SERIOUS GAMES FOR OVERCOMING PHOBIAS
The Benefits of Game Elements

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Abstract

This thesis analyses the benefits of applying game elements to a Virtual Reality application for overcoming phobias, with a special focus on acrophobia, i.e. the fear of heights. Two different prototypes using the Oculus Rift head-mounted display were developed with a gradually exposure to heights. Both prototypes shared the same acrophobic scenario, but one included extra features from games such as engagement, motivation or goals. Twenty-four participants, divided into two groups of twelve, with moderate aversion to heights tested the prototypes. The participants’ heart rate and the time that they looked down from high altitudes were also measured and evaluated. The study showed slightly higher results regarding motivation for the prototype which included the additional game elements. Future studies should include a different head-mounted display, which would allow a longer time of play without motion sickness, and the participation of people diagnosed with acrophobia.

Key words: Acrophobia, motivation, phobia treatment, Serious Games, Virtual Reality.
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1 Introduction

Video games are increasingly present in our daily lives and their market is having a major expansion these days with the new portable devices. Games are the result of the combination of different elements or features that entertain people. As a result, these "game elements" have been applied to other projects aimed at other purposes beyond pure entertainment. These projects generally named “Serious Games” (SG) are currently present in areas such as health, education, military, business, etc.

Phobia treatment is one of the sectors where SG have not been fully exploited, where most applications seem to be limited to Augmented Reality (AR) or Virtual Reality (VR) systems, which are not usually designed with the good balanced characteristics of games (fun and engagement, more than a simple simulation of the real world). More specifically, the fact that no game with features such as engagement or motivation for acrophobia could be found, would motivate the implementation of a simple prototype that could be used by therapists to enhance the patients’ experience during exposures to heights.

Several opportunities of the SG for phobia treatment are analysed in this study. Garcia-Palacios, Hoffman, Carlin, Furness and Botella (2002) found the strong preference by patients to use VR instead of in-vivo exposure in phobia treatments. Three different studies about SG for other specific phobia treatments (technophobia, cockroach phobia and speech disorder) are also presented, where they all found some benefits after being tested with patients who suffered from these phobias. Moreover, the recent launch of the head-mounted display (HMD) Oculus Rift in 2013, also brought a sharp increase of interest in people to use VR at the time that this study was conducted. Moreover, since this HMD was sufficiently portable and accessible to all, it might be a good opportunity for patients to undertake phobia treatments in their own homes.

The study was aimed to investigate and evaluate how game elements could influence the patients’ motivation in overcoming a fear when game elements (such as engagement, feedback, missions, etc.) are applied to a VR application for phobia treatment, with a special focus on acrophobia, i.e. the fear of heights.

For this experiment, two different prototypes were developed with Unity 4 Pro and C#, Oculus Rift, a wireless controller, a pair of headphones and a biofeedback device for measuring the participants’ heart-rate. Both prototypes were designed to share the same acrophobic scenario, where the participants were exposed to different levels of heights gradually. The game elements were the only difference between them, so that one of the prototypes included some features such as missions, music or animated characters and all these elements were excluded in the other prototype.
2 Background

2.1 Acrophobia

Nowadays, mental disorders play an important role in health, mainly due to the large number of people suffering from such disorders, which according to World Health Organization (2003), is estimated to 450 million people worldwide.

As part of those mental disorders, phobias are classified as sub-types of anxiety disorders and divided into three different categories: social phobia, specific phobias and agoraphobia (American Psychiatric Association, 1994). People who suffer from any kind of phobia usually have involuntary, irrational and uncontrollable reactions when they are involved in a situation where they feel an inexplicable fear. Some studies estimate that about 9% of the population has experienced a reaction due to a phobia (Doctor, Kahn & Adamec, 2009). In addition, Botella, Bretón-López, Quero, Baños and García-Palacios (2010a) refer Agras, Sylvester and Oliveau (1969); Boyd, Rae, Thompson, Burns, Bourdon and Locke (1990); Essau, Conradt and Petermann (2000); and Magee, Eaton, Wittchen, McGonagle and Kessler (1996) to expose that only 20-40% of those affected by phobias have been treated. Among the different types of phobias, the most common phobias are the following: insects or spiders phobia; acrophobia (fear of heights); flying phobia; driving phobia; or social phobias.

Specifically, acrophobia, which belongs to the category of specific phobias, is an extreme or irrational fear of heights, which make people who suffer from it to avoid some situations in daily life such as elevators, terraces or stairs. Some studies have evaluated the presence of acrophobia in people, finding a significant percentage of people affected by it. Fredrikson, Annas, Fischer and Wik (1996) found that 6.3% of men and 8.6% of women of population suffer from acrophobia (with a sample of 20.000 participants) and Chapman (1997) refers the ECA Study, where they found that 4.7% of the population might be affected by acrophobia. According to Burns (1980), acrophobia is a disorder that can worsen in the course of life and become chronic. For that reason, the author further stress the importance of being treated in case of suffering from it.

2.1.1 Treatment for acrophobia

The classic treatment for specific phobias has usually been through a single exposure, named "in vivo". Garcia-Palacios et al. (2002) refers Antony and Swinson (2000), Marks (1987) and Mathews (1978) to argument the basis of phobia treatments and the successful results after being applied to a wide range of phobias. During an “in-vivo” session, the patient has to face the fear in a real situation, being always controlled by a specialist. But unfortunately, this experience is not pleasant for many patients and specialists are currently looking for alternative ways to prepare patients to perform the exposure session. Furthermore, depending on the type of phobia, the real exposure could pose a risk to others (such as driving phobia) or a great cost to the patient (fear of flying), so that technological tools are used for this purpose.

Cognitive-behavior therapy (CBT) is also currently used in many of treatment for people affected by anxiety, depression or phobias. One of the existing definitions for CBT is:
CBT is a generic therapy that combines behavioral interventions (direct attempts to reduce negative emotions and behavior by altering behavior) as well as cognitive interventions (attempts to reduce dysfunctional emotions and behavior by altering individual appraisals and thinking patterns).

Xu, Zhut, Zhang, Lit, Lit and Kang (2011, p. 212)

According to Xu et al. (2011), CBT treatment usually consists of several therapy sessions in which the patient interacts directly with computer software, instead of being treated by a therapist. Therefore, this treatment becomes more accessible to the general public, which may not afford the sessions with experts.

2.2 Virtual Reality and Biofeedback in phobia treatments

These days the use of new technologies is more and more involved in therapies to treat fears, where Virtual Reality (VR), Augmented Reality (AR) and external devices for biofeedback play an important role.

2.2.1 Biofeedback

Biofeedback can be defined as a method for measuring some parameters related to the human body such as heart rate, blood pressure, muscle tension or breathing. Five studies were identified by Clough and Casey (2011) related with anxiety, depression or insomnia disorders. After their investigation, the authors concluded that biofeedback brings new possibilities for psychotherapy, especially for anxiety, somatic and sleep disorders. They also found that the advantages of handheld biofeedback systems (portable, cheap and user-friendly devices) have not been exploited enough.

Probably the greatest utility of biofeedback devices used in phobia treatments is that they allow to collect objective data without requiring interruptions for patients to report their status, which may ruin the level of immersion or concentration of patients. This occurred in several studies, as the one performed by Juan and Pérez (2010), in which the participants had to report their state of anxiety in six different times of the test.

