement and gives a good platform to ask project related questions.

Data Collection

There are multiple ways to gather data in an interview setup, Preece, Rogers and Sharp [51] suggest the following three possibilities: The first and least technical would be to use notes and a still camera covers the interviews. When working alone the test subject could easily get bored when the interviewer is taking the notes, when working in pairs the problem remains, that the notes have to be readable and understandable, even after several interviews [51]. The second option is audio recording and still camera. An audio recording is less intrusive than a video recording, however lacks the visuals.. The last option suggested by Preece, Rogers and Sharp [51] is a video recording. This is the most complete way of documenting a test, but can be intrusive [51].

It is important, that the test subject feel at ease to talk about how they perceive the image and commit to the questions asked. Having a visual record is not as important, hence the decision was made to use audio recording. In order to make the analysis more efficient one person will lead and guide the interview whereas the other person will take notes of important thoughts given by the test subjects to speed up the transcribing process.

To be sure that the data collected from the test subjects is as unbiased as possible a controlled environment [51] was selected appropriate for this research so that differences in answers can be credited to the change of the presented stimuli.

Repeated Exposure

To be absolutely certain that every test participant has enough time to focus on every detail in the advertisement the decision was made to repeat the advertisement three times in a row. Repetition is an important factor of advertisement in general. People are likely to see the same advertisement several times and not just once. Especially advertisements on television are likely to be repeated several times during specific airtimes. Consequently, watching the advertisement three times was deemed appropriate to not yet bore the participant but ensure that everyone had the chance to not only focus on the message of the advertisement but also on the imagery presented. Another factor adding to this is the limited capacity model [53] which suggests that the cognitive amount to process stimuli is limited. As discussed the competition of the stimuli [5] [6] can be influenced by a variety of factors. In order to encompass the possibility that some spectators might not have the capacity to perceive the VFX presented on the first exposure, as their primary focus might be set on the message of the advertisement, the fact of repeating the advertisement three times assures that all participants had the time to perceive the advertisement in detail.

6.2 Preliminary Tests

Two preliminary tests will be used to verify basic assumptions for this research. These two tests will establish if people are able to identify different definition levels in smoke simulations and how well they are able to recall smoke clouds. It is suspected that participants are able to differentiate between a high and low defined smoke simulations and that they are better at recalling fire than smoke.

6.2.1 Pre-test: Expectations and Beliefs

As an indication for the first hypothesis it is required to establish how detailed people remember hyperrealistic and real life phenomena. As decided in the analysis [4.4.1 Choice of Fluid Simulation] fire was deemed as a phenomenon that people have seen previously in real life. The hyperrealistic element was chosen to be smoke. In order to determine how detailed both of these element are stored in the memory a technique is needed that will test the memory of the phenomena without influencing the participants. The solution is to ask demand test subjects to draw smoke and fire in two separate images. They will get the task to draw both phenomena in the highest detail possible. Although, the test subjects might have different levels of drawing skills comparing the two images will give an indication which if the two phenomena is recalled in more detail. It is suspected that they have a very clear idea how fire looks like, but not about smoke. The aim is to ask 10-15 people to draw smoke and fire. If it already crystallizes that people have a very detailed or a very rough memory of smoke these insights will be used to determine the high and low voxel definition levels for the following tests.

Results

A total of 15 people participated in this pre-test. Every test subject was provided with a pen and paper. The collected drawings of this test showed that participants had a harder time drawing smoke than fire. For many test subjects it was hard to relate to smoke, which resulted in the fact that several test subjects asked what is meant by *smoke*. It was not mentioned that the participants should put fire or smoke in a context however, 80% of the participants drew smoke and fire in a specific situation. Examples were the bonfire, a factory or cigarettes.

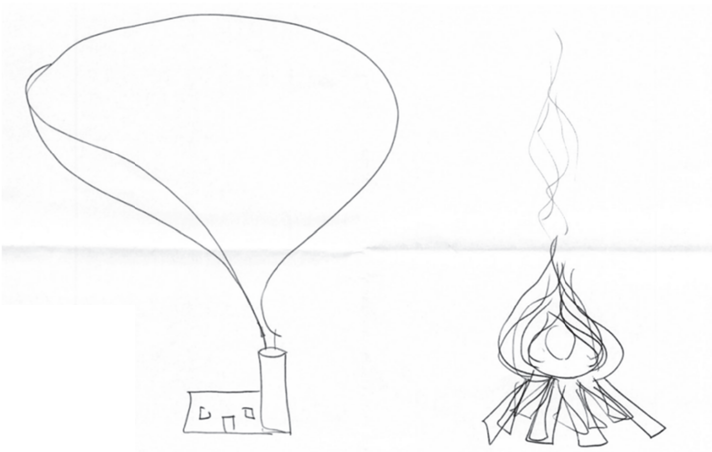


Figure 6.2 Test participant no. 11

When comparing the level of detail in the drawings it became clear that people were able to depict fire in a much higher level of detail, Figure 6.2.

An example of a participant drawing fire and smoke without context. Again, the fire is much more detailed with several flames and even sparks, illustrated in Figure 6.3.

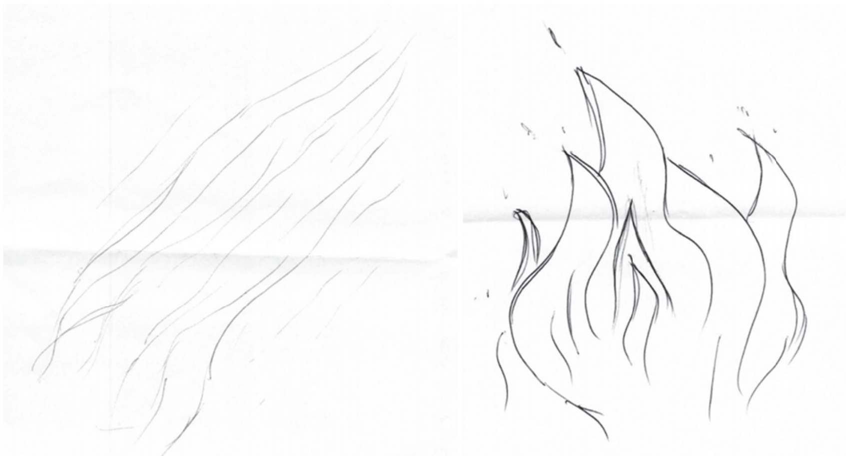


Figure 6.3 Test participant no. 5

From the first pre-test it can be concluded that people have difficulties in relating to smoke without creating a context for it. Just imagining a smoke cloud appears to be difficult and ended most of the time in a rather abstract than detailed image. Hence, it can be assumed that the participants had a clearer representation of fire than of smoke. This could indicate that smoke is harder to evaluate as fire.

Overall, this means that memory of the smoke seems to be vague or at least of little detail. This result can be used to an advantage when simulating smoke clouds. If people do not remember how detailed these clouds look, then it might not be necessary to simulate them in highest detail level possible. From the results of this preliminary test a tendency can be found that hyperrealistic representation (smoke) was overall less well detailed depicted than phenomena that people have experienced in real life (fire).

6.2.2 Pre-test: Perception of Smoke

The initial test is used to confirm that people in general are able to tell the difference between a high level voxel definition smoke simulation and a low one, as well as their perception of realism. A film clip of a single smoke simulation in front of a black background will be displayed in different resolution levels. The test subjects will be asked to bring the smoke simulations in the correct order starting with either the highest or lowest resolution. By sorting the smoke simulations the subject's ability to judge the detail level the simulations is tested. The expectation is that people are generally able to see the difference in detail when the smoke is displayed in front of a black background, without any context. If overall people are not able to tell the difference between the smoke simulations the voxel definition difference will have to be increased until they can clearly distinguish between them. The second task asked of the test subjects will be to let them rate the realism of the smoke simulations. This will show if people perceive the most detailed smoke representation as most realistic. It is suspected that some test participants will rate a lower detail smoke simulation to be most realistic, especially if they have never seen a big smoke simulation in real life before.

If the test subjects are able to distinguish between the low and the high smoke simulation then the same voxel levels will be used in the main tests, when the simulations are added to the selected advertisement. If the test subjects are not able to detect the low voxel setting anymore when merged with the advertisement, then it can be derived, that the context (hence the schema) affect the perception of the smoke simulation. Due to the placement in a context the smoke simulation might only be schematically processed and the low details level would not be detected. From the outcome of this test it will be able to suspect the outcome of second hypothesis. In case the test subjects are not of the opinion that the highest defined smoke cloud is the most realistic this would give the fist important indication that the low level smoke might not be spotted.

Results

15 participants were presented with a looped film clip of four smoke simulations. These four smoke simulations would run simultaneously and be consistently in the same random order.

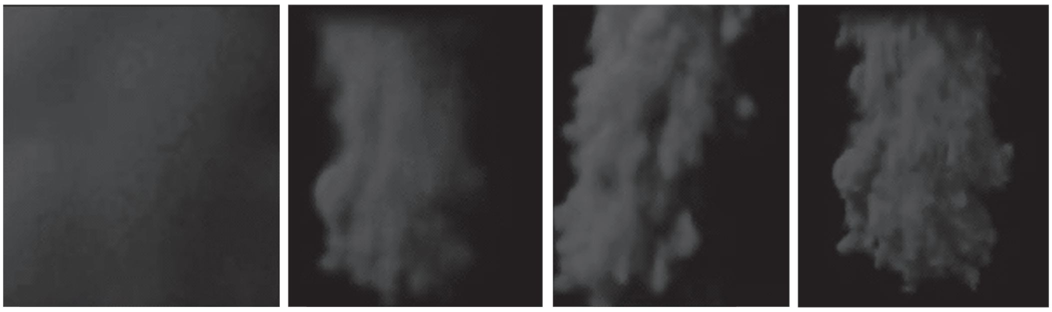


Figure 6.4 Four versions of smoke

The outcome of this test was that 91% of the test participants had the same interpretation of detail of the smoke simulation. This means that nearly all were able to put the four presented smoke simulation in the correct order.

When asked about the realism of the smoke simulation however, the participants' responses were split in half. Exactly half of the test participants chose for the most detail simulation to be the most realistic one. However, half voted the two middle smoke simulations to look most realistic (although they were less detailed). This shows that detail and realism are judged differently.

One participant brought up the question of if he should rate the smoke simulation according to "Hollywood realism" or according to "realism". This is an indication for the fact that depending on the schema that is called for the images get analysed differently. Once the participants rate the advertisement as Hollywood style, they might accept the low level VFX as they expect these effects and hence process them schematically.

Another important point that can be derived from these results is that due to fact that 50% of the test subjects rated the medium level smoke simulation as most realistic it can be expected that their memory of a smoke cloud does not consist of high level detail.

6.3 General Test Overview

6.3.1 The Baseline Test

The baseline test is the first test in the main phase of testing. It will serve as a control condition for the upcoming tests with either fire or smoke simulations. It will be conducted after the preliminary tests are completed.

The baseline test will check the general perception of the advertisement without any alterations. The test setup and procedure will be the exact same as for the following tests (same questions, same cover story etc.) only that no VFX is added to the advertisement. By doing this it will be able to determine if the spectators think that the original version of the advertisement includes VFX and if they think effects were removed from the film plate. Important to mention is that no VFX were used in the advertisement (expect for colour grading) [5 Advertisement Selection]. Comparing the baseline results to the results of the versions with implemented VFX will show the overall influence of the manipulations.

6.3.2 The Smoke Test

The smoke test will combine all the previous tests and is essential for the outcome of this research. This test will run in the exact same way as the baseline test, just one thing is different: a smoke simulation is added to the image. The smoke will be used in two different detail levels as an in between variable. One version entails the smoke in a high voxel definition and one in a low voxel definition. Each participant will be exposed to either the low or the high voxel definition version. The smoke will be implemented in the highest and lowest definition, as determined in the preliminary test.

The reason for this setup is to test if the audience is able to notice the difference between the smoke simulation once they are applied to a context. In the smoke test it will become clear if the schema selected for the advertisement has an influence on the perception. If the test subjects will not spot the low level smoke cloud then it can be derived that the smoke simulation was judged as schema conform and only schematically processed.

As expected in the second hypothesis the fact that people have no detailed memory of smoke will influence their perception of the VFX smoke simulation. In case the low defined smoke is not detected by the test subjects that will be an indication to support the second hypothesis.

6.3.3 The Fire Test

The final tests will focus on testing the EBM by comparing the effect of hyperrealistic with non-hyperrealistic phenomena. The third hypothesis states that real life knowledge of an element will influence the way they judge the presented stimuli. Participants are therefore expected to detect the fire more easily.

For the test this implies that the advertisement will be changed once more, by adding fire instead of smoke (however in the same voxel definition simulation settings). Just as the smoke test this fire test will add fire as an in between variable which includes two versions: one high detail and one low detail version.

It is expected that test subjects will detect the low voxel version of the fire implemented into the advertisement. Once the fire gets noticed as VFX the spectators are reminded that the presented imagery is unreal and hence will disbelief the imagery.

Overall, if it turns out that people did not notices the low voxel smoke but do notice the low voxel fire. This would confirm the EBM because smoke as a hyperrealistic element is accepted whereas fire as a well known phenomenon is evaluated as distracting. That would indicate that limited budget productions should consider the detail level of each VFX carefully, depending on its appearance in the real life.