Specifically, heart rate is one of the most commonly methods used in studies of phobia or anxiety disorders (Licht, de Geus, van Dyck & Penninx, 2009; Meehan, Insko, Whitton & Brooks, 2002; Emmelkamp, Bruynzeel, Drost & van der Mast, 2001; Shalev, Sahar, Freedman, Peri, Glick, Brandes, Orr & Pitman, 1998; Kawachi, Sparrow, Vokonas & Weiss, 1995). Although most of these studies show that it is not easy to reach an accurate conclusion with heart rate information, using this variable helped these researchers to analyse data, conducting a joint interpretation of the results with other variables.

2.2.2 VR and AR

Virtual Reality (VR) can be defined as a combination of technologies that creates an unreal world where the user is able to interact (Gregg & Tarrier, 2007). More specifically, the term VR exposure therapy (VRET) is also used when VR is applied to specific phobias therapies.

Garcia-Palacios et al. (2002) analysed two previous studies where they found a strong preference by users to use VR instead of in-vivo exposure in therapies. This is one of the
reasons why most researches in this field prefer to investigate the use of VR in exposure therapy for anxiety disorders (Clough & Casey, 2011). One of those studies, performed by Powers and Emmelkamp (2008), made some comparisons between in-vivo and VRET exposures and found that VRET is slightly more effective than in-vivo exposure.

Augmented Reality (AR) is a variant of VR in which the user has a view of the real world, but it is mixed with virtual items (Garcia-Palacios et al., 2002). The differences between VR and AR were tested in a study by Juan and Pérez (2010), where the authors compared presence and anxiety for both in a treatment for acrophobia. They performed the study recreating the same scene for the VR and AR systems, namely a room with an animated hole that produced the acrophobic situation. After being tested by 20 people who did not suffer from acrophobia, the results showed that both systems gave the same level of presence and anxiety.

According to Botella et al. (2010a), the main benefit of using VR or AR in phobia treatments is the possibility of having a controlled environment, where situations and elements can be managed depending on the state of the patient. Furthermore, the authors also argue that these tools allow patients to be more confident during the treatment, instead of doing it in a real environment. Lastly, they also explain that these types of tools make it possible to emulate situations that may be difficult or expensive to perform (such as getting on an airplane or climbing a very tall building) and include animals such as cockroaches or snakes without them being damaged accidentally.

On the other hand, an important factor to take into account in a VR system for acrophobia is the level of presence, since according the studies performed by Schuemie, Bruynzeel, Drost, Brinckman, de Haan, Emmelkamp, and van der Mast (2000) and Friedman, Regenbrecht and Schubert (1998), there is a connection between the level of presence and the fear in a VR environment with heights.

In addition to that, a study performed by Coelho, Santos, Silva, Tichoon, Hine and Wallis (2008) exposed eight acrophobic participants to a VR environment and found that the anxiety of the participants did not only depend on the height at which they were exposed, it was also affected by the lateral movements they had to do at that height. Participants’ anxiety levels were much higher when they had to move around the scene than when they were in the same scene without movement. Coelho, Waters, Hine and Wallis (2009) illustrated that, by stating that in the same way that babies learn to overcome their obstacles and stay in balance, people affected by acrophobia should train their visual and sensorial systems and learn how to move in situations with heights.

It is also important to note the large number of new VR projects which are being developed at the time of this study, probably due to the ease for any developer or researcher to find a head-mounted display (HMD) as Oculus Rift, whose first version for developers started to be delivered in March 2013 (Oculus VR, 2013). Among these new projects, there are some available that make use of VR for the simulation of acrophobic scenarios:

- The VR prototype developed by the company Inition (2013) was showed at the Digital Shoreditch Festival 2013. It integrated Oculus Rift, Kinect for positional tracking, 3D sound and a real plank. In the prototype, the players had to walk across a real plank that simulated a plank of wood between the roofs of two tall skyscrapers.
- The company Worldviz showed the VR project “Pit” at IEEE VR 2013 Conference (Worldviz, 2013), which simulated the environment of a metal storehouse and it was compatible with Oculus Rift. The prototype showed climbing platforms, while those below were falling.

- PsyTechVR, a company dedicated to the treatment of phobias with VR, included a VR simulator for the treatment of acrophobia as part of the product IRHA (Anxiety Management Platform for Virtual Reality), only offered to specialists for helping them in phobia treatments (PsyTech, 2013). The tool simulated a city where the user was standing on a platform located on the outside part of a building. Then, that platform raised to the top of the building, while the user could look from different levels of heights.

### 2.3 Serious Games

Serious Games (SG) are being used in variety of purposes such as healthcare, education, military, corporate, etc. There is no exact definition for SG, but one is exposed as follows:

> Serious games are digital games, simulations, virtual environments and mixed reality/media that provide opportunities to engage in activities through responsive narrative/story, gameplay or encounters to inform, influence, for well-being, and/or experience to convey meaning.

Marsh (2011, p. 63)

As stated by Boyle, Connolly and Hainey (2011, p. 73), SG are based on very different characteristics such as “voluntary, enjoyable and challenging activities with varying conditions which can specify goals, objectives, rules, moves, constraints, feedback, payoffs and consequences”, where the motivation and engagement during the game must be at least as important as learning outcomes after playing. Other researchers (Harteveld, Guimarães, Mayer & Bidarra; 2010) exposed a study based on the previous experience of developing a game to train levee patrollers in the Netherlands. As Figure 1 shows, Harteveld et al. (2010, p. 336) maintains that SG must be designed balancing three equally important components: “Play (e.g., engagement, fun, immersion); meaning (e.g., reflection, relevance, transfer) and reality (e.g., fidelity, realism, validity)”.

![Figure 1](image)

**Figure 1** The Design Philosophy. Adapted from Harteveld et al. (2010, p. 325)
2.3.1 Serious Games in Healthcare
Nowadays, SG are being applied in the field of healthcare with considerable success. Different areas where SG are been used in that field were identified by Susi, Johannesson & Backlund (2007) as follows:

- **Physical fitness**, those games that make the exercise more appealing for people using the engaging elements of video games.
- **Education in health/self-directed care**, such as games that teach children about healthy habits.
- **Distraction therapy**, those games aimed to distract people during uncomfortable treatments.
- **Recovery and rehabilitation**, those games that simulate and stimulate the rehabilitation for certain conditions.
- **Training and simulation**, such as games designed to train doctors to perform surgery.
- **Diagnosis and treatment of mental illness/mental conditions**, such as games developed for deficit hyperactivity disorder (ADHD) or post traumatic stress disorder (PTSD).
- **Cognitive functioning**, such as games aimed to train memory.
- **Control**, those games with biofeedback equipment for a better understanding and/or measurement of the players’ vital rates.

2.3.2 Serious Games for phobia treatment
There is currently a lack of SG for phobia treatment with the entertainment aspect of games. However, there are some available SG contributing to the treatment of phobias:

- **Audition: The Game** (Lavender & Gromala, 2012): These authors developed a third person game for investigating the potential role of SG in treating stuttering and similar speech disorders. In one part of the game, the user had to ride a skateboard through traffic with a mouse or trackpad. This action part was included to increase the game’s engagement and compare the player’s stress level with the “serious” part of the game. The other part consisted in reading a text that appeared in the screen while a second person (a therapist or researcher) evaluated the user’s reading. During the test sessions, a biofeedback device allowed the authors to perform the method Galvanic Skin Response and measured the participants’ level of stress based on the sweat activity. After testing the game with 12 individuals, the authors did not notice any sign of improvement in the participants’ speech disorder, but they found other information that could be used in future treatments. Specifically, they found that the stress level for most participants increased just before the audition and in the moment they had to start reading the text, and it decreased as the speech progressed. The test results also showed that the prototype met the characteristics of a game, resulting attractive, interesting and challenging for the participants.

- **Multi-Touch Automated Teller Machine** (Carvalho, Bessa, Peres, Magalhaes, Guedes & Oliveira; 2012): This game with multi-touch interface was created to help people digitally excluded (including people who suffer from technophobia, i.e. the fear of new technologies) to use the Portuguese Automated Teller Machine (ATM). The authors decided to create a game prototype as the best way to access their target group, since the
participants would reject a direct exhibition with a real ATM. Moreover, they also though that using a SG where they could interact and communicate with other people and the game would make them feel more comfortable. The game consisted of several levels, in which the user was challenged to perform various actions with the virtual ATM. They tested the game with nine participants with ages between 32 and 78 and they observed that at the beginning some of the participants felt revulsion of touching and interacting with the game. However, they lost their fear and learned to use it when the test ended. The results also showed that the intuitiveness of the game was positive for participants.

- **Cockroach Game** (Botella, Breton-López, Quero, Baños, García-Palacios, Zaragoza & Alcaniz; 2010b): This prototype was created aimed to study the utility of a SG for the AR exposure in the treatment of cockroach phobia. The author state that "mobile phones will soon become the most important platform for changing human behavior" (Fogg, 2007, p.5) to argue that the impact of SG has just started and they referred some new treatments for children with emotional problems which are currently making use of SG, but its effectiveness has not been tested yet. Botella et al. created a mobile application where the user had to complete several puzzles, whose pieces appeared after “killing” virtual cockroaches. They used the application for a single case study (a woman with cockroach phobia) based on the hypothesis that the patient may feel more familiarized with insects and thus reduce the level of fear and avoidance before the exposure session. The authors also guaranteed that the participant had the opportunity to leave the game at any time if she needed it. The results showed that it helped the participant to improve and consolidate her level of fear, avoidance and belief in the catastrophic thoughts, although it was a single case study that needs to be extended and be tested by a larger group of people.

These three presented studies found some benefits after testing their SG prototypes with patients who suffered from different phobias. The results of two of these studies showed improvements in the participants’ level of fear and avoidance. The other study found no improvement regarding the phobia. However, the prototype used for the experiment resulted attractive, interesting and challenging for the participants, which could increase the users’ motivation to play more times and maybe find a long-term improvement. Unfortunately, it is not easy to find a SG for acrophobia that incorporates elements of the game in a similar way as these three exposed cases did.

On the other hand, several opportunities of SG in phobia treatment were identified in other studies (Botella et al., 2010b; Clough & Casey, 2010): They might be helpful for therapists to measure their patients’ variables, such as the grade of anxiety or avoidance, especially when if the patients use these SG at home; SG for phobia treatment also may help the patient to feel more familiar with the phobia that is being treated, reducing the patients’ level of fear in the phobic situation; and finally, SGs for phobia treatment could increase participation and homework adherence between sessions, which may prepare patients to be ready for the one-session exposure therapy.
Problem

As stated previously in the background, there is currently a lack of studies about phobia treatments using SG. More specifically, the fact that no game with features as engagement or motivation for acrophobia could be found, would motivate the implementation of a simple prototype that could be used by therapists to enhance the experience of people during experiences with heights. All studies presented in section 2.2.2., deal with applications that use VR and/or biofeedback. Comparing these systems with the SG definition of Boyle, Connoly and Hainey (2011), most of them did not include characteristics of games such as challenging activities, varying conditions, objectives, feedback or consequences. A similar result was obtained after comparing the design philosophy of Harteveld et al. (2010) with those applications. They were mainly designed with a high grade of fidelity, realism and validity (component "Reality"), where the game was commonly based on an imitation of the in-vivo exposure, but forgetting the entertainment or engagement part (component "Play") that a SG game should provide as these authors stated.

Furthermore, three different studies about SG for other specific phobia treatments (technophobia, cockroach phobia and speech disorder) were also presented in section 2.3.2., where they all found some benefits after being tested with patients who suffered from these phobias, improving their level of fear and avoidance or motivating them to use it again since they resulted attractive, interesting and challenging. Taking these results into account, it would be useful to check whether a SG for acrophobia could also achieve similar results and improve the participants’ level of fear or motivate them to use it frequently.

As it was previously discussed in section 2.2.2., Garcia-Palacios et al. (2002) found strong preference by users to use VR instead of in-vivo exposure in therapies for phobias. This would motivate the idea that specialists would still be interested to expose patients using VR applications that simulate different level of heights. In addition, probably due to the recent launch of Oculus Rift in 2013, many people have become interested in VR. The free commercialization of a HMD and the grade of realism and immersion that the device achieved were important factors for that interest regarding VR. Moreover, many projects are being developed with VR at the time of this study and the market is expected to continue growing, as new and improved HMD will be available soon. This facility of having an own HMD at home could be a big opportunity for VR phobia treatments, since the patients could use SG for treatment at any time, from anywhere. That would also bring them the possibility of being treated with VR in a completely comfortable environment for them as their own home.

The importance that the level of presence (Schuemie et al., 2000; Friedman, Regenbrecht & Schubert, 1998) and movements (Coelho et al., 2008) have in the participants’ anxiety levels was also mentioned in section 2.2.2. Today it is still not easy to transport body movements into an application, but a HMD with head or position tracking which also brings a good level of immersion could be a good option for it. Moreover, it should be ensured that the participants will not be interrupted directly or indirectly during the exposure, since that might affect the level of presence or anxiety of them, affecting the final results of the study. As it was exposed in chapter 2.2.1., it seems a common thing in test sessions in phobia studies that participants have to communicate their level of anxiety in different times of the exposure, but it could be avoided with a biofeedback device that analyses and stores the body measures of the participants automatically.
This thesis is based on the following research question: “What are the effects, in terms of patients’ motivation, when game elements (such as challenging activities, engagement, varying conditions, objectives, feedback or consequences) are applied to a VR application for phobia treatment?”. 

3.1 Aim

The aim of this study is to investigate and evaluate how game elements could influence in patients when these elements are applied to a VR application for phobia treatment, with a special focus on acrophobia, i.e. the fear of heights.

Hypothesis: Participants would feel more motivated to use a VR application for phobia treatment if it would include game elements (such as challenging activities, engagement, varying conditions, objectives, feedback or consequences) rather than one that would not.

3.2 Method

3.2.1 Prototypes and Hardware

Two PC-based prototypes were designed and implemented with the purpose of being used as a treatment tool for overcoming acrophobia. The decision of creating two different prototypes was motivated by the possibility of making comparisons between them concerning the possible effects that both could cause among participants.

Both prototypes were designed to share the same acrophobic scenario, where the participants were exposed to different levels of heights gradually. The game elements were the only difference between them, so that one of the prototypes was closer to the SG definition of Boyle, Connoly and Hainey (2011) or Harteveld et al. (2010), including some features as engagement, motivation or goals (“PG”). These elements were excluded in the other prototype, which was intended to be closer to a simulation of the real world rather than a commercial video game (“PS”).

Due to the time limitation, the prototypes were implemented with known technologies previously used by the student, which also brought a lot of possibilities for developing a realistic environment as Unity 3D and C#. The sense of realism of the prototypes and the immersion of the users playing them were improved by using the HMD Oculus Rift (version “Development Kit 1”), which brought head tracking, another advantage being that it was compatible with the current version of Unity. A wireless Xbox 360 controller was also used to allow the player to control the walking and jumping movements or leave the game instantly in case it was necessary. Moreover, an external biofeedback device was also included in the prototypes to measure and control the different users’ heart rate during the game. Specifically, the device used in the experiment was Polar WearLink+, which was placed in the body of the participants through an elastic fabric and transmitted the heart rate information (in beats per minute) via Bluetooth to an Android mobile device with the application HRnavi. These heart rate logs were subsequently analysed with the application Polar ProTrainer 5 for PC. Additionally, it was also necessary the use of a pair of headphones during the test sessions in order to improve the users’ immersion, prevent them from asking
questions while they were testing the prototype and avoid interruptions from external sources.