If it turns out that both low level detail VFX remain unnoticed that would be a clear sign for the industry to think about optimising voxel definitions in general as it appears that people have difficulties in perceiving detail.

6.4 Test Setup

The test setup for the baseline test, the smoke test and the fire test must be equal. Preece, Rogers and Sharp [51] in their book on Interaction Design bring up a list by Colin Robson who suggests a framework for testing which entails the following items:

Space, actors, activities, objects, acts, events, goals, feelings [51]

According to the points listed by Colin Robson the test setup was designed. Labs will be used as *space* for the focus groups sessions. The labs is located close to potential test subjects and offered a controlled environment. In the lab the participants will be separated from other students, sounds or events which minimized the influences from the surroundings, this guaranteed privacy and no interruptions [54]. The *actors* will be the authors of this thesis as the conductors of the present research. The *activities* will be divided prior to testing to have a consistency throughout the all the test sessions [54]. The *objects* used during this experiment will be iMac 27" (2560 × 1440) to display the advertisement as well as a Logitech Z5500 sound setup. A round table assured that all participants will be able to see each other, chairs as well as paper and pen were provided. To make the setup comfortable candy and water were offered to the participants.

6.5 Test Procedure

Test subjects that agreed to take part in the focus group session will be invited into the lab. They will be greeted and informed that first of all they would watch an advertisement for three times and afterwards an introduction would be given. Giving an introduction after the exposure of the advertisement will assure that the participants are as neutral as possible during the exposure. To put the participants at ease [54] some guidelines will be given before the session starts. The participants will be encouraged to comment and interrupt each other during the upcoming session. Furthermore, they will be informed that the participants will remain anonymous and that there are no correct or incorrect answers; it is solely important what they experienced and expected. Lastly, they will be asked for the permission to audio-record them. Afterwards the interview will start and last around 15-20 minutes. Once the interview is done the words and drawings acquired during the session will be collected from the participants, then they will be thanked and are free to go.

6.6 Choice of Participants

The target group was chosen to be a convenience sample of Medialogy students. The reasons for this are, that first of all these students have a general interest in mediated experiences and most probably already have made some experience with film, CG and VFX. Especially, the students from higher semester have been working with VFX can therefore be considered upcoming experts in their field. Another point is that form this target group a general familiarity with advertisements and virtual content can be assumed. This is important when analysing the obtained results – when avid VFX enthusiasts are not able to spot the degraded level of definition of the VFX, it is likely that someone who does not have any experience with VFX will not spot it. Furthermore, students in general are an interesting target group, hence the results which will be obtained by students might be especially interesting for brands developing advertisement for them.

The focus groups consisted of 4-5 participants at a time. The ideal setup is that the participants would know each other and have an easier time interacting with each other. Hence, the aim was to pick participants of existing project groups which would ensure that these persons have been working with each other already. This facilitates the intragroup [54] behaviour to make it easier for the participants to express their own opinions.

It must be assured that no participant will be tested on more than one condition to ensure an unbiased point of view. In case participants from the preliminary tests would have participated in the smoke test again they would have known that the previous focus was on smoke or fire and hence would be able to guess the real focus of the test. Paying extra close attention to the VFX would bias the results, as that might lead to the detection of the VFX as described in the EBM. Consequently, it is important that the test subjects would not know about the intentions of this study.

6.7 The Choice of Questions

The focus group sessions were completely scripted to make sure that the needed information will be gathered. Additionally, by asking the exact same questions the comparability of the focus groups can be assured. The following section will discuss the selection of questions.

Before the baseline test one focus group was used to determine if the questions and the order of the questions was effective and relevant. Based on that the three questions were removed from the questionnaire and one question was added in [14.1 Appendix A: Interview Questions]. The final questionnaire consists of 13 questions and tasks in total.

Right after the advertisement has been displayed three times all participants will be asked to write down five words or sentences coming to their mind right after the exposure. The strategy was chosen due to the risk that participants might have an impact on each other. In these five words the participants will write down their independent thoughts on the advertisement without any influence from any of the other members. Furthermore, these words represent their initial and most prominent thoughts on the advertisement. By evaluating these words it will be possible to get an insight into the subject's first impression.

1. *Please use two minutes to write down the first five words that come to your mind about this advertisement.*

Once all participants finish writing a set of introductory questions will be asked. These questions will be used to determine if the participants knew the brand or the advertisement before and if they had real life experience with a motorcycle crash before. As mentioned in earlier [3.5Experience & Schemata] previous experience with the advertisement can have an influence on the perception of the advertisement hence, if the participant knows the advertisement it is likely that the VFX will be spotted. In case the participant has seen a severe motor cycle crash in real live he can judge the displayed crashes with much more detail. As it is generally unlikely that the motorcycle will start to burn in an ordinary crash this participant might call the VFX more easily. Additionally, these questions serve as a warm up phase which allows every participant to start talking and feel that their opinion and experience is important.

2. *Have you ever seen this advertisement before?*
3. *Do you know the brand?*
4. *Have you ever seen a motorcycle crash in real life?*
5. *Do you generally enjoy slow motion effects?*

The main phase begins with asking one participant retell the advertisement as detailed as possible. This shows what the participant focused on and how many details the test subjects were able to pick up during the three exposures.

6. *Could you try to retell what happened in the advertisement as detailed as possible?*

The participants will be asked to read out the five words or sentences they wrote down and explain their decision. The participants are able to compare their experiences amongst them. This might spark a discussion as each participant is will be asked to justify their own perceptions, or agree or disagree with the perception of the other focus group members. If no test subject mentions the VFX during this stage, it can be assumed that the VFX did not have a major impact on them (even if they might have seen it, which will be determined later on during the session).

The next part of the focus group session is aimed to separate the crashes and will give the test subject the chance to express the most elements of each crash that had an impact on them.

7. *Which of the crashes was most memorable, why?*

By asking for the memorability of the crashes it is aimed to determine what the test subjects focused on. This will test the unaided recall of the crashes. Generally, it is assumed that either the first crash or the last crash would be best remembered due to the primacy [55] or renceny effect [56]. If the test participants notice something unusual in the images which get processed in more detail they might be able to remember it better and therefore bring it up.

Afterwards, to help the test subjects to remember the crashes better the images will be handed to them showing the three crashes. The images will be the exact same for all the tests (baseline, smoke and fire).

Figure 6.5 First, second and third crash

As depicted above, the image of the second crash was chosen right before any of the VFX started. This way it will be universal for all the tests.

With these images in front of them the participants will be asked to name the biggest differences were between the crashes. With this question it is aimed to determine if the VFX had a significant impact on the viewer. If the participants start evaluating the setting or crash style, it can be concluded that the VFX did not have a major impact on the viewer, as their focus was on other elements of the image.

9. What was the biggest difference between the crashes?

By now, it should have been established if the participants saw the VFX. The next step is to identify if the thought the smoke was real or CG. Hence, the next question will be:

10. How much of the advertisement is film footage and how much is computer generated?

At this point, it is expected that the participants will have one of the three opinions: (1) they think that elements in the advertisement are obviously VFX which stroke them as unreal. (2) They think all is real. This means they did not notice the VFX and hence believed the image. (3) The participants believe that some elements in the advertisement might be VFX. The elements might be the VFX but this might also be other elements in the image. But spotting the VFX and accepting the VFX are two different situations. It is important that the viewers are not distracted by the VFX. When evaluating the scene logically they might still come to the conclusion that the VFX must have been computer generated. Yet, the spectators did not spot the VFX as disturbing.

The following two questions are dedicated to the schema they applied to the advertisement.

11. Would you consider these crashes as Hollywood style?
12. What would have changed to make the advertisement more Hollywood style?

By asking the question "Would you consider any of these crashes as Hollywood style?" it refers to the effect and not Hollywood as a general term. Thereby it was only necessary to define Hollywood within the scope of effect, and not the entire Hollywood industry. Hollywood creates state-of-the-art effect and cheesy effect. Therefore this thesis defines Hollywood style as:

Thesis Definition: Hollywood Style

Over-exaggerated effects with the intension of amplifying the visuals, but without relation to the quality of execution.

When asking for Hollywood style the intention is to determine what the participants expected from the advertisement. The reason for asking the Q11 is to determine if the implementation of a VFX changed the overall categorisation of the advertisement. By adding a VFX to the advertisement spectators might change the schema and thereby their expectations. Knowing if the advertisement was re-categorised allows to correlate if the change of expectations has an effect on the acceptance or distraction rate.

13. Please draw smoke and fire as detailed as you can in two different drawings

Finally, the last task will be to draw fire and smoke in two separate images (just as the first pre-test). By comparing the images derived from this it is intended to see the effect of the exposure of the advertisement. It is suspected that those who have spotted the VFX will draw a different smoke/fire than those who did not.

At the very end, all test subjects will be provided a chance to give any last comment that they would like to add.

14. Do you have any last comments?

These questions are designed to not lead or bias the participants. Asking for CG in the images (#10) might be leading the participants slightly but it was deemed appropriate to ask for CG at this late stage of the interview.

7 Design Requirements

The design requirements for the VFX and the advertisement will be investigated in the following. It is the purpose of this chapter to join the theoretical analysis with the design phase. The following requirements are based on the findings in the analysis and the test methods derived in the previous chapter. It will be explored which features VFX must fulfil in order to solve the final problem and to test the hypotheses.

7.1.1 Characteristics and Choice of VFX

The Expectation & Belief Model is based on the idea that elements that people have not experienced in real life cannot be recalled in the same amount of detail level as element people have experienced and interacted with in reality . As derived in the Analysis smoke and fire will be used as fluid simulations to fulfil these conditions. As two different VFX will be implemented in the advertisement it must be assured that all other parameters except for the voxel definition of the simulations are identical and comparable. Hence, it is important that the simulation technique is the same for both VFX. The high and low voxel definition will be taken from the pre-test. In the pre-test both voxel definitions have been specified and will be used for both the smoke and the fire test.

The composition of the VFX should be the exact same in all tested conditions. Furthermore, it should not be necessary that to remove other elements from the original advertisement or add more than one element to it. If there are any additional manipulations made to the film plate the effect the overall appearance of the advertisement might be changed and hence influence the test results.

Another requirement is that there may only be one VFX at a time in each condition. When thinking about VFX in movies elements such as rain, wind, fire, smoke etc. often appear at the same time to make the scene more dramatic. In this research however it is important that only one VFX is implemented at a time.

7.1.2 Placement of VFX

Once the VFX have been determined there are several other requirements that need to be fulfilled during the design phase.

In the pre-analysis it was mentioned that in order to created perceptual realism the implemented effects need to interact with the film place [3.6 Perceptual Realism]. This indicates that the implemented fluid effects should be composited in the same way, so that the lighting and colour suits the surroundings. Additionally, collisions with elements in the image should be countered with collision responses etc. to fulfil the basis of perceptual realism. Again this compositing should be the exact same across all conditions.

As the very first images and the very last images of a movie clip might be better remembered due to the either the novelty of the stimuli [55] or the recency [56] of the exposure the VFX should not be integrated in either of these scenes.

8 Design

This chapter has the purpose to thoroughly structure the ideal design for the future test. Firstly, the scenes of the chosen advertisement will be described. Secondly, this chapter covers design choices by fulfilling the requirements given in the previous chapter, and a range of design choices regarding the specific implementation of fluid simulation within the chosen advertisement. Conclusively, this chapter will create implementation requirements to encounter every design detail of this thesis.

8.1 Scene Descriptions

The previous chapter concerned the interconnection of the theoretical and the test methodology which result in requirements of the design. This works as guidelines for this chapter.

The original advertisement consisted of several scenes in slow motion. Some of them were very lengthy and some were fast edited. The advertisement was re-edited into containing three scenes in total for the sake of testing and to meet the requirements of the selection [5 Advertisement Selection]. Furthermore the design requirements indicated that the first and the last scene would be remembered the best. The new re-edition version has three scenes with a duration spanning from 7 to 10 seconds, and the first and last scene should not include the implementation of the VFX. This was decided due to not making the VFX more prominent than necessary, and it was the idea of having the participants perceive the first scene, find the corresponding schema before being exposed to the fact that the camera angle is steady and thereby enhancing the audience possibility to detect and evaluate the VFX. Smoke and fire simulations are possible events of the impact in this chosenVFX scene. The following will explain each scene in detail after the editing which will be the test advertisement.

8.1.1 Scene 1

The first scene consist of a highway tunnel where a spinning and tunbling motorcycle are moving along the road as illustrated in Figure 8.1. Several pieces of the motorcycle are flying off in midair which is assumed to attract the viewer's attention, and to be remembered the most. The scene is kept in super slow motion and has a duration of ten seconds. The camera is following the motorcycle tumpling direction, making the camera angle steady.

Figure 8.1 Advertisement scene 1

8.1.2 Scene 2

The second and middle scene has another motorcycle sliding on the ground from the right side into a big rock. Due to the road sliding some dust are present in this scene. The environment is different. This scene is shot in a warm dessert and it portrays a brown cliffside, a road and the rock in the middle of the frame. It is shot directly at the Cliffside and no movement, zoom or any other camera technique is used in the scene. This scene will contain the VFX. It has been decided to use the impact of the rock and the motorcycle to emit smoke or fire depending on the version. Only one of the effects will be present at the time. The steady camera enhances the audience possibility to detect and evaluate the VFX.