3.2.2 Participants

Participants of the test sessions were recruited through advertisements at the campus of the University of Skövde, websites for social interaction between students of the university (such as Facebook groups) and some bulletin boards in Skövde. The participation was voluntary and the participants did not receive any compensation for their time or results. Participants diagnosed with acrophobia were excluded due to the difficulty of having a specialist involved in all the test sessions.

3.2.3 Procedure

Each test session was performed individually and took place in an environment where the participants could feel comfortable, such as a room at the University of Skövde or in their own home. The participants were randomly assigned to two different groups: Prototype with a greater variety of game elements (“PG Group”) and Prototype with very few game elements (“PS Group”). The participants were not informed of the existence of a different prototype apart from the one which they tested in order to ensure that the results were not affected.

First, the participants had to read the instructions of the corresponding prototype (see Appendix A for the PG and Appendix B for the PS), which explained the purpose of the study; possible risks; guarantee of confidentiality of their personal data; missions of the game; controls; and time limitation. In case they agreed to continue the experiment, they were asked to fill in some fields of the questionnaire: age; how often they play video games (on a scale between 1 and 5) and the level of fear of heights before the experiment (also on a scale between 1 and 5). After that, they were required to read the seven questions that should be answered on a scale between 1 and 5 after playing each level. Thereupon, the participants’ heart rate before the experiment was measured. Then, they were required to play the three levels for a maximum of five minutes and without a minimum time set, since the participants were able to stop the test at any time. After each level, they were required to answer the seven questions concerning the last level played about their sense of heights and enjoyment. And lastly, the participants were required to fill in the last field of the questionnaire, which concerned about their level of fear of heights after the experiment. The rest time between levels was not set, so the participants could take the time that they considered appropriate in order to prevent motion-sickness.

The total amount of time played and the output video of each test session were also recorded and stored in case additional information (such as progress, movements or decisions of the participants) were required in the analysis part after the test sessions. Moreover, the time that the participants were over the bridges in the game was also stored. This time placed on bridges was divided into three different situations: when the participants looked straight ahead; when they bowed their heads slightly; and when they looked down completely. The heart rate of the participants before and during the test sessions was also measured and stored.
3.2.4 Ethical considerations

It is also important to understand the ethical considerations of a psychotherapeutic treatment in case that any of the developed prototypes will be used in a future phobia treatment. Taking into account some ethical codes (European Federation of Psychologist’s Associations, 2005; The European Association for Psychotherapy, 1995), aspects as confidentiality, integrity and respect for the patient’s rights and dignity should be guaranteed in the game. As it is normal in a phobia treatment, patients must feel free to stop the treatment at any time, here it would be appropriate that the user has the opportunity to leave the game very easily and at any time if necessary.

Regarding the test sessions, since acrophobic participants were excluded, the participants were only informed about the purpose of the study, the risk of nausea that might feel using the prototype and the guarantee of confidentiality existing on any personal data resulting of the test sessions.

Another ethical aspect considered during test sessions was the privacy of the participants. This gained even more importance after the decision to use a device to measure heart rate during the test sessions which was placed in contact with the body of participants. Thus, they were asked to place the device under their clothes for themselves and use a different room if they needed it.

3.2.5 Expected results

It was expected that, if the sense of heights would adequate in both prototypes, participants would notice a greater improvement in their fear of heights in the PG. There are several reasons for expecting these results. Adding missions, feedback and characters that interact with the player, participants may be sufficiently motivated to play the maximum time set for each level, while in the other prototype they were likely to end before the maximum time, obtaining a shorter time of exposure. Moreover, in the PG, it was also expected that participants were concentrated in different parts of the game in order to complete the level (enemies, timer, etc.), so they might be unconsciously training themselves to move in an environment with heights. Finally, in the second level of the PG it was necessary that the players looked at the ground or from different angles in several moments of the game, so probably the participants who played that prototype have been more exposed to the fear.

On the other hand, it was also expected that, if the content of the levels resulted interesting and engaging enough, the motivation of the participants would be higher for the PG. The missions, characters that interacted with the player, music or timers would make that the participants felt more motivated to use the PG than the other prototype.

3.2.6 Limitations

The original plan for the test sessions was to complete each of the three different levels in different weeks or days progressively for all the participants. Thus, they would not be affected by past expositions with Oculus Rift and the improvements in the fear of heights could be analysed after a continued use. This idea was discarded because of the lack of time of participants at the time of this study, as it would be difficult to attract a significant number of participants for three different sessions, especially if the prototype that they tested would not motivate them enough. Even so, several participants of each group were contacted after
the official test to conduct a follow-up experiment with those who were interested. Unfortunately, none could participate in that post-study due to lack of time they had in the weeks in which the experiment was conducted.

It was also thought at first to recruit only persons who suffered from acrophobia for the test sessions, but then it was changed to people with any kind of rejection of heights but not diagnosed with acrophobia. The reasons for that change was the impossibility of performing the test sessions with a specialist, the complexity of the ethical considerations and the difficulty of finding participants diagnosed with acrophobia.

Due to the high latency and poor resolution of the current version of the HMD Oculus Rift (Development Kit 1) at the time of this research, it was likely that the player would feel motion-sickness after using it for a few minutes, and probably, this feeling would get worse in each of the exposures carried out on the same day for that person. For that reason, the game was divided into three short levels with a maximum time of 5 minutes instead of a much longer game as it was originally planned. It has recently been announced that the future version of Oculus Rift and some others HMDs, which will appear in the coming months on the market, will have a higher resolution and hopefully they will not cause any feeling of nausea.

Moreover, due to lack of time for developing the prototypes, the missions that the players were required to complete were static and repetitive, which would limit the game life but it would guarantee the exactly same conditions in case of this study was repeated.
4 Prototypes Design

As it was previously mentioned in section 3.2.2, the prototypes were developed using Unity 3D in combination with C# scripts. Other game engines were also considered as Game Maker or Unreal Engine, but previous knowledge of the student were better for Unity and that may ensure better results in less time.

Both prototypes were designed as a 3D environment with a first person controller, since it was the best way that it was found in order to improve the feel of realism and users’ immersion, especially using Oculus Rift. Moreover, the Pro version of Unity 4 was required in order to integrate a component with two cameras for each Oculus Rift’ lens. In addition, and due to the time limitation of this thesis project, it was decided to take the different assets that appeared in the prototypes (music, sounds, terrains and 3D models) from existing sources.

As introduced in section 3.2.2, both prototypes share the same acrophobic scenario, with leveled height exposures. Therefore, and given the importance that the user could feel the sense of height, the first part of the project was mainly focused on finding an acrophobic situation that could be translated into a game. Several scenario alternatives for the prototypes were considered: elevators with crystals; climbing towers; big wheels; zip-lining and crossing bridges between buildings. The idea of using a small helicopter and a GoPro camera in combination with Oculus Rift was also taken into account, since it would provide a completely real and active environment for the player, who may also recognize it. After some testing, this option was discarded mainly due to the low resolution of the current version of Oculus Rift, since the results did not bring the grade of realism required for this study and the feeling of dizziness, which was frequent due to the movements of the helicopter. Finally, the choice was the scenario with tall buildings and bridges to cross them, despite of being one of the most widely used in successful games as Mirror’s Edge (EA, 2008) or simulators (Inition, 2013). The decision was motivated by the belief that being on top of a building could be one of the most realistic and experienced situations by people, in addition to the many possibilities that it could bring for implementing the storyboard and missions of the game.

As it was planned, the results of the preliminary experiment (section 5.1) were also taken into account for the prototypes design. The issues reported by the participants of that study were fixed successfully. The main issue moved the camera slightly to one side, affecting the motion sickness of participants, but it was solved after replacing the thumbstick used for turning the character around with the triggers of the Xbox 360 controller. Moreover, the preference of the participants of the previous study by playing short games was also considered and the prototypes were divided into three short levels. The sense of heights was also improved after adding some missions in the prototype with game elements where the participants were required to look down or from different angles in several occasions of the game in order to complete the levels.

Both prototypes also included background processes that automatically stored the amount of time that each participant played the different levels. Moreover, the number of frames in which the participants were over bridges in the game were also automatically stored. These amount of frames were divided into three different groups depending of the position of the participants’ head: when the participants looked ahead (Y axis of the cameras’ local position > 0.12); when the participants’ head was slightly inclined downwards (Y axis of the cameras’
local position between 0.12 and 0.06); and when the participants looked down completely, catching sight of the character's feet (Y axis of the cameras' local position < 0.06).

4.1 Prototype PG

The prototype which included a larger number of game elements was named “The bomb”. The main menu of the game (see Figure 2) included background music and buttons that allowed the participants to select one of the three levels, access to the credits screen or quit the game (see Figure 3).

![Figure 2](https://via.placeholder.com/150)

**Figure 2** PG design: Main menu

![Figure 3](https://via.placeholder.com/150)

**Figure 3** PG design: Level selection

A countdown timer was set at the top of the screen in each level with a maximum time of five minutes to complete. Once the time was up, a message appeared and prevented the participants to continue playing. The decision of adding a timer was taken after checking in the pilot study (section 5.1) the desire of several participants to continue playing despite they exceed the maximum time set for each level. Thus, there is no possibility for participants of the main experiment to continue playing after the set time, while simultaneously it could increase the pressure of the players during the game.

Feedback mechanics were also applied to this prototype. Therefore, if the players did something incorrect in the game (like jumping to the ground or touching an enemy), an unpleasant sound was heard and a text message appeared on the screen (see Figure 4). This
message did not allow participants to continue the game until they chose to continue or exit the level. In case they preferred to continue playing the game, their player’s character was placed in a set position, but it conserved its status in the game.

Figure 4  PG design: Negative feedback (I)

Negative feedback (sound and message) also appeared when the five minutes of maximum time for each level was up, which only allowed participants to quit the level (see Figure 5).

Figure 5  PG design: Negative feedback (II)

Positive feedback (sounds and texts) was also used after the players completed a level (see Figure 6).
4.1.1 Level 1
In the first level of “The Bomb” (see Figure 7), the mission consisted in collecting five detonators (located in different parts of the scenario) before a bomb, which had just been placed by a terrorist, exploded. In addition to the mission and the previously mentioned feedback mechanics, the game features added to this level compared to the PS were: A character with human voice explaining the mission of the level; several enemies to be avoided; five items to find; and the need to jump to reach higher platforms.

The buildings in this level were the lowest ones compared to the other two next levels and the bridges between the buildings were wide and made of steel. This level was considered as a training for the participants to learn how to use the controls and get used to Oculus Rift. For that reason, it was not mandatory that they were to look at the floor at any time to complete the level.

Figure 6  PG design: Positive feedback

Figure 7  PG design: Level 1
4.1.2 Level 2

The mission of the second level of “The Bomb” (see Figure 8) consisted in collecting eight bombs that the terrorist have placed in different parts of the scenario. The player must be careful collecting those bombs and just grab them when they were blue, as they were changed every 5 seconds from red to blue and vice versa. In case that the player would pick a red bomb, the frustrating sound and game over screen appeared. In addition to the mission and the feedback mechanics, the game features added to this level compared to the PS were: A character with human voice explaining the mission of the level; eight items to find and pick only when they were in a concrete colour; and the need to jump to reach higher platforms.

The buildings in this level had the medium level of heights of the three levels and the bridges between the buildings were narrow and transparent. It was necessary that the players looked down in several occasions to complete the level due to the mission and the transparent and narrow bridges.

![Image of Level 2](image.png)

**Figure 8** PG design: Level 2

4.1.3 Level 3

In the third level of “The Bomb” (see Figure 9), the mission consisted in reaching a distant building (where the terrorist was located) through a maze of transparent bridges. Once there, the player had to jump from the highest point of the scenario to the ground, where he or she was rescued. In addition to the mission and feedback mechanics, the game features added to this level compared to the PS were: Three characters with human voice explaining the mission of the level or acting as an enemy; and the need to jump from the highest to the lower point. So it does not include many additional elements in this game, this is probably the closest to the PS and it is expected that the results in the study were more similar between the two groups compared with the others levels.

The buildings were the highest ones of the three levels and the bridges to cross the buildings were transparent and the narrowest ones. The bridges are floating and they intersect each other, forming a maze in the air. Moreover, it was necessary that the user looked down during most of the time to avoid falling and finding the correct path.
4.2 Prototype PS

The prototype with fewer game elements did not have any storyboards or different missions. The participants were only required to reach different platforms lighted. There was also no music, characters, timers or counters. In case that the players would hit the ground, they were returned automatically to a central platform, but they would not receive any audio or text feedback. The only sounds added to this prototype were the walking sound (in order to not affect the users’ level of immersion) and a short sound used when the lighted platforms were reached (so that players could notice that the target platform had been reached and could find the next one). In addition, the maximum playing time was also controlled in this prototype, closing the game automatically after five minutes.

4.2.1 Level 1

In the first level of this prototype (see Figure 10), the buildings were the lowest ones compared to the other two next levels and the bridges between the buildings were wide.
4.2.2 Level 2
The buildings in the second level of this prototype (see Figure 11) had the medium level of heights of the three levels and the bridges between buildings were narrow and transparent.

Figure 11 PS design: Level 2

4.2.3 Level 3
In the third level of this prototype (see Figure 12), the buildings were the highest ones of the three levels and the bridges between the buildings were transparent and the narrowest ones. As in the third level of the prototype with game elements, bridges are floating and they intersect each other, forming a maze in the air. For that reason, it was also necessary (as it was for the other prototype) that the user looked down during most of the time to avoid falling and finding the correct path.

Figure 12 PS design: Level 3
5 Tests and Analysis

5.1 Preliminary test

A preliminary study was conducted at the beginning of the developing phase. Its aim was to collect useful impressions, ideas and reactions from the participants and apply these to the final version of the prototypes. The study was mainly focused on comparing and evaluating the enjoyment aspects between two game prototypes where some game elements were applied. Moreover, the sense of heights and motion-sickness of the participants were also measured and compared. Both prototypes were developed with the same scenario (on the top of tall buildings), but they had different mechanics, storyboards, duration and levels of heights.

The prototype named “Bomb” was the shortest one, since it could be completed in less than 5 minutes. It included some game elements such as collecting items and time pressure. In this prototype, the action took place at a higher altitude than the other prototype, but the bridges which participants had to use to move between buildings were wider. On the other hand, the prototype named “Zombies” was the longest one, taking at least 12 minutes to complete, and it brought game elements such as collecting items, avoiding enemies and the option to continue playing after the participants’ character had died. The action in that prototype took place at a lower altitude than the other prototype, but the bridges were narrower.