Figure 8.2 Advertisement scene 2

The implemented smoke and fire simulations must be placed prominent and work as part of the message and plotline of the advertisement. Furthermore these simulations should be composed as part of the scene to fulfil the theories of perceptual realism [3.6 Perceptual Realism]. The duration of the second scene is seven seconds.

8.1.3 Scene 3

The third and last scene is shot in a dark environment but similar to the first scene. The motorcycle is sliding along the road for six seconds before the advertisement payoff and brand logo appears on top. The camera is following the motorcycle in a constant distance, making the angle steady as in the first scene. The motorcycle is further away from the camera which is making this scene less intense.

Figure 8.3 Advertisement scene 3

8.2 Smoke Simulation

The smoke test consists of the fluid simulation depicting a smoke cloud from an impact of a motorcycle and a large rock in the side of the road, seen in Figure 8.2. Because the smoke test is divided into two tests, two versions of the smoke effect must be designed and implemented. Four different voxel settings were defined in the pre-tests. Due to the interesting results of how the participants rated the realistic looking smoke, where half chose the second lowest voxel definition simulation and half the highest. These two voxel definitions were chosen as the test settings for the smoke test and the fire test which will be described in the following chapter. As determined in the pre-test the low version has 70 voxels per unit whereas the high has 300. A potential difference in simulation time, but also the appearance and the movement of the cloud might change due to the amount of collisions, internal forces and common turbulence fields. The greater the voxel count is the bigger influence the fluid particles within the voxel definition have on each other.

The smoke cloud must evolve and move in the upper left direction due to the path of the motorcycle and the surrounding dust within the given scene, illustrated in Figure 8.4.

Figure 8.4 Scene 2 with smoke simulation design

It is crucial that the VFX implemented in the scene fits the colour scheme, blends correctly with the pieces flying off the motorcycle moments after the impact (see Figure 8.5) and moves at the same pace as the original slow motion footage in order to create convincing and non-disturbing VFX. The design and the compositing must be at industry standard level in order to create a foundation for future testing. It is not the idea of this thesis to deliver test material that is perceived as intrusive and amateur VFX. The thesis is written for the VFX industry and hence a certain minimum of requirements must be fulfilled for the future results of this project to be valuable for the industry.

Figure 8.5. The original scene with flying pieces of the motorcycle

8.3 Fire Simulation

The fire test is designed identically to the smoke test. It is the same scene, the same impact direction, same voxel settings, but with fire flames instead of a smoke simulation.

An explosion of the motorcycle could have been the occurring event following the impact, especially in Hollywood movies. Explosions create a questioning challenge: Do people know how a mushroom shaped explosion cloud looks like. The decision was made on fire flames due to the level of detail the participants drew fire flames in the preliminary tests. An additional argument was how both smoke clouds and explosion clouds are hyperrealistic elements due to their rare appearances. It is very important to create a non-hyperrealistic test to support the results of the smoke test, and consequently test the synthesised Expectation & Belief Model.

Figure 8.6 Scene 2 with fire flames simulation design

The design of the flames has the same voxel parameters as the previous smoke design, a 70 voxel definition and a version with 300 in definition. Although the settings are the same as smoke, the simulation and turnaround time will increase even further in this flame simulation, due to the natural detailed movement of the flames and how the heavy computational fire fluid solver is.

8.4 Implementation Requirements

The valuable decisions within the design chapter must be realised in the final product which serves as material for the future testing. These decisions are stated in implementation requirements in order to ensure the progress. The following listed requirements will serve as guidelines for the implementation as this section concludes the design chapter. The requirements are divided into two groups: a set of CG simulation requirements and a set of compositing requirements.

The simulations must follow the design decision to have two versions of 70 and 300 voxel definitions. All other fluid solver settings and render settings should be kept identical for a fair comparison. Furthermore, the simulations should not travel with greater or lower velocity than the footage indicates, giving the impression that it does not travel in the same slow motion speed. The turnaround time and simulation time usage should be noted for a comparison of effect versus production time.

After the simulation is rendered into a sequence of images the compositing phase commences. The colour scheme of the original footage must reflect the implemented effect. Both the flying pieces from the motorcycle and the original dust from the footage must be blended with the implemented effect to create depth and not appear as the effect is composed on top of the footage.

9 Implementation

This chapter describes the processes behind creating the different parts of the product associated with this report. It covers the implementation in the same chronological order as each part was created. The work of smoke & fire simulations, the compositing of the rendered materials for the final advertisement will be discussed. The goal of this chapter is to provide an understanding of the complications and choices made in the process as well as work as a natural extension of the design chapter.

9.1 General Setup

Besides explaining process of creating the product and the challenges it formed, this chapter will in addition discuss the turnaround time and the total of simulation time in such as production. For the last matter a presentation of the setup is necessary, due to the rapid development in both hardware and software performances.

9.1.1 Software

The chosen CGI package for developing the simulations was Sidefx Houdini [57]. At the time of writing the latest version was 11.0.658. Houdini is an industry leading software solution for VFX studios. It is responsible for a great part of the effects created for the feature films in Hollywood. Houdini is built on a node-based procedural workflow and is created especially for simulation effects and physics driven effects. Houdini has a variety of optimised solvers for fire and smoke simulations, making the choice of software straightforward. This project strives to create research for the VFX industry, and was therefore crucial to select software at an industry standard and had its strengths in the area of simulations.

9.1.2 Hardware

All the development, simulation, rendering and compositing were created on the same workstation computer, due to the later comparison of turnaround and simulation time. Once again, this workstation should be at the current performance standard of the market. This project did not have the possibility to make use of a farm of workstations as a VFX studio has available in their production pipeline. This is however not very important, due to this study focus mainly on turnaround time and simulation time, which are present at the individual artist workstation and not posted for the farm for execution. Furthermore, this is the reason why rendering time is not a research oriented parameter of this thesis, due to it mostly gets executed on a render farm level.

The workstation used was:

Model	**Dell Precision m6500**
CPU	Intel Quad Core i7 920 2.00GHz
MEMORY	8 GB DDR3 1066MHz
GRAPHICS	1GB Nvidia Quadro FX 2800 (96 cuda cores)
HDD	OCZ Vertex 2 120GB SSD
OS	Windows 7 x64

Figure 9.1 Workstation for the development

It is necessary to make clear that simulations and turnaround time depend on the hardware available. If the workstation had 16 GB memory and two quad cores processors the results would be radically different. Equally, if Houdini had a new updated fluid solver it would influence the results. Nevertheless, this comparison is fair because the exact same setup is used.

9.2 Smoke Simulation

The design requirements dictate a production of two smoke simulations with the only difference of respectively 70 and 300 in voxel definition.

The *pyro solver*, which solves both smoke and fire simulation has been a part of Houdini since version 10. This solver has the capabilities to solve both simulations simultaneously, but for this research only one simulation will be delved with at a time. The solver is fairly complex and has hundreds of parameters and inputs. Figure 9.2 illustrates the structure of the pyro solver, a larger version can be found in [14.3 Appendix C: Pyro Solver]. This is the all the nodes that makes the simulation possible. A node is what Houdini is based upon. Nodes are building blocks with certain prebuild functionality. Adding notes together creates an outcome. The pyro solver has hundreds of nodes which makes it complex to calculate the fluid simulation. It calculates density, temperature, burn, fuel, heat, velocity and collision each iteration which normally is frame based. Burn and fuel are only relevant to fire simulations, because they control how and at what speed the fire burns.

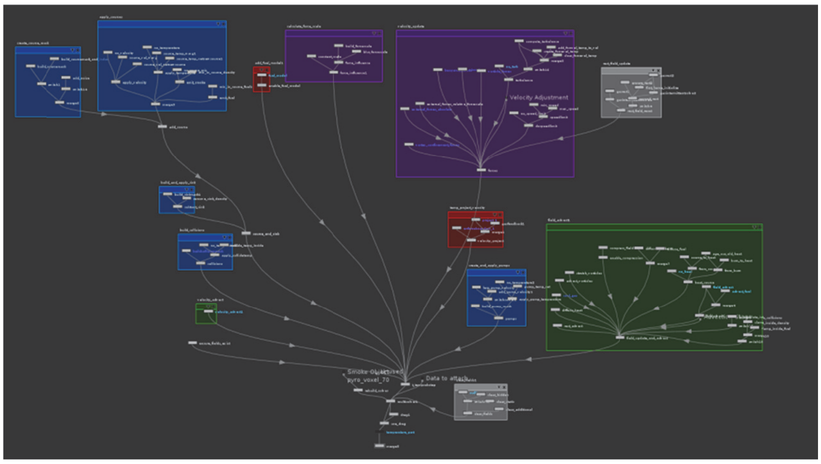


Figure 9.2 The complexity of the pyro solver

The goal was to create a smoke simulation at the same tempo as the slow motion footage and making the simulation appear as a burst of dust into the air from the impact of the motorcycle. A rolling smoke cloud as seen in impacts and explosions was the desired result. This was accomplished by working with the following parameters, besides combustion and fuel advection which are used for fire simulations:

The most influential Pyro Solver Parameters [58]

Buoyancy: An upward force controlling how the particles move depending of the density pressure of the surroundings.

Viscosity: A force which tries to ensure that neighbouring voxels have the same velocity.

Cooling Rate: Controls how fast the temperature field trends to zero.

Turbulence: Force to manipulate the velocity field.

Combustion: Takes the fuel field and turns it into a burn, temperature, and density fields.

Fuel advection: How fast the fuel should move relative to the other fields, such as temperature and smoke.

All the parameters are interconnected, meaning it would be impossible to predict how one parameter exactly affects, due to the solvers complexity. In order to accomplish the rolling motion of the smoke cloud, a strong turbulence field must be introduced to manipulate the particles velocity field. Hot smoke tends to move greater distances, giving a greater effect of the turbulence force, hence the cooling rate should remain very low. In addition to the turbulence it also ensures a longer life of smoke before it vanishes. The end result should not become noisy and random which it will with strong turbulence. A fairly high viscosity force ensure the particles of the voxels to keep together at the same velocity, giving a less random movement but maintaining the rolling effect. Finally, having a very low buoyancy lift force aids in keeping the simulation slow motion.

9.2.1 Workflow and Turnaround

Once the desired effect was captured in a very low voxel definition (20) for quick turnaround time, a steady increase of the voxels was started as described in [4.4 Fluid Simulation & Workflow] as Scenario one. This is the stage this thesis is focused on. An increase of 20 in voxel changed the simulation, due to a higher definition of the smoke and more collisions, more heat, more turbulence, larger fields etc. occurred. Now the artist needed to re-evaluate and adjust all the above parameters to maintain a similar effect with a higher definition. While increasing the voxel definition the turnaround time increases drastically, making this workflow tedious. Once the desired effect is accomplished, another voxel increase was introduced. The process keep repeating itself until the simulation has the anticipated definition and the effect is acceptable. Working the way up to a voxel definition of 70 was an easy task, but the road to 300 is certainly a different story. Not only did the turnaround time get slower by the iteration, but the smoke simulation needed to simulate to frame 50 before it was possible to inspect how the smoke evolved. Such a turnaround took 28 minutes and 44 seconds to simulate 50 frames at voxel 300 as seen in Figure 9.3. Meaning the VFX artist pushes the simulation button, waits 28 minutes and 44 seconds until it is possible to figure out if the change was the correct settings, otherwise changed settings - wait once again and hope for a better result.

Frames	Fluid effect	Voxel definition	Turnaround time
50	Smoke	70	19sec
50	Smoke	110	59sec
50	Smoke	150	2min 26sec
50	Smoke	200	6min 29sec
50	Smoke	300	28min 44sec

Figure 9.3 Turnaround time for the smoke simulation

The simulation time grows as the size of the smoke does. This desired simulation has a low cooling rate, giving the smoke a great possibility to survive longer. The more smoke particles the solver must address in the calculations each frame the bigger the turnaround time and consequently the simulation time is. Figure 9.3 is a great example of this. From 19 sec with 70, in the middle 150 voxel definition requires an artist to wait 2min 26sec to the maximum of 300 where a the artist needs to wait 28min 44sec before the first 50 frames can be reviewed.

9.2.2 End Result

The total duration of the effect needed for the advertisement was 211 frames (7 seconds). Figure 9.4 illustrates the differences of the two implemented effect in simulation time.

Frames	Fluid effect	Voxel definition	Total simulation time
211	Smoke	70	1min 28sec
211	Smoke	300	2h 4min 40sec

Figure 9.4 Total simulation time for smoke

The differences in Figure 9.5 might not appear that big, especially when you take the 2 hours into consideration. The biggest difference is the movement. The left, 70 version, animates as a great ball without much collision and rolling effect, whereas the image to the right, 300 version, has one big rolling motion, but also several small turbulences and collisions that makes this cloud appear much more detailed when watching a animation of them with black background. The high version turbulence fields create a detailed movement behaviour which is very prominent when comparing the two versions. It will be very interesting to test whether test participants have the ability to perceive these details, due to they will not have the two versions for a comparison.

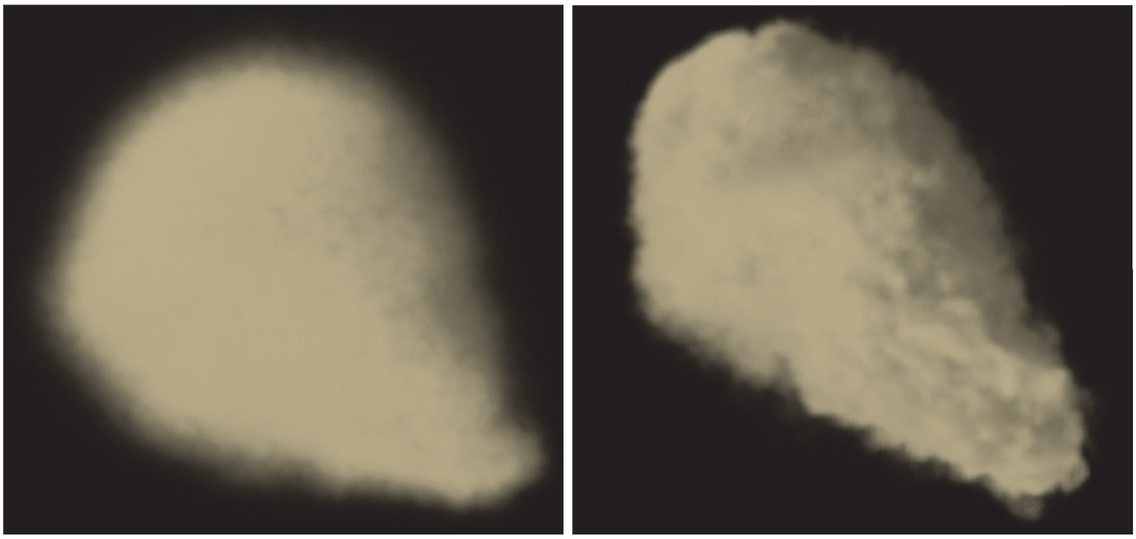


Figure 9.5 Smoke rendered result. Left: 70 Right: 300

9.3 Fire Simulation

The parameters that needed focus were different, even though fire simulations are calculated with the same solver within Houdini. When working with fire, fuel advection and buoyancy lift are two delicate matters. Changing one of them a bit will influence the simulation greatly. The buoyancy needed to be greater than the smoke due to fire travel faster and further per unit than smoke. In order to have the flames fit the scene and the crash, the fuel advection was adjusted to size the flames accordingly. Apart from tweaking parameters for an accepted end result, other aspects are important. Even though rendering techniques is without the scope of this project, the simulations needs to be a representation as close to real fire flames. Fire is rendered using a shader that colourises the flame from the intensity by interpreting the field as a temperature distribution. Figure 9.6 depicts the temperature field of the fire simulation. The hottest areas are coloured white and light blue, middle temperature yellow and lowest temperature red leading to dark red. This information is essential for the simulation artist to control the temperature field of the fire, while striving for the desired result.

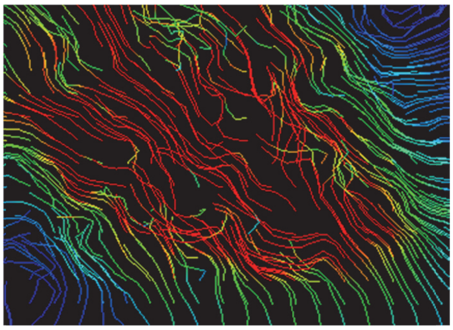


Figure 9.6 Tempeture field of the fire simulation. Shows a 2D slide of the simulation. Red is hot, whereas red is middle temperature and blue has no fire.

9.3.1 Workflow

The balance of controlling a warm centre while bursting relatively large flame from the impact of the motorcycle was difficult. Lots of turnaround time was used to adjust how the frames grow. As in the smoke simulation workflow, the procedure is identical. The artist starts with a very low voxel definition and builds up the simulation slowly. This is based on the workflow of scenario one from [4.4 Fluid Simulation & Workflow].

Comparing the fire and smoke turnaround times, Figure 9.7, it is evident that fire had shorter durations. This is because the smoke particles lifespan is much longer than fire. Fire burst from the core into flames and vanish, whereas the smoke cloud keeps growing.

Frames	Fluid effect	Voxel definition	Turnaround time
50	Fire	70	16sec
50	Fire	110	45sec
50	Fire	150	1min 41sec
50	Fire	200	3min 54sec
50	Fire	300	12min 31sec
211	Fire	70	1min 11sec
211	Fire	300	56min 47sec

Figure 9.7 Turnaround time & total simulation time for fire simulation

The turnaround workflow of an artist creating fire at a voxel definition level of 300, would be 12min 31sec, but only 16 sec with 70 in definition. This workflow is much faster than smoke workflow, but the difference between 70 and 300 is huge. Since this workflow is faster than the smoke workflow, it is still a long wait to sit tight for more than 12 minutes. The images below in Figure 9.8 illustrates the final rendered versions, which besides the obvious shape differences also misses colour variation in the 70 version, due to it lack of definition in the temperature field.

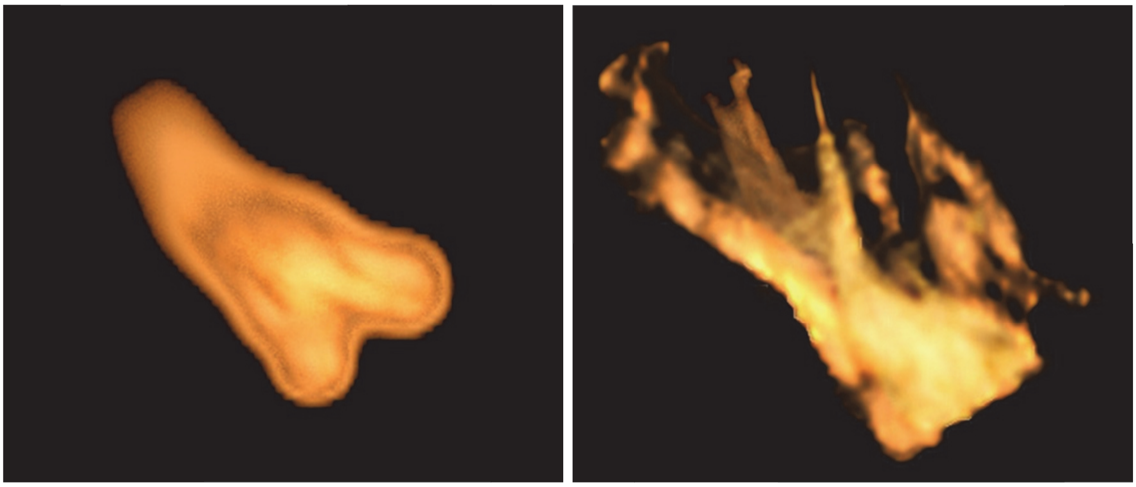


Figure 9.8 Rendered fire simulation. Left: 70 Right: 300

Both the smoke and fire simulations have great differences in turnaround and simulation time in for voxel definitions. Seen from a production management perspective, the voxel definition should be at the lowest possible value, but still meet the client expectations. The future test results will indicate if the version of 70 can fulfil the audience expectations. If it does than it the viewer will accept the image as shown in the EBM. Otherwise, the audience will notice the element as VFX and will therefore be reminded that the presented imagery is not real.

9.4 Compositing

The final part of the implementation chapter concerns the composing. The four different image sequences were rendered for the compositor to work with. The goal was to combine the simulations with the advertisement in the exact same manner. The test methods stats that the different versions of the advertisement needs to be compared in the test analysis, thus all the compositing, colour grading of the simulations, masking etc. must be identical in each of the versions.

Masking out pieces flying off the motorcycle was a choice stated in design chapter. Five of the biggest piece were selected and were rotoscoped in a new layer. The idea was to composite these pieces on top of the fire or smoke simulation to create depth in the image, and thereby blending the simulation into the frame.

Figure 9.9 Rotoscoping piece of the motorcycle

Colour grading of the smoke simulation was needed for it to appear as part of the footage. The original scene contained some dust clouds floating at the ground of the road. The colour scheme of these dust clouds was used to colour grade the rendered material. The final step was to blend the edges of the smoke/fire with the original underlying footage. This was accomplished by blurring the alpha channel of the outer edges of the simulation. Then these edges were assigned a screen blend mode for underlying colours to appear in the smoke and fire.

The final composited result is illustrated in Figure 9.10. It is easy to identify the differences in the fire versions, whereas in the smoke the differences are in the animation, and are therefore hard to depict in a still frame.

Figure 9.10 Final composited result. Left side: 70 versions. Right: 300 versions. Top images are fire whereas the lower images are smoke.

10 Test Result

This chapter will present the results and corresponding analysis of the five main tests plus the results of one iterative test. These main tests include a baseline test, the smoke implementation in high and low definition as well as the fire implementation in high and low definition. The smoke or fire implementation was added to the second scene of the advertisement, as described in both the design and implementation chapter. At the end of the current chapter an iteration of smoke will be introduced in a very low definition as a sixth test.

Due to the fact that this research chose to conduct a qualitative research the results will refer to the entire set of data acquired during the focus group sessions. The overall answers by the test subjects as well as single quotes and the five written words will be considered. In order to efficiently evaluate all focus groups across the different version the choice made to include tables for certain questions which show the percentage of answers. It is known that focus groups are a qualitative approach to acquiring results, however, due to the relatively high amount of different tests the tables were considered to support the structured evaluation of the results. Furthermore, they give an indication how the entire set of participants across the focus groups reacted to the questions.

The total number of participants for each condition was achieved by conduction focus groups with 4-5 test subjects. Due to that each test condition had a varying number of overall participants, as illustrated in Table 10.1. In order to make the results more comparable all following figures will show the percentages instead the numbers of participants.

The findings of each test will be stated in the percentage of the corresponding number of participants. The comparison among the tests can be slightly influenced by the fact that the amount participants varies across the different versions. As evident from the distribution of participants the test versions with smoke were tested more extensively. The reason for this the elemental role of the smoke results to answer the final problem statement.

	Total number of participants
Baseline	14
Smoke low	18
Smoke high	21
Fire low	15
Fire high	15
Smoke iteration	16
Total	**99**

Table 10.1 Total number of participants per condition

One part of the main test that will not be used to determine the results are the drawings acquired at the end of each focus group sessions. Already in the preliminary test the drawings of smoke and fire were used to gather evidence for the fact that smoke is more difficult to depict than fire. It was hoped that the drawings acquired during the main tests would show indications of change (in detail or context) depending on the exposed advertisement version. Yet, the main test drawings only supported the tendency found in the preliminary test, but did not allow to draw any further conclusions. Consequently, the drawings were considered inconclusive and will not be taken into account during the results and analysis of the test. The results of the drawings can be found in [14.2 Appendix B: Test Results - Evaluation of the Drawings].

10.1 Setup

Figure 10.1 Test Setup

The setup, Figure 10.1, was designed to encourage for discussion due to the oval table and the interview setting in the middle as decided in [6.4 Test Setup]. Furthermore, an observer was placed behind the participants to take notes. These notes were used for additional quotes, attitude and the overall mood which can be hard to extract from the audio recordings. Body language and the appearance of the participants were written down, to ensure that the test analysis did not misinterpret opinions stated during the tests.

10.2 Results

The test results will delve into the crash remembrance, their overall attitude towards the advertisement and if the advertisements were considers as Hollywood style. This will lead to the test analysis which is a cross referenced result of acceptance and distraction.

10.2.1 Crash Remembrance

	Scene 1	**Scene 2**	**Scene 3**	**Standard Deviation**
Baseline	57%	29%	14%	0,75
Smoke Low	11%	78%	11%	0,49
Smoke High	73%	18%	9%	0,66
Fire Low	67%	33%	0%	0,50
Fire High	27%	73%	0%	0,46

Table 10.2 Q7: Which crash was remembered the best?

Baseline

The participants were asked to state which of the three crashes they remembered the best. At this point no image of the different scenes was shown to aid their memory. As indicated in Table 10.2 the results of the baseline show that the first scene had the greatest impact on the participants and hence was best remember by 57%. The reason for this might be either the primacy effect [55], because the first crash was novel and thereby most impressive. Or the remembrance in the baseline condition stems from the amount of debris and parts flying off the motorcycle. However the standard deviation of 0,75 indicates that the answers in the baseline are insignificant compared with the others.

Smoke

The *smoke low* and *high* voxel simulation version are almost each other's opposite. 78% of the *smoke low* participants remembered the implemented smoke scene best. This indicates that the remembrance increased vastly due to the smoke effect. It apparently made the scene more memorable which shows that the exposure of the low smoke simulation changed the overall perception of the scene. The *smoke high* version is more in line with the baseline test. 73% of the *smoke high* participants favoured the first scene whereas only 18% remembered the second scene best. Scene 3 did not have a great impact on any of the smoke test subjects.

While talking about the remembrance of the scene, one test participant from the *smoke high* version stated the following regarding the second scene:

> *"I thought that one was making quiet a lot of smoke, I was trying to notice on the 3rd run though how the smoke looks like, because I was focusing on different things each time. And it just seemed like an awful lot of smoke… but I don't know if that happens in real life, it was just interesting to see"*
>
> *Participant smoke high*

The above quote represents the general feedback given through these sessions. The participants state that they recognised the smokes appearance, but have a hard time criticising it.