Ten participants aged between 22 and 25 years old, all of them students from the University of Skövde, tested the game prototype. Based on an adapted questionnaire of the GameFlow criteria for evaluating player’s enjoyment in games (Sweetser & Wyeth, 2005), the prototype "Bomb" obtained slightly higher results for enjoyment. Moreover, additional highly relevant information was collected and taken into account for the development of the final prototypes. The results showed poor sense of height in both prototypes, mainly because they were in a very early stage of development. There was also a lack of tasks where the participants were required to look down or use any viewing angle that would produce more sense of height. It was also important to notice that some bugs in the code moved the camera slightly to the left side during the game, which affected the level of motion-sickness of some participants in a negative way. The test results also showed a high preference of the participants for a game with a short duration, mainly due to the high latency and poor resolution of the current version of Oculus Rift. Using this HMD did not affect everyone equally; not taking into account the two participants that had used Oculus Rift frequently before the test, some participants exceeded 17 minutes playing the prototypes and others could not spend more than 8 minutes and 30 seconds playing them.

5.2 Main test

30 participants took part of the main experiment and were randomly distributed into two different groups before the test session: Those who played the prototype rich of game elements (“PG Group”); and those who tested the prototype with fee game elements (“PS Group”).
Of these 30 subjects, 6 were not finally included in the study, since their score concerning their level of fear of heights before the experiment was rated as "low" or "very low". The 24 remaining subjects (7 females and 17 males), aged between 21 and 35 years old, composed the sample of this study, with 12 participants in each group. The frequency of playing video games for these 24 participants resulted in 3.1 (on a scale between 1 and 5).

The results were not divided by gender, since no significant difference was found between them. All data collected for participants is available in Appendices D (PG) and E (PS).

5.2.1 Heart rate analysis

As previously indicated in the background, heart rate measurement has already been used in some studies of phobia or anxiety disorders (Licht et al., 2009; Meehan et al., 2002; Emmelkamp et al., 2001; Shalev et al., 1998; and Kawachi et al., 1995). These studies show that it is not easy to reach an accurate conclusion with heart rate data, but it could be a useful variable for the general data analysis, performing the joint interpretation of results with other variables.

The heart rate of the participants in this study was measured in order to find any differences or similarities in both testing groups and use this information in conjunction with other variables to reach a general conclusion, since the participants' heart rate during the test session could be affected by other factors such as nervousness to participate in an experiment which was new for them or unexpected perceptions during the game.

Unfortunately, the heart rate information could not be obtained for all participants in this study, since the Bluetooth connection between the Polar WearLink+ device and the Android mobile phone used in the experiment occasionally stopped working after being used for a while. It was not possible to determine which of the two devices caused the problem, so the problematic device could not being replaced for the remaining test sessions. Thus, from the 12 participants of the PG group, only 5 complete samples with information regarding the different stages of the test session (before the experiment and each level of the game) could be collected. For the PS group, from the 12 participants selected for the study, only 7 complete samples could be collected with information regarding these four stages of the test session. Although the samples were small and had a different number of participants for both groups, the results are shown below, which would have extended to a larger number of participants in order to get a clearer conclusion.

Figure 13 shows the heart rate (in beats per minute) of the PG group. There was no clear trend for the data of these participants, but for most of the participants, the peak heart rate was reached playing the second level.

Figure 14 displays the heart rate of the PS group. The data for this group were even more varied, with more distributed tendencies and several participants who were relaxing as levels increased.

Lastly, Figure 15 displays the difference between the mean beats per minute for participants in both groups before and during the experiment. As can be seen, the results for the PG group resulted positive, which could mean that the participants’ mean heart rate increased in 11.6 bpm over their heart rate before the experiment. On the other hand, the PS group
obtained opposite results, with a mean heart rate of 5.56 bpm lower than the one they had before the experiment.

**Figure 13** Results: Heart rate of the PG Group

**Figure 14** Results: Heart rate of the PS Group
5.2.2 Background logs analysis

Figure 16 shows the mean of time played (in seconds) for both test groups. As can be seen, the time that the PS group spent playing the game grown in each level, whereas it decreased in each level for the PG group. Comparing both, the PG group played more time than the PS group.

Figures 17 and 18 show the mean time that the participants for the PG and PS groups respectively spent in bridges. That time is divided into three different categories: when they were looking ahead; when their head were slightly inclined downwards; and when they were looking down completely. As can be seen, there are no large differences concerning the time that the participants spent on the bridges for both groups.
5.2.3 Questionnaire results

The graphs below show the average of the 12 participants from each test group (PG and PS), distributed among the 3 levels which made up the test sessions.

Figure 19 displays the results of the responses regarding "I noticed that I was at a high altitude" for both test groups. As can be seen, height in the different levels was perceived differently between both test groups, although the results were incremental between levels for both.

Figure 17 Results: Time on bridges distributed by head position for the PG group

Figure 18 Results: Time on bridges distributed by head position for the PS group

Figure 19 Results: “I noticed that I was at a high altitude”
Figure 20 shows the results of the responses regarding “I could feel fear of heights”. The results of both prototypes resulted very similar and were incremented for each level.

**Figure 20 Results: “I could feel fear of heights”**

Figure 21 shows the results of the responses regarding "I enjoyed playing the game" for both test groups. As can be seen, the results concerning enjoyment were much higher for the PG group, where the three levels were rated above 4 (“Agree”).

**Figure 21 Results: “I enjoyed playing the game”**

Figure 22 displays the results of the responses regarding "I would like to play the game again" for both test groups. The results for the PG group, which obtained results closer to 4 ("Agree"), were slightly higher than the ones for the PS group.

**Figure 22 Results: “I would like to play the game again”**
Figure 23 shows the results of the responses regarding "I did not feel motion-sickness" for both test groups. As can be seen, the results between both groups were quite different. Thus, the PG group obtained scores above 3 ("Uncertain"), whereas the PS group only scored below 3 ("Uncertain").

![I did not feel motion-sickness](image)

**Figure 23** Results: “I did not feel motion-sickness”

Figure 24 displays the results of the responses regarding "I became more comfortable with heights after playing the level" for both test groups. Since it was not expected that any participant improved their status when they were in a situation with heights for only 5 minutes, this question was added to the questionnaire to check if any of the prototypes could have the opposite effect, that participants could substantially increase their fear of heights. As figure 24 shows, the results of both prototypes grown linearly as the heights at each level also increased.

![I became more comfortable with heights after playing the level](image)

**Figure 24** Results: “I became more comfortable with heights after playing the level”

Figure 25 displays the results of the responses regarding "I would recommend the level for acrophobia treatment" for both test groups. The results were generally better for the PG, whose third level was rated above 4 ("Agree").

![I would recommend the level for acrophobia treatment](image)
Results: “I would recommend the game for acrophobia treatment”

Figure 25 Results: “I would recommend the game for acrophobia treatment”

Figure 26 shows the mean participants’ level of fear of heights before and after the experiment for both groups. These results were not included in the questionnaire to check which of the two prototypes had helped them more to overcome the fear of heights, since these results could be affected by subjective factors and the time of exposure for each participant in this study was too short (15 minutes) compared with other studies that have proven effective for acrophobia using VR with longest sessions during weeks or months (Coelho et al., 2009; Emmelkamp, Krijn, Hulsbosch, de Vries, Schuemie & van der Mast, 2002; Krijn, Emmelkamp, Biemond, de Wilde de Ligny, Schuemie & van der Marst, 2004).