Fire

The remembrance of scenes was differently distributed in the fire tests. The first scene was best recalled by 67% of participants in *fire low.* In *fire high* 73% of recalled the second best. No one in the two test considered the third scene as memorable. Compared to the baseline this indicates that in the fire conditions the first two scenes were perceived as more memorable, because 14% of the baseline test recalled the third scene best.

10.2.2 Response to the Advertisement

When evaluating interviews it was not only possible to collect answers to each question, but also the overall attitude of the participants throughout the sessions. An important note was that the participants were not directly asked for their attitude; the Table 10.3 is based on the five words and the expressions the participants used throughout the sessions when talking about the advertisement. Those that did not state an attitude, neither during the interview nor on their set of five words, were qualified for the column *no comment*. The standard deviation is overall quite high in these questions, due to the no comment category. Especially the *smoke low* gets a high deviation due to 44% of the participants was not quoted for an opinion towards the advertisement. Furthermore the *baseline* results are insignificant with the evenly spread out answers.

	Aesthetic cool	Dramatic serious	Unreal boring	No comment	Standard Deviation
Baseline	29%	29%	14%	28%	1,27
Smoke low	22%	22%	12%	44%	1,30
Smoke high	82%	9%	0%	9%	0,92
Fire low	0%	20%	40%	40%	0,84
Fire high	0%	33%	67%	0%	0,58

Table 10.3 Overall response to the advertisement

Smoke

A clear tendency is the condition of *smoke high* induced 82% of the participants to state that the advertisement was cool, beautiful, awesome or even aesthetic. This is more than three times higher than in the *baseline* condition. The most basic assumption that can be made of this is that the smoke changed the participants' attitude in a positive way. This is the first indication that the viewers were not distracted by the VFX. It appears that the *smoke high* even heightened their attitude.

> *"Awesome images, simple but powerful"*
> *"Beautiful was my first thought"*
>
> *Participants smoke high*

Fire

Comparing that to the versions which included the fire VFX this percentage drops to 0%. This clearly shows that the spectators did not feel induced to use positive words in their answers. Instead, the used of words such as unreal, fake or boring increased. Interpreting this shift in attitude it can be suspected that the participants did not like the imagery as much which point to the fact that they were distracted by elements in the advertisement.

> *"The flames were a bit synthetic – a bit unreal, which really stood out in a way"*
>
> *Participant high fire*

> *"The fire effect was not that nice"*
>
> *Participant fire low*

Smoke & Fire

One interesting tendency is that *smoke high* appears to make the advertisement less serious, especially in comparison to the version with the *fire high*. This tendency is supported by the clearer results in the fire versions due to the lower deviation of the answers. *Fire high* has only 0.54 making unreal and boring attitude prominent. Furthermore the answer for this might be as explained by one of the test subjects:

> *"I had the reaction: if this is supposed to keep us from making accidents than it does not have a very good effect, because this is so beautiful. [...] It did not give me a feeling of 'wow how sad' it was more 'wow how beautiful'!"*
>
> *Participant high smoke*

This might be the reason that only 9% of the participants articulated words such as dramatic or severe in the *high smoke* condition.

10.2.3 Hollywood style

Table 10.4 summarises if people rated the advertisement as Hollywood style. As described earlier in [6 Test Methodology], the test subjects were asked to use their own definition of *Hollywood style*. Even though these answers were expected to be random, nearly all of the participants had a very similar definition of how to make the advertisement more Hollywood. Explosions, sparks, shaky camera movement, time shift etc. were words the participants chose to describe to amplify the Hollywood style.

	Yes	Maybe/ not sure	No	Standard Deviation
Baseline	43%	0%	57%	1,07
Smoke Low	44%	44%	11%	0,71
Smoke High	55%	18%	27%	0,90
Fire Low	67%	33%	0%	0,58
Fire High	100%	0%	0%	0,00

Table 10.4 Would you consider any of these crashes as Hollywood style?

Overall, the findings show that the baseline test without VFX does not have any significant tendency as being Hollywood style. In all the other conditions the majority of participants rated the advertisement as Hollywood style. In general, this shows the tendency that VFX changes the opinion about the advertisement. The majority of participants declared the advertisement as Hollywood style based on one single effect. This is a noteworthy observation as apparently the implementation of a single VFX changes the perception of the advertisement. This correlation is even more intense in both fire conditions due to the fact that no participant decided to judge the advertisement as non-Hollywood style. Moreover, both fire versions have low deviations thereby strengthen the significance of the Hollywood style results. The reason is how anything related to fire is associated with Hollywood more than smoke, as the following quotes show:

> *"I think that just having the bicycle having some particles on fire [...] that would create a dramatic effect. Fire is such a traditional Hollywood element"*
> *Participant smoke low*

> *"One thing that is missing is sparks, Hollywood would definitely do sparks."*
> *Participant smoke high*

> *"[To make it more Hollywood] I would probably put an explosion in. "*
> *Participant smoke low*

One thing to note about the VFX is that the voxel definition seems to have an effect on the viewer. *Fire high* was perceived more Hollywood style than *fire low* definition with 100% against 67%. The smoke conditions remain similar with a small favourer of 11% to *smoke high*. This indicates the level of the effect was associated with the term "Hollywood" also.

> *"The crashes are really dramatic, stereotype Hollywood"*
> *Participant high fire*

This is the end of the presented test results. The following chapter will delve into the meaning of these answers and the reason of either distraction or acceptance of the exposed advertisement.

10.3 Analysis

The following chapter will use the previous results together with the key element of this research Table 10.5 to analyse the findings and thereby answer the final problem statement.

	Distraction	Acceptance
Baseline	14%	86%
Smoke Low	20%	80%
Smoke High	0%	100%
Fire Low	100%	0%
Fire High	47%	53%

Table 10.5 Did people accept the VFX

Table 10.5 is the result of an analytical approach to question 10: *"How much of the advertisement is film footage and how much is computer generated?"*. It was recorded how many of the participants judged elements in the advertisement to be VFX. These numbers do not show the detection of people seeing the smoke or the fire, but if they thought that VFX elements in the advertisement were distracting.

Table 10.5 was derived by cross referencing the detection or acceptance of VFX in the advertisement with the previously discussed questions. The combined results led to the assumption that participants who did not spot any VFX in the advertisement accepted the imagery. It was concluded that participants who found distracting VFX in the imagery were reminded of watching virtual imagery and consequently disbelieved it.

Baseline

As presented in Table 10.5 in the baseline test 14% of the participants expressed that they noticed VFX in the advertisement. Although the advertisement does not include visible VFX, some suspected the imagery to be VFX. One explanation for this effect might be that spectators attributed the slow motion effect as VFX.

> *"In real life you don't really notice the bits and so you associate slow motion with animation"*
>
> *Baseline participant*

This indicates that although there was no visible VFX in the advertisement participants judged the slow motion effects to look like VFX.

Smoke Low

As shown in Table 10.5 *smoke low* scored an 80% acceptance rate which means that only a few participants mentioned suspected the advertisement to entail VFX elements. This test result was not anticipated, as the design of the *smoke high* and *smoke low* should have defined the two ends of the border of acceptance. Participants should have spotted the smoke as VFX in the *smoke low* version in order to define the bottom line of acceptance. Instead the clear majority believed that the entire advertisement was film footage. In relation to that an interesting point was made by one of the test subjects in the *smoke low* version:

> *"I saw the first scene and I thought that it was CG, then I saw the second one and thought that was more real, then I saw the third one again and thought it was CG again."*
>
> *Smoke low participant*

This statement indicates that this participant closely focused on the imagery during the three exposures of the advertisement. Hence this participant evaluated the imagery instead of watching the message of the advertisement and thereby had a very narrow focus. Still, this participant found the second scene most real, which is unexpected. As previously explained, the second scene had a 70 voxel smoke simulation implemented which was designed to be detectable as a VFX and thereby distract the viewer. Hence, it is problematic to determine the border zone of acceptance at 70 voxel due to the fact that only 20% perceived the low smoke as distracting.

However, even though the *smoke low* condition was not interpreted as VFX it still had an effect on the viewer. When reconsidering the results stated in the previous chapter in combination with the knowledge that the participants did not consciously separate the smoke clouds from the advertisement, some of earlier findings appear in a new perspective.

Having the results of Table 10.5 in mind, the results of Table 10.2 [Remembrance of the crash] could have been an effect of the unconscious evaluation of the smoke clouds. 78% of the participant remembered the second crash the best, which is 50% more than in the baseline. This means that the 70 voxel smoke simulation was perceived by the participants and increased their remembrance of the scene. Although most of them did not detect the smoke as VFX they still evaluated the smoke in more carefully. The smoke simulation was just detailed enough to be accepted as film footage. This process could be the reason why the participants remembered the crash better. Additionally, the *smoke low* condition left 44% of the participants in doubt if the presented imagery would fit to their interpretation of Hollywood, as shown in Table 10.4. Keeping in mind that the clear majority of *smoke low* did not spot the VFX this uncertainty about the Hollywood style could indicate that they are conflicted about their impression. There must have been something wrong about the low definition smoke simulation that induced the participants to not judge it as Hollywood style.

Smoke High

In the *smoke high* version all of the participants were of the same opinion – they all accepted the imagery. In the high version of smoke no test subject mentioned VFX or believed that elements in the advertisement were CG. This shows that they judged the imagery in the advertisement to be entirely film footage.

This 100% percentage acceptance rate was guided by a considerable amount of positive response, as previously presented in Table 10.5. In combination with the high acceptance this indicated that the participants were not in doubt about the smoke simulation, but instead absorbed by the imagery. This supports the assumption that the participants accepted the imagery.

Fire low

Both fire versions led to very different result compared to the smoke versions. The *fire low* version distracted 100% of the participants, which was an expected finding.

40% of the participants used the negative terms when talking about the advertisement and not a single one used a positive word. This shows that they were not impressed by the imagery. 67% of the participants in the *fire low* version claimed to remember the first scene the best. It would have been assumed that due to the clear detection of the fire and the negative perception of them the second scene would be best remembered. The reasons for this are not clear. Speculations about this come based on comments by the participants such as:

> *"The [second crash] was not as interesting to me"*
>
> *Participant fire low*

It might be that due to the fact that the fire was clearly a VFX the interest in that scene plummeted. This could have led to the fact that participants started scanning the first crash for VFX and hence were able to remember it best.

Fire high

The *fire high* version distracted 47% of the participants and was accepted by 53% of them. In other words, half of the participants found the fire appearance distracting. This is a big difference compared to the *fire low* version.

> *"The flames were a bit synthetic – a bit unreal, which really stood out in a way"*
>
> *Fire high participant*

This quote was a common statement from *fire high* focus groups. People were not satisfied with the appearance of the fire and thought it was VFX. From the hypothesis it was expected that people would be much more critical with non hyperrealistic effect, but it was a surprise that still half of the participant could not be satisfied with a 300 voxel definition simulation. This indicates that the border of acceptance of fire simulation must be even higher than 300 voxel.

The tendency that participants did not like the look of the *fire high* is reflected in Table 10.5, which stated the overall negative attitude of the participants towards version. When cross-referencing this result to the distraction rate it can be concluded that getting distracted by elements in the scene changes the attitude in a negative way.

In addition to that, 73% of the participants in the *fire high* version stated that they remembered the second scene the best. As the flames were added to the second scene this indicates that due to the fire this specific scene got more attention and was hence best remembered. Partly, the flames might have been distracting, as 43% % of the participants in the *fire high* version were distracted by the advertisement. But it might also be because 67% judged this version to be fake and unreal.

10.3.1 Expectation & Belief Model

Hyperrealism vs. Non-Hyperrealism

After having analysed the high and low versions of fire and smoke separately the next step is look for differences or similarities in between the smoke and fire versions.

The EBM anticipated that the VFX of a hyperrealistic element will remain unnoticed by the viewer because the viewer does not have a comparable representation in memory which consequently results in the acceptance of the images. The non-hyperrealistic element is more likely to be spotted as VFX, due to the fact that it was perceived in real life.

As Table 10.5 shows the smoke simulations were overall accepted whereas the fire simulations distracted the participants. According to the Expectation & Belief Model it can be stated that the hyperrealistic element, smoke, achieved a higher acceptance than the real life phenomenon, fire, although they had the same definition settings.

It appears that the current finding confirm the Expectation and Believe Model. Hyperrealistic elements are accepted in a lower definition than non-hyperrealistic elements.

Schema Evaluation

The results acquired so far indicate that the smoke simulation was considered as schema conform. This assumption can be made due to the fact that participants accepted the *smoke high* version to a 100%. If the smoke would not be considered a schema conform element than it would have been singled out by the participants and thereby increased the detection rate.

43% of the *fire high* version accepted the fire. Although this is less than expected it can be stated from this that the overall idea of using fire in this scene suited the schema and can be justified. This justification can be supported by the fact that all across all of the versions participants suggested to add more fire, explosions and sparks to the image. This means that the reason for the fire to be detected should be the inadequate detail level rather than the phenomena itself.

When talking about schemas in the EBM another result should be brought up. Table 10.4 shows if the participants interpreted the advertisement as Hollywood style or not. In the *smoke high and low* around half of the participants would not consider the advertisement. Contrasting to that, the clear majority of participants of the *fire high and low* versions consider the advertisement as Hollywood style. From this it can be deduced that fire, as a typical Hollywood element, changed the overall categorisation of the advertisement. This could indicate a change of schema. As elaborated on in the analysis [4.5 Synthesising the Model] all elements in the perceptual field are constantly evaluated in order to select a suitable schema. Once s schema is selected the elements in the visual field are matched to it. Assuming the fire did not suit the prior schema the results indicate that identifying the fire as VFX induced to change the schema again. What makes this interesting is that this might have changed the expectations on how the VFX must look in order to be accepted in the image.

Decreasing the voxel definition in the *smoke low* and *fire low* lead to the fact that an increased amount of participants were not sure how to categorise the advertisement. From the general comments throughout the focus group sessions the idea to make it more Hollywood was often supported by the name *Michael Bay* who is known for brilliantly executed high-end effects. This might be an explanation for the fact that although 53% of the *fire high* version accepted the advertisement they still rated it Hollywood style. Because the participants perceived the fire they re-categorised the advertisement, no matter if the fire was detected as VFX or footage.

10.4 Smoke Very Low Iteration

Based on the fact that 80% of *smoke low* participants accepted the appearance of the simulation, it is not possible to define the bottom end of the border of acceptance. The acquired results for smoke are therefore inconclusive. Consequently, a new test iteration was needed with a new smoke simulation.

The test design, the questions in the interview and the setup remained the same. The only element that changed compared to the previous versions was the simulation of the smoke. The previous low version of smoke had a 70 voxel definition. This new very low version aimed to lower that even more and was consequently designed to have the voxel count of 30. Giving the fact that voxels are 3D cubes and every time a voxel is increased by one the definition is three times greater, or vice versa three times lower when decreased. Imagining the effect of decreasing the smoke by 40 explains how undefined and very low detail this new iteration is.

This is an overview of a new implementation iteration. Table 10.6 compares the different time spend on simulating the three smoke effects.

Frames	**Fluid effect**	**Voxel definition**	**Total simulation time**
211	Smoke	30 (very low)	26sec
211	Smoke	70 (low)	1min 28sec
211	Smoke	300 (high)	2h 4min 40sec

Table 10.6 Comparison of total simulation time

The final render was completed after the simulation. Figure 10.2 illustrates the differences between low and very low render. The difference is significant, which is hard to detect in a still image. The difference is the movement and shape change of the smoke cloud as explain in the implementation chapter. The very low version has a voxel definition of 30.

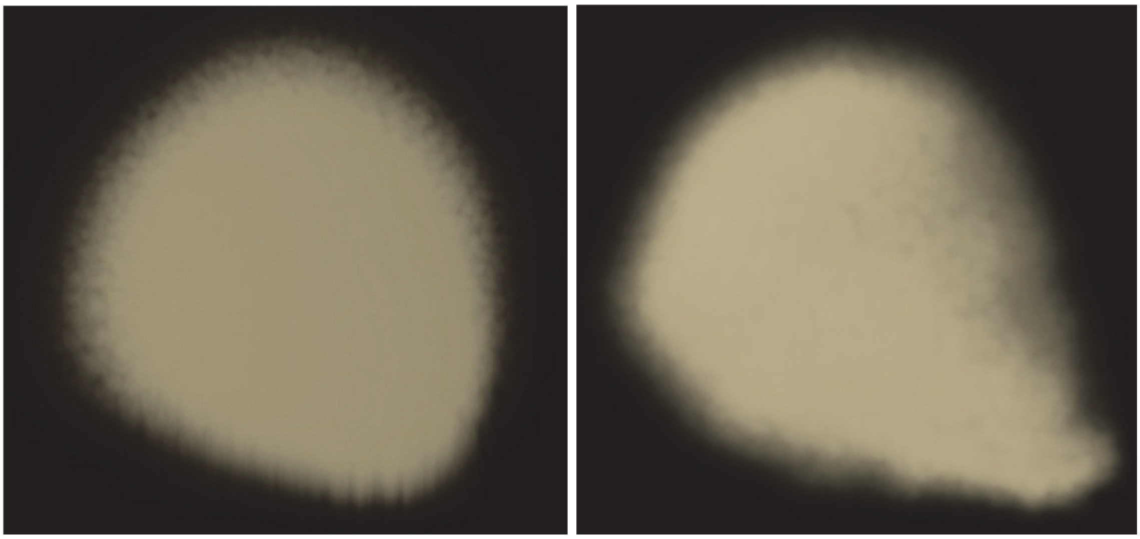


Figure 10.2 Final render. Left: Very low smoke. Right: Low smoke

The *smoke very low* version was tested on 16 new participants. It was expected that all of them would detect the smoke simulation as VFX. If so, the border of acceptance could be estimated.

	Scene 1	Scene 2	Scene 3	Standard Deviation
Smoke Very Low	25%	67%	8%	0,58
Smoke Low	11%	78%	11%	0,49
Smoke High	73%	18%	9%	0,66

Table 10.7 Q7: Which crash was remembered the best?

The findings show that the remembrance of *smoke very low* was similar to the low iteration. 67% remembered the scene 2 best whereas 78% remembered the same scene in *smoke low*, as seen in Table 10.7. As well as the deviation is very similar, but higher due to the higher remembrance of scene 1 in *smoke very low*. As argued for *smoke low* this indicates that 67% of the participants evaluated the scene more carefully due to the smoke. Unexpectedly that effect did not increase by decrease from the *smoke low* to *very low*.

	Distraction	Acceptance
Smoke Very Low	67%	33%
Smoke Low	20%	80%
Smoke High	0%	100%

Table 10.8 Smoke very low. Did people accept the VFX

Table 10.8 illustrates a comparison of the three smoke versions in acceptance and distraction. With 67% distraction in *smoke very low* compared to 20% in *smoke low*, the lower border of acceptance was found. This indicates that somewhere between 30 and 70 voxel definitions would be the border of acceptance for smoke in this particular advertisement.

> *"One thing that was CGI for sure was the dust cloud, they had some serious issues with the alpha blending there, It almost seemed like it got worse the second or third time, but it was maybe just me noticing it more"*
>
> *Smoke very low participant*

It was not expected to find that 33% of the participants still accepted the *smoke very low* even though this version has almost no definition and appears as a bubble without details.

> *"I noticed a lot of dust in the second one that I did not feel was realistic, I thought that was added, that huge dust cloud."*
>
> *Smoke very low participant*

From this quote it can be derived that the participant saw the smoke simulation and felt it was unrealistic. The interesting aspect is, that the participant does not know why the smoke looked unreal, but just "felt" is was not right. The participant has no detailed idea on how the smoke should behave and what to judge the simulation on.

Summing up, the *smoke very low* iteration was able to establish the bottom end of the border of acceptance. This result is very interesting because people seem to be uncritical to the effect like smoke and this information can be beneficial for the VFX industry.

10.5 Hypotheses Analysis

Four hypotheses were formulated in the end of the analysis. After having conducted the tests and analysed the results the next step is to evaluate if the hypotheses can be accepted or rejected.

1) Hyperrealistic representations are stored in memory with less detail than real life experiences.

The first hypotheses can be accepted based on several supporting tendencies. An indication that emerged from this research is that the participants were not able to critically judge hyperrealistic phenomena, but were very good at criticising non-hyperrealistic ones. This in reverse points to the fact that their memory of these elements differs.

Secondly, the preliminary test [6.2.2 Pre-test: Perception of Smoke] resulted in participants 50% judging the two middle detailed smoke simulations as most realistic. This indicates that due to a less detailed representation of the hyperrealistic smoke in memory the participants judge the less detailed simulation as realistic.

Lastly the preliminary test [6.2.1 Pre-test: Expectations and Beliefs] suggests that participants were better at drawing fire in detail than smoke. Although the overall task of drawing images must be considered with care this could be a further clue that the representation of the hyperrealistic element is vague in memory.

2) People accept a less defined representation of smoke due to the vague smoke representation in memory.

This hypothesis can be accepted. It was proven, that highly defined smoke simulations were accepted by the participants. Even the *smoke low* simulation was accepted by a clear majority of the participants which was an unexpected result. Only when decreasing the voxel definition to very low the participants were distracted by the smoke simulations. This proves that people generally accept smoke simulations even in low definition. Taking this argument into consideration it can be argued that people accept a less defined representation of smoke due to their vague smoke representation in memory.

3) The majority of people are distracted by highly defined representations of fire due to their detailed memory of fire.

This hypothesis can be accepted. As expected it was shown that the low definition of fire distracted all of the participants. It was not expected that *fire high* distracted half the participants. This was interpreted that people are great at judging and evaluation fire simulations. Hence, it can be stated that the majority of people is distracted by high defined representations of fire due to their detailed memory of fire. The high defined representation should not be understood as general, but as this thesis's definition of high, being 300 voxel.

4) Low definition fire simulation triggers schema changes and results in disbelief.

This hypothesis can be accepted. The low defined fire simulation resulted in disbelief for all of the participants who were exposed to it. All of them detected the fire simulation as VFX and increased their usage of negative words such as *fake* and *unreal* in that context. The second argument of this hypothesis is that a schema change happened once *fire low* was detected. This can be accepted due to the fact that the majority of participants who were exposed to the *fire low* version rated the advertisement as Hollywood style which suggested a schema change.

10.6 Results & Production Workflow Optimisation

The results clearly indicate that simulation of a hyperrealistic element can be lowered in order to optimise the production costs.

The *smoke very low* iteration was designed to find the lower end of the border zone of acceptance for smoke as a hyperrealistic element. The findings suggest it to be between 30 and 70 voxel definition, in other words between the *smoke very low* and *smoke low*. This suggestion is established on the assumption that the majority of participant accepted the imagery. It is important that the acceptance is close to 100% for the VFX industry. Consequently, 80% acceptance in *smoke low* would not be good enough. The voxel definition would only be reduced if it is assured that the viewer accepts the image nonetheless. Finding the balance between acceptance and optimisation is substantial to suggest usable results for the industry.

The following two parameters have the purpose of defining the border of acceptance for smoke. The first parameter is the distraction/acceptance findings, whereas the second is the turnaround workflow. These two parameters would indicate how defined a fluid simulation would be in order to be accepted, but at the same time optimise production costs.

As shown in Table 10.8 the *smoke low* has 20% distraction, which is too much. S*moke high* on the other hand has 0%. Hence, the border zone is in between. Looking at the results illustrated in Table 10.9 from a production point of view, the lower the VFX artist's turnaround time is, the more iterations are possible to produce per day and consequently a more efficient end result.

Frames	**Fluid effect**	**Voxel definition**	**Turnaround time**
50	Smoke	70	19sec
50	Smoke	110	59sec
50	Smoke	150	2min 26sec
50	Smoke	200	6min 29sec
50	Smoke	300	28min 44sec

Table 10.9 Turnaround time for smoke simlations

The challenge is to balance the voxel definition with turnaround time. Increasing the voxel definition has an exponential increasing effect on the turnaround time as explained in [4.4 Fluid Simulation]. The challenge is to define the voxel definition just high enough to simulate the desired result without losing significant details. This balance was analysed and based on that a range of 150-200 in voxel definition was chosen. Having the fast turnaround time of 2min to 6min, but still a decent definition of the fluid simulation made the decision. It was not the intension to decide on a specific number but instead on a range, because every VFX simulation is different and a specific number would be nonsensical. This range of voxel definition is the border zone of acceptance for smoke.

10.7 Summary

The following table is a summary of the results and analysis elaborated upon within this chapter.

	Results
Smoke	- The high defined smoke simulation was accepted by 100% of the test participants. - 80% of the test participants accepted a low definition of the hyperrealistic smoke simulation. - Taking the definition of the hyperrealistic smoke simulation to extremely low resolved in 33% acceptance. - High defined smoke was rated as aesthetically pleasing.
Fire	- Half of the test participants were distracted by high defined fire simulation, which proves a more critical approach to non hyperrealistic elements. - All of the test participants felt distracted by the less defined fire simulation. - High defined fire was rates as unreal and fake.
General	- EBM was proven by verifying all of the hypotheses.

Table 10.10 Summary of the test results

11 Discussion

This discussion chapter will scrutinise the most important decisions conducted throughout the making of this project. It will reflect if some decisions could have influenced the findings of the research. The following topics have been selected for a thoroughly discussion:

- Choice of test methods
- Influence of Cover Story
- Original Dust Cloud Influence
- Fire without Smoke
- Fire vs. Smoke
- Slow Motion vs. Real-Time
- Evaluation of Repetition

Choice of Test Methods

The choice of test method is often a delicate matter and has great consequences. When looking at the acquired results, the choice to interview the participants in an in-depth discussion and collecting their first reactions on advertisement was valuable.

During the test design it has been scrutinised heavily whether a questionnaire would give better and clearer results. A questionnaire has the advantage of leading to statistical based and comparable results but has the potential of being misunderstood by the participants. The participants in general provided the required information when evaluating the test results of the current research. The specific quotes and answers allowed evaluation of the participants' perception of the different simulations in the advertisement. The qualitative results analysed will always be biased to some extend by the analyst due to the interpretation of quotes and answers given in the main tests. Taking this into account the current research method was appropriate, but the results should not be generalised.

A point of discussion in the test chapter that should be mentioned is the amount of different tests that were used to answer the final problem statement. With two pre-tests and a total of six main tests the overall number of tests was high. Each test was important and necessary to determine the answer for the final problem statement, however it also brought the challenge of keeping the research focused.