Figure 26 Results: Level of fear of heights before and after the test session

In conclusion, as Figure 27 shows, the PG group obtained better results regarding enjoyment (“I enjoyed playing the game”); motivation (“I would like to play the game again”); motion-sickness (“I did not feel motion sickness”); improvement (“I became more comfortable with heights after playing the level”); and recommendation for acrophobia treatment (“I would recommend the game for acrophobia treatment”). The only two results where the PS group obtained a higher rate (“I noticed that I was at a high altitude” and “I could feel fear of heights”) could be due to the level of distraction or enjoyment of participants from the PG group, who might not have dedicated time enough to appreciate the heights.
5.2.4 Analysis

First, it should be noted that due to the difficulty of finding people diagnosed with acrophobia and be assisted by a specialist, the results of this study may not be directly extended to people diagnosed with acrophobia. Second, given the small number of participants and the fact that a single session of exposure, the results could not be generalized to a real phobia treatment, followed and monitored for several sessions. Thus, the focus of this analysis is to compare the results and come to a conclusion that could be proved with some further study.

The heart rate results shown that the mean beats per minute of participants of the PG group increased during the experiment, whereas they decreased for the PS group. But unfortunately these results cannot be fully trusted, since the sample was not large enough and there is no way to demonstrate that that the rate differences were caused by the heights exposure.

Regarding the time that the participants from both groups played the game, it resulted in more than a minute and a half of play (from 15 minutes at maximum) for the PG group. However, this difference could have been even greater if the third level were not considered. The results of the last level for the PG group should not be taken into account in the same way as the other levels, as it was highly dependent on other factors such as the playing skills of the participants. Thus, the third level could be completed in about two minutes if the participant of the PG group took the best path and did not fall on many occasions, whereas it was different for the PS group, where the game finished when the participants decided to stop it or the 5 minutes passed. In addition, comparing the results of time played with those regarding enjoyment and motivation, it can be seen a strong relation between them. Thus, those levels which participants liked most were played longer for both groups. Considering
all this, it could be concluded that through game elements added in the PG, which improved motivation and enjoyment of participants, it resulted in a longer time of play. That longer time of play could also mean a longer time of exposure.

The results regarding the time that participants for both groups spent on bridges did not show major differences between them, although it was mandatory for the participants of the PG group to look down in different parts of the second level to complete. This time they spent on the bridges increased as levels increased, as expected. Moreover, this time on the bridges where they could better appreciate heights could influence the sense of height and fear of heights that participants felt, as the results of both grew also as increased levels. However, there are two reasons why a study with more participants should be considered before reaching a conclusion on these results. First, the time participants were on the bridges was based on an estimation. It was calculated with the number of frames in which the participant was placed on bridges divided by the mean frames per second that the computer used in the test sessions obtained for that particular level during a 15-minute test. Secondly, those seconds that the user jumped was not considered in the measure, which was prevalent for certain participants and made the results may not correspond to reality. If this data would correspond exactly to reality, and not considering the first level (participants were not required to look down) and the third level (participants had to look down in the same way in both groups), the characteristics of game applied to the second level would not have resulted in more time looking down. As it was observed in the PS Group, many participants also looked down several times without it being mandatory.

The control question concerning the frequency with which participants played video games was included in the questionnaire in order to check whether there were significant differences between the levels of interest in gaming in both groups that could affect the results of motivation was used. The results on the frequency at which they played video games was somewhat higher for the PG Group, with a difference of 0.58 points on a scale between 1 and 5. For this reason, it would be interesting to see the results of this study whether participants were evenly distributed in the groups taking into account the frequency of playing video games.

The results regarding heights (“I noticed that I was at a high altitude” and “I could feel fear of heights”) were higher for the PS group. It could be due to the level of distraction or enjoyment of the PG group caused by the added game elements to that prototype. Perhaps they were so distracted that did not dedicate time enough to appreciate heights. These results may have been influenced by the time where participants from both groups looked down when they were on the bridges, which was also increased in both groups as levels increased, as it was shown in figures 17 and 18. However, these results also may have been influenced by other factors unrelated to their perception of heights, since participants were informed about the height increase at each level after reading the test instructions or the questionnaire. All the results obtained for “I noticed that I was at a high altitude” in the questionnaire were rated between 3 (“Uncertain”) and 5 (“Strongly agree”), which could mean that heights was perceived in both prototypes. The results of the PG group have a higher correspondence with the reality of the experiment, since the level of height between levels in both prototypes grew exponentially. The results obtained for “I could feel fear of heights” were also rated between 3 (“Uncertain”) and 5 (“Strongly agree”) except the first level for the PG group, which obtained a score below 3 (“Uncertain”). These low results for the first level of the PG group compared with the PS group could be due to the lack of tasks
where the participants were required to look down and the high grade of distraction, which may not leave them time enough to appreciate heights.

The enjoyment (“I enjoyed playing the game”) and motivation (“I would like to play the game again”) resulted higher for the PG group. These results could mean that the game elements added to the PG were effective and improved the participants’ experience during the game. In addition, as discussed above, this may also have influenced the played time of participants, which also increased according to the enjoyment and motivation results. On the other hand, perhaps these results could be even more variants if the duration of the game would have been greater. Participants played only a maximum time of 5 minutes at each level. It might be interesting to see these results after playing for much longer. Regarding the results of enjoyment, it can also be seen as the third level obtained the same score for both groups. The good results for that level compared to the other levels for the PS group could be because the final level of the PS group (as it was explained in the PG design) had more similarities with the level 3 of the PG group than the others.

The results regarding motion sickness were the worst rated from the questionnaire, especially for the PS group, which was rated below 3 (“Uncertain”). These results could indicate that the game elements added to the PG helped in some way to participants not feel motion-sickness, probably due to a more distracted exposure. Taking into account the results of both groups, it could be concluded that the current version of Oculus Rift affected in a negative way to participants, influencing the rest of the experiment results.

The level of fear before and after the test sessions were asked to confirm that no one could feel worse after the experiment. Nobody answered in that way and the level of fear of heights decreased for both prototypes after the experiment, which could confirm that none of the participants felt worse after the experiment. This could also be confirmed with the results regarding “I became more comfortable with heights after playing the level”. The results for that question were slightly higher for the PG group, maybe caused by a less exposure to the heights, since as figures 19 and 20 show, the level of heights and the fear of heights that they felt were lower for that group. Furthermore, there is no reason to think that any level caused them even more afraid of heights, since the only level below 3 ("Uncertain") was the first level of the PG group, but with a score very close to 3.

Finally, the results for "I would recommend the game for acrophobia treatment" were also better for the PG group. They grow linearly for the PG group, where the third level resulted the best rated and the first one obtained the worst rate. The third level was also the best rated for the PG group, but the worst rated for them was the second level. These good results for PG, together with good results on motivation and enjoyment, might assume that the game elements were effective in a game designed to overcome acrophobia.

5.2.5 Observations
Following, various observations that were perceived during various test sessions are described.

Only one person of the 12 participants in the PG group completed the three levels successfully. For the rest, it was observed that none of the three levels was much easier compared to others. The first level was the one who fewer people could complete (only two),
maybe because, according to the results, it was the level that motivated in minor way to participants.

The HMD Oculus Rift affected the participants in a different way. Only some of them could play for 15 minutes at most of the session, but some others did not exceed 6 minutes in the test session because they were starting to feel motion-sickness. In fact, once completed the test session, seven participants made the suggestion to perform the same study using a HMD which does not produce motion-sickness. In general, the participants were also quite critical with the loss of resolution that the current version of Oculus Rift provides, especially after they saw the game resolution on the computer screen.

It was also a common suggestion that the player could walk faster in the game. This was something that was done consciously, because after several tests during the development phase, a lower sense of motion-sickness was perceived when the player movements and the falls were slower. Some participants reported that due of the slowness of the player movements, they decided to jump instead of walking in the game. One particular case where this occurred was on one of the bridges of the second level. Most participants made no jump there, whereas one of the participants, who also reported the slowness of the character, made seven consecutive jumps on that bridge.