An option might have been to only search for the bottom end of acceptance by comparing the low versions of a hyperrealistic element and a non-hyperrealistic element. Yet when looking back at the results acquired, the indications gained by the high versions were of great value and without them the final considerations would have been incomplete.

Furthermore, a doubtable formulation was made in the interviews: *Q11: Would you consider these crashes as Hollywood style?* A broad definition of what "Hollywood style" can imply it was given before the test phase. But the term Hollywood can have various different meanings depending on the person interpreting it. Consequently, the participants might have had a different understanding of Hollywood style than anticipated. Hence, it is not clear why participants chose to rate the advertisement Hollywood style from the current set of results. Some factors that might have aided the Hollywood style could be the use of slow motion, the VFX, the overall look and feel of the advertisement or simply the fact that three motorcycles get destroyed. The implemented VFX versions were compared to the baseline results, which established how the advertisement is perceived without VFX. In reverse it is deduced that the change in opinion is based on the implemented VFX. This means that the answers to the question are comparable.

Influence of the Cover Story

The cover story chosen for the test interview had the role of making the participants believe that this research focuses on the effect of slow motion on the perception of details in advertisement. This story was used to limit the amount of influence on the advertisement exposure. Any previous knowledge on the focus of this thesis would have biased answers. It should be discussed if the fact that the test participants had no idea of the real agenda of the test they might have induced them to put a major focus on delivering answers concerning the effect of slow motion.

Firstly, the cover story was told to the participants after the exposure of the advertisement. Thus, it was assumed that the participants would not be influenced when watching the advertisement. Focusing on slow motion during the introductory questions of the focus group session was not disturbing as it helped to determine the overall attitude towards the presented advertisement. The task to give a very detailed description of their experiences with the presented stimuli was beneficial to determine which details the participants detected in the imagery. After that, the questions stirred the participants away from the slow motion topic. An advantage of focus group sessions is that once participants started to give answers pointing to slow motion again, the interviewer redirected their focus to the respective questions. Hence, it can be assumed that the influence of the cover story did not affect the results which were used to answer the problem statement.

Original Dust Cloud Influence

A dust cloud from the original film plate appeared in the same area as the implemented smoke and fire simulations. It was a design decision to use the impact of the motorcycle as the framework for the implementation, due to the nature of how impact can cause either explosions or at least some sort of displacement of the surrounding materials and airborne particles. To some extend this was already the situation due to the original film plate as illustrated in Figure 11.1.

Figure 11.1 The original dust cloud without any implemted VFX

In a professional VFX production this could often be the case, as visible VFX is often used to exaggerate an effect of the original film plate. This study is however different, due to the analytical approach and methodology for this thesis research. The fewer parameters influence the final result of the test the better. The original dust cloud could aid the implemented smoke simulation to fit into the scene and thereby might increase this simulation trustworthiness. It was attempted to minimise this effect by giving the smoke simulation a different colour than the dust cloud, thus the spectator was able to differentiate between the dust produced by the environment and the smoke simulation generated by the crash. Considering that the dust cloud was also part of the fire simulation the overall influence is assumed to be equally beneficial for both simulations. In case the dust cloud favoured the blending of the smoke simulation this effect would weaken the test result. Yet, when looking at the findings of the *smoke very low* iteration the participants did not have any difficulties in separating the smoke simulation and finding it disturbing for the overall image. It is therefore assumed that the influence of the original dust cloud is minimal. This indicates that even with a possible aid of the dust cloud the smoke simulation did not result in a disturbingly higher rate of acceptance.

Fire without Smoke

As described in the design chapter the fire was designed to emit no smoke in the fire test. This decision was made because the fire flames should be simulated and shown alone as a separate simulation. As commonly known, flames without smoke are not realistic because fire always emits smoke when burning.

The findings of the current project clearly indicate that fire was detected by the majority of the participants and resulted in distraction. The most straightforward conclusion would be that the test participants found the flames unreal or not fitting the scene. Another possibility is to evaluate how the fire is depicted in the scene. Several participants added smoke to their fire drawings in the pre-tests which indicates that they generally associated smoke with fire. In the non-hyperrealistic version of the advertisement this combination was not the case, as the smoke was deliberately not simulated. It was decided that this thesis needed to separate the two simulations to truly test their separate voxel definitions and how the participants responded to each of the shown phenomena. In the fire simulation versions the missing smoke could have been the reason for spectators to lose belief in the image. A counter argument is that in the *fire high* version a total of 43% accepted the imagery. This means that although fire would always be accompanied with smoke nearly half the participants were not distracted by the missing element.

Additionally, the previously discussed topic of the original dust cloud might add positively to this effect. As the original dust cloud was also part of the fire simulation versions participants might have interpreted the dust cloud in combination with the fire, as a replacement for the smoke.

Either way, considering the 43% of acceptance of the *fire high*, the influence of the missing smoke should not be major on the final results of the project.

Fire vs. Smoke

In order to answer the final problem statement it was necessary to compare how participants perceived high or low definition effects of two different fluid simulations. It was decided that these two simulations would be smoke and fire. Comparing these VFX is a crucial part of this project and therefore it is indispensable that this choice is discussed. One of the most obvious questions arising is: Is it possible to compare a grey smoke simulation with colourful fire?

The discussion about comparability can to be evaluated from two different points of views. When debating the comparability of grey sedate smoke with bright flickering fire during the perception process conclusion could be that fire would be more likely to be noticed by the viewer. In the previous project *Zero Detection* the competition of stimuli in the visual field was studied and outcome was that the more movement and colour the element possesses the higher the chances for it to attract the spectators' attention. Based on that argument the fire would attract more attention than the smoke simulation and thereby make them incomparable. This is a valid argument when evaluating the limited cognitive capacity and thereby the question which stimuli would be priorities during a short exposure. Yet for the current project this competition for attention is only of secondary relevance. Due to the fact that the entire advertisement has only three clean steady shots in slow motion and is repeated three times it can be assumed the entire set of stimuli had a fair chance of being perceived.

Although the difference in appearance had an influence on the perception process of the two simulations the effect of that might not have influenced the final result. The VFX were implemented in a prominent position on a relatively clean film plate which allows assuming that the acceptance of the simulated versions was not based on the fact that participants did not have the time or capacity to see the VFX. For the research at hand, the important point is if the stimuli were detected as a fake and unreal.

Slow Motion vs. Real-Time

As derived in the advertisement selection chapter many reasons favoured the selection of the utilised advertisement. One aspect that was considered as a strong point was the fact that this advertisement consisted entirely of slow motion shots. Having learned from the project Zero Detection that action-packed fast-edited scenes overcharge the cognitive capacity of the spectators the idea of using steady slow motion shots seemed to be the perfect solution. Slow motion allows the spectators to perceive a higher amount of detail of the presented stimuli and gives them time to process the entire scene.

The fascination about slow motion derives from the chance of perceiving the extremely small and fast elements slowed down. The consequences spawning from the use of slow motion for the implementation of VFX are complex. As the viewer has more time to evaluate and judge the effect there is less chance to get away with inconsistencies or flaws in the design. The overall level of detail must be good enough to blend into the detail rich imagery. This demands the VFX artist to work very precise and accurate on the appearance of the effect.

As people in general are not used to this effect it slow motion can evoke reactions such as:

> *"The 2nd crash with all the details seemed like too perfect"*
>
> *Participant smoke high*

Keeping the aim of the project in mind if participants did not spot the low VFX in slow motion than they would certainly not see it in real time. There is a weakness to this statement though: the movement. As mentioned above, people are unfamiliar with slow motion. The problem that arises is that people are consequently not able to know how elements would naturally move in a fraction of their normal speed. The currently implemented VFX benefits from this unfamiliarity. It was argued that changing the voxel settings does not only influence the overall look of the simulation but also its movement. The implication of this is that in a real time advertisement spectators might have been able to spot the simulations more easily, as low voxel definitions result in bulky undefined movements. Certainly, this is a hypothetical statement as when shown in real time the exposure would have been much shorter and influencing factors such as motion blur would aid the blending of the VFX. Nonetheless, both the smoke and the fire simulation profited from fact that they were exposed in slow motion as the spectators were unable to judge their movement.

Evaluation of Repetition

As part of the test procedure the advertisement was repeated three times in all of the six test versions. This choice was made to make sure participants had enough time to perceive the entire advertisement with care [6.1Determining the Method]. It was assumed that the slow motion, the minimal edit and the triple repetition would ensure all participants had enough time to perceive and remember the entire image.

A negative effect of the repetition is an unnatural condition. One might easily be exposed to the same advertisement more than three times in an ordinary situation, but these exposures would happen over the run of a couple of days and not directly in succession. In the worst case, this triple exposure might bore the participants and cause them to let their focus drift away.

Looking at quotes from the interviews it can be concluded even after the third repetition several test participants were not able to recall the entire advertisement and message.

"I think there is a last part, but I don't remember it"

Participant smoke high

"I don't remember the 3rd [crash] at all"

Participant smoke low

"I can't really remember this in detail"

Participant baseline

When critically evaluating if repeating the advertisement was the right decision the lack of recall from the participants indicates this was the correct decision. Although the direct repetition could have been tiresome it appears the participants did not experience it that way.

"I didn't mind watching it a couple of times"

Participant smoke low

Concluding, it can be derived that repeating the advertisement appears to be the correct choice. This way the participants were given the chance to focus on all the elements in the imagery. Applied in the industry this only means that repeated exposures spread out over several days can only lower the detection rate.

What is uncertain is how more exposures of the advertisement would have influenced the results. As established, it was difficult perceiving all the details happening throughout the advertisement even after the third repetition. The reason for this could be the test subjects tried to focus on as many elements in the imagery as possible because they were aware of being part of a test and got asked about the content. The chance that concentration of the participants' declines and their focus drifts to unrelated thoughts would increase with every additional exposure. Furthermore, if they were not distracted by the VFX after the third exposure additional exposures might not change that impression.

12 Conclusion

This chapter concludes on the findings of the test. The purpose is to determine whether the final problem of this thesis was answered.

The motivation of this thesis was to delve into limited budget VFX production and the problematic take on how to effectively limit the creation of VFX. How and where should VFX studios cut down to increase their productivity, but at the same time maintain a reasonable end result? This question led to a preliminary analysis of VFX in general which consisted of the current work of VFX studios, perceptual realism and schemata. The delimitation of the preliminary analysis narrowed the scope of the project and formulated final problem statement. This established the need for a synthesised theoretical model to test and answer the statement. This model was given the name: Expectation & Belief Model. The VFX was delimited to fluid simulations to narrow down the research and make it more precise. A thorough analysis was initiated for the purpose of building the foundation for the model. The topics elaborated included suspension of belief, hyperrealism, fluid simulation and perception. These theories were the foundation for the Expectation & Belief Model. Furthermore the decision of implementing two fluid simulations was maid, being smoke and fire. One should be a hyperrealistic element whereas the other should not, due to the design of the EBM. Meanwhile, an investigation of a suitable advertisement was started. Certain requirements were to ensure that the selected advertisement was essential for the scope of this thesis, including the need of finding an advertisement where fire and smoke were suitable. A test method and strategy were analytical determined in order to answer the problem statement. Two preliminary tests were conducted to determine if people were capable of differentiating quality and realism of fluid simulations and to how people recall smoke and fire by making them draw these. Five different versions of the advertisement were created as part of the test strategy to determine the border of acceptance. The need for a sixth test arose due to surprising smoke test results.

Design requirements were created to ensure that the design decisions were based on the theories of the analysis and preliminary analysis chapters. Fire and smoke were to be designed to fit the motorcycle crash scene within the advertisement. The final turnaround time and total simulation time spoke for itself in the implementation. The difference of turnaround time from 19sec to 28min 44sec in the range of 70 voxel smoke simulation to 300 voxel definition is radical. This step did not result in a difference from the participants' point of view. The results indicated that the participants accepted the 70 voxel definition version of smoke, but not even the high version of fire. This led to the assumption that fire as a non-hyperrealistic element requires great amount of simulation definition in order to be accepted by the audience.

Concluding the Hypothesis

Four hypotheses were used to determine the answer to the final problem statement in the current research. The findings acquired were able to prove all these hypotheses.

From the analysis of the hypothesis it can be concluded that hyperrealistic elements are stored with less detail in memory and thereby led to a higher acceptance rate despite a lower definition. Although the participants perceived and evaluated the smoke simulations they accepted them. Consequently, having a less detailed memory of hyperrealistic elements makes it hard to critically judge them. This effect was stronger than expected. The estimated bottom end of voxel definition was still accepted by the majority of participants and had to be decreased.

On the other hand, the non-hyperrealistic phenomenon distracted the majority. It was detected as distracting VFX by nearly all the participants and influenced their attitude in a negative way. Participants had a more detailed representation of fire in memory which gave them the possibility to evaluate the VFX in a critical manner. By noticing that elements in the image were simulated they were reminded of watching a film which led to disbelief.

Concluding the Final Problem Statement

- How to define the border zone of audience acceptance for limited budget fluid simulation effect in a advertisement video based on the Expectation & Belief Model?

The answer to final problem statement can be divided into three arguments.

1) The Expectation & Belief Model was able to provide and fundamental theory to approach the optimisation of the VFX production. By suggesting a lowering of the definition level of hyperrealistic elements it abuses the fact that people have not yet experienced these elements in real life. On that account people are not able to critically judge the simulation of hyperrealistic phenomena and thereby accept the imagery despite the lower simulation definition.