Overall, taking into account the physical behavior and reactions of the participants during the test sessions, seemed to be entertained, motivated and challenged in a similar manner to that experienced playing commercial games, especially with the PG. Many of them even were startled after falling or perceiving unexpected events in the prototypes, so it would have been useful to have also recorded the behavior of the participants during the test sessions and analysed this together with other results.

The actions performed by the participants within the game were also varied during the test sessions. Especially in the PS group, participants used some time looking down and seeing the sights.

5.2.6 Hypothesis

Hypothesis: Participants would feel more motivated to use a VR application for phobia treatment if it would include game elements (such as challenging activities, engagement, varying conditions, objectives, feedback or consequences) rather than one that would not.

Considering the answers of participants for “I would like to play the game again” and “I enjoyed playing the game” as those that correspond to the motivation of the participants, these results were slightly higher for the PG group. This would show that the game elements added in the PG properly fulfilled their purpose and therefore, confirm the hypothesis raised in this study.
6 Conclusions

This thesis has explored the benefits of applying game elements to a game for phobia treatment. Two different prototypes using the HMD Oculus Rift were developed with a gradually exposure to heights. Both share the same acrophobic scenario, but only one prototype included some features from games as engagement, motivation or goals.

A study was done with a sample of 24 participants (7 females and 17 males), aged between 21 and 35 years old, with any kind of rejection of heights, but not diagnosed with acrophobia. They were randomly distributed into two different groups: Those who played the prototype rich of game elements (PG Group) and the ones who tested the prototype with fee game elements (PS Group). The experiment was identical for both groups, in which they had to play individually each of the three levels of the game for a maximum time of 5 minutes per level. During the experiment, the time that they were playing, the participants' heart rate and the positions of their head when they were on a bridge in the game were measured. In addition, a questionnaire had to be completed for each participant in different stages of the experiment.

6.1 Summary of results

The results of this study seemed to indicate that the additional game elements added to the PG achieved a greater level of motivation and enjoyment for the participants, further increasing the playing time.

However, as a result of the problems encountered to use the current version of Oculus Rift for a long time, it was decided to perform the experiment with three levels of very short duration (up to 5 minutes each). As a consequence, the hypothesis formulated in this thesis could not be fully proved, as 15 minutes of play at most could be very little time to check the motivation of participants. In addition, the playing time of this study could also be considered short compared with real phobia treatments with VR, where patients often have longer exposures for multiple sessions. Therefore, it would be interesting to perform a study with a longer playing time or more continuous test sessions.

Whereas the hypothesis was valid, it would be interesting to look at how to extend these results to those people diagnosed with acrophobia, because the level of motivation during this type of exposure may be very different for them.

6.2 Discussion

The results from the heart rate showed some differences between both groups. Although it could not be tested with a significant number of participants, it seemed that this type of biofeedback could be interesting for being used in experiments related with phobias.

According to the questionnaire results, game elements applied to PG resulted in a slightly better motivation and enjoyment of participants; a better fit for the game to be used in a phobia treatment; and a longer time of play. In addition, a lower level of motion-sickness could have been achieved after adding those elements to the prototype. The level of heights perception and fear of heights resulted lower for PG, but it could mean that the exposure to the fear could have been more unconscious through the game elements.
Regarding the time that participants for both groups spent in bridges, it could not be find any significant differences between them. However, it seemed to be an interesting way of evaluating and controlling how participants behaved during the game and how they were exposed to the heights.

Moreover, the control questions of the questionnaire regarding the level of fear before and after the test sessions could confirm that none of the participants felt worse after the experiment, since this decreased in both groups.

### 6.3 Future work

It would be interesting to continue this study and see the evolution of the results after applying various changes could be made as future work.

One of such changes would be to extend the number of participants and conduct a continuing study sessions. So although the maximum time set for each level would not be increased, it could reach a better conclusion regarding the motivation of the participants after playing them for a few times. Furthermore, this could also check whether or not the level of fear of heights could improve after using the prototypes for a longest and continued time. For this new experiment would also be advisable to use a real measure of seconds in which the participants were over bridges and also consider the time in which participants jumped (being located on bridges) as part of that time. Moreover, to ensure that the results regarding the sense of heights were not influenced by the instructions given at the beginning of the experiment (in which they were told they would be subjected to different height levels progressively), it would be interesting to repeat some levels, not having a progressive levelling of heights or finishing the test session repeating the level with the lowest level of heights. It could also be useful in order to obtain a much clearer results, to record and analyse the physical behavior of the participants and their reactions during the test sessions.

It could be also interesting to conduct the study with only people diagnosed with acrophobia with the help of a specialist. Thus, it could fully extend the findings of this study to acrophobic people and probably to other people affected by other specific phobias.

Another interesting point for future study would be to use a different HMD, since the low latency and resolution of the HMD used in this study (Oculus Rift, Development Version 1) affected in a negative way to the participants’ state during the experiment. This may have influenced the results of this study, so it would be useful to know the results that would have been obtained if that factor had not existed. Moreover, in case of using a HMD or screen which does not cause feel motion-sickness to the participants, the duration of the levels could be longer. In that case, the prototypes may contain more game elements, such as a more complete storyboard which would allow to increase the immersion of the participants in the game.

Lastly, with more time devoted to the development of the prototypes, levels could include different missions depending on how many times the participants had played at these levels, in order to ensure that these did not result repetitive and the level of enjoyment of participants was not influenced dramatically after playing them for several occasions.
References


Appendix A - Written instructions for PG Group

Purpose

The purpose of this test session is to evaluate the motivation, engagement and presence of a game prototype as part of the thesis project “Serious Games for Overcoming Phobias: The Benefits of Game Elements” from University of Skövde.

Risks

The game includes scenarios with high heights, so the participation of people diagnosed with acrophobia is not recommended.

It requires the use of the head-mounted display Oculus Rift, which might cause nausea or dizziness. If during the game you experience any of these symptoms, please stop immediately and rest for a while until you feel better.

Confidentiality

No personal or private data resulted from the test session will be used.

The prototype

The game is divided into three different levels, in which the height level will be gradually increased.

During the game you will play the role of the captain of a group for clearing explosive devices and you will have to finish some missions at the top of several buildings from a city. You will always know where to go if you find the object or person that is lit.

Controls (Joystick)

- **Left thumbstick**: Control of the character.
- **Button “LB”**: Select the previous option in the menu/options screens.
- **Button “RB”**: Select the next option in the menu/options screens.
- **Buttons “Start”, “X” or “A”**: Start/continue in the menu/options screens.
- **Button “A”**: Jump.
- **Button “LT”**: Move the camera to the left.
- **Button “RT”**: Move the camera to the right.
- **Button “Back”**: Quit the game.

Time

The maximum time to play each level will be 5 minutes and there is no minimum time. After each level you will have the time you require before starting the next one.
Appendix B - Written instructions for PS Group

Purpose

The purpose of this test session is to evaluate the motivation, engagement and presence of a game prototype as part of the thesis project “Serious Games for Overcoming Phobias: The Benefits of Game Elements” from University of Skövde.

Risks

The game includes scenarios with high heights, so the participation of people diagnosed with acrophobia is not recommended.

It requires the use of the head-mounted display Oculus Rift, which might cause nausea or dizziness. If during the game you experience any of these symptoms, please stop immediately and rest for a while until you feel better.

Confidentiality

No personal or private data resulted from the test session will be used.

The prototype

The game is divided into three different levels, in which the height level will be gradually increased.

The mission of the game is to climb or touch the different platforms that are lit.

Controls