2) In order to be able to measure the difference of hyperealistc and non-hyperrealistic phenomena a measure of acceptance was developed. By correlating the attitude, remembrance and detection of VFX in the advertisement the overall acceptance and distraction rate for the different versions was determined.
3) In order to define the border zone high and low definition levels were specified. Matching the acceptance rate with the definition level helped to point out the upper and lower end of the border zone. To answer the final problem the overall motivation of saving budget by lowering the turnaround time was integrated into the process. By balancing the turnaround time with the lowest definition that would lead to an expected rate of 100% acceptance the final answer to the problem was found.

The findings of this thesis are considered clear and answer the final problem statement. They should be considered indications, as they have not been tested in order situations and hence not general answers. These results are considered relevant for the VFX industry. VFX studios have very different definition standards when it comes to simulations and this project acknowledges that. The findings have the purpose of informing the industry about how hyperrealistic elements can be lowered in definition and thereby increase productivity. Even though this study uses 70 and 300 voxel settings, and some studios would have much higher standards, these results are relative indications, and are thereby applicable in most cases. A VFX studio simulating a hyperrealistic simulation of 800 voxels, they could potentially lower the voxel definition intensively and optimising both the turnaround times and overall production workflow.

By looking at the turnaround time savings of this project, going from 300 to 70 a save of 28 minutes is possible. No doubt, that the industry will not implement simulations that low, but keeping the balance between turnaround time and end result would be very beneficial for the industry. Studios might implement a 150 voxel simulation for a hyperrealistic element, which will optimise and cut down 22 minutes in turnaround time. This is result in a great increase in iterations possible per day.

Conclusively, lowering the fluid simulation's voxel definition of a non-hyperrealistic element in advertisement will tend participants to accept the visuals. However hyperrealistic elements require great simulation definition in order for audience acceptance. The border of acceptance of smoke has been defined as 150-200 voxel whereas the fire remains higher than 300 voxels and thereby unknown.

13 Future Development

As with any project development options, changes from the original plan and implementation modifications are bound to arise. The results of testing and slight design inconsistencies beg the question what could have been done better or improved if time had allowed it. This critical review has been settled within the discussion chapter. This chapter will look into future development of the project and is divided into four subchapters. This division is done first and foremost to provide a logical and structured overview of the thoughts behind each development and to state the outcome of these whilst providing ideas and solutions on how to further develop this project.

General Fluid Simulation Results

Based on the results of how people perceive smoke and fire simulations, how could these findings be applicable to other types of fluid simulations?

Both smoke and fire simulations are very common effects and are the foundation for many other fluid based effects. Snow/sand storm, hurricane, water are all possible to develop with fluid simulations and their algorithm solvers. Therefore these finding can to some extend be used for other project with fluid based effects. No doubt that the parameters of the fluid solver needs adjustments to encounter the desired effect, but the overall theoretical approach of analysing which type of element the VFX artist is supposed to mimic is indeed crucial. Whether the element is hyperrealistic is just as valuable to consider, as regular effect consideration like, movement, placement, key element or background, in or out of focus etc.

In order to directly apply the results of this project to other effects would involve more testing. Water simulation needs great detail level due to its non hyperrealistic nature. Only new test iterations would answer if the results of the fire simulation would be similar to water. Furthermore, new test iterations will answer if every type of simulation has its own definition level due to the common established schema of that particular phenomenon. It would be interesting to test other hyperrealistic elements to determine if they have a similar low distraction effect in low defined simulations.

Border of Acceptance – Fire

When thinking of new test iterations, it should be mentioned that the results of fire did not define a border of acceptance. Even at voxel definition of 300 the participants responded with negative statements concerning the advertisement and only half of the participant believed in the imagery. By designing two new test iterations with e.g. 450 and 600 in voxel definition the audience acceptance is possible to occur. Fire simulation with additional smoke emitting from the fire flames would ideal representation of fire. As discussed this was not within the scope of this project, but could be necessary if the audience would tend to get distracted by fire alone, even at very high definitions.

Real-Time Effects

The advertisement was based on slow motion footage. Believable VFX is depended on two parameters; appearance and movement as described in [4.4 Fluid Simulation]. The border of acceptance is the main scope of this project and thereby includes both of these parameters. Voxel definition affects both the appearance and movement, but the slow motion advertisement creates a surreal environment and thereby makes the detection of movement harder to judge for the audience as described in the discussion chapter.

This suggestion is considering the possibility of different results by testing the same implementation in a real-time version of the advertisement. Slow motion effects are often considered as difficult to create due to the extended exposure of the given effect, which in many cases is true. Although when the goal is to simulate a real-life phenomenon, the case might be different. This suggestion has the eager to find a solution to this hypothesis. This investigation could potentially lead to advise which simulations would be more efficiently created in slow motion than in real-time or vice versa.

Meet the Industry

The above suggestions to future development paths of this project revolved around the usage of the results and how to improve them whereas the following suggestion is quite different. The results of this project are clear; optimise your production pipeline while working with hyperrealistic elements. This message should be presented to the industry, giving the opportunity to receive feedback and hear their opinion regarding lowering simulation quality to optimising production costs. An interesting discussion could spawn from this presentation. Topics that could benefit the further progress of this thesis are:

- Is the VFX industry ready to lower quality?
- How would VFX studios meet a client's limited budget with current methods?
- What are today's standards in voxel definition for fluid based simulations?
- Would the given studios care to use this research?

- If yes, how? And to what extend?
- How does the industry consider working with slow motion? (the above suggestion)

14 Appendix

14.1 Appendix A: Interview Questions

Intro/Warm Up:

1. Please use 2 minutes to write down the first 5 words that come to your mind about this advertisement.

2. Have you ever seen this advertisement before?

3. Do you know the brand?

4. Have you ever seen a motorcycle crash in real life?

5. Do you generally enjoy slow motion effects?

Main Session:

6. Ask one participant to describe as detailed as possible what happened in the advertisement.

7. Which of the crashes was most memorable, why?

9. What was the biggest difference between the crashes?

10. How much of the advertisement is film footage and how much is computer generated?

11. Would you consider these crashes as Hollywood style?

12. What would have changed to make the advertisement more Hollywood style?

Outro:

13. Please draw smoke and fire as detailed as you can.

14. Do you have any last comments?

14.2 Appendix B: Test Results - Evaluation of the Drawings

After the remembrance factor it is time to delve into the drawings and how the participants drew both smoke and fire images as the final task of the test. When discussing the findings that can be derived from these drawings it is important to keep in mind that comparing the drawing style of two images is a subjective and inexplicit task. Hence, the findings stated in Figure 14.1 should be considered as interpretations therefore result in tendencies, not facts. The most detailed drawing each participant was plotted into Figure 14.1. In case no or little distinction of detail in drawings could be determined the drawings were declared as even.

	Detailed smoke	Detailed fire	Even detailed
Baseline	14%	57%	29%
Smoke low	9%	36%	55%
Smoke high	11%	78%	11%
Fire low	0%	100%	0%
Fire high	0%	80%	20%

Figure 14.1 Evaluation of the drawings

Throughout the main tests the results from the pre-test were confirmed. Overall people drew fire in a higher detail than smoke. This indicates that the hyperrealistic element smoke was recalled in less detail and hence the drawn as such.

All the participants who were exposed to the advertisement which included fire were judged to draw the fire in a higher detail than the smoke. This could point to the fact that the participants saw the fire in the advertisement and consequently were able to draw them in more detail. It must be noted though that the flames were overall drawn in more detail, hence this result might be biased.

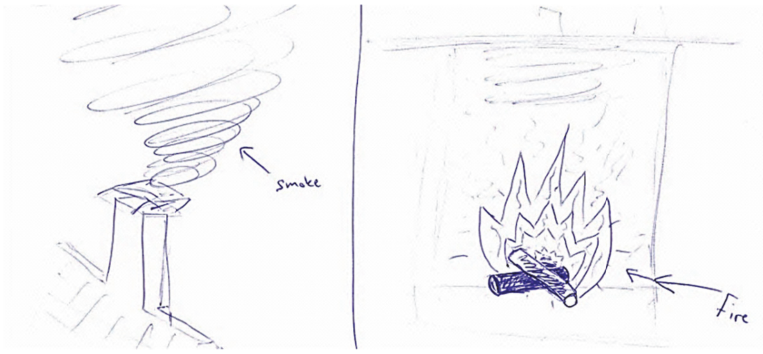


Figure 14.2 Example drawing low fire (fire more detailed)

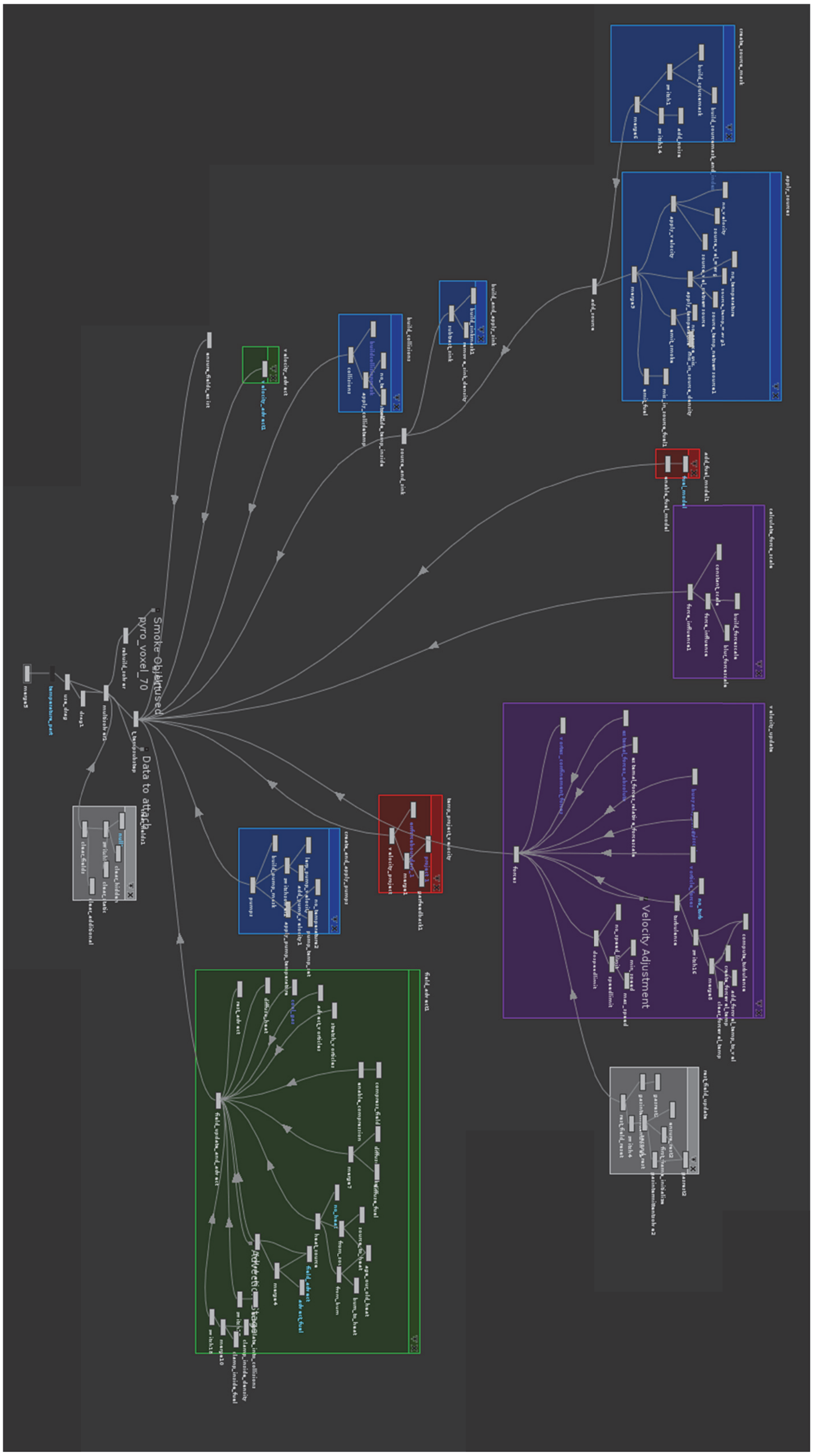
One tendency these numbers indicate is that depending on the fact if the VFX is labelled as not schema conform it gets processed intensively. When looking at the *smoke high* version it appears that the test participants were able to draw fire in more detail than smoke. This means that they might have rated the smoke cloud as schema conform and hence did not process it in depth, but only schematically.

The majority of participants were judged to draw both phenomena in even detail in the *smoke low* version. This could be due to fact the participants evaluated the smoke cloud more carefully. As the voxel definition was noticeably lowered in the *smoke low* condition the participants might have noticed the smoke cloud but were not sure if it was conform with the image or not:

> *"There is a lot of dust particle in [the 2nd crash] that would be hard to do with a computer"*
>
> *Participant smoke low*

This quote shows that this participant actively processed the smoke and rated the probability if it was CG or not. Consequently, when asked to draw smoke it might be easier to recall an image of smoke and hence draw it in more detail.

14.3 Appendix C: Pyro Solver



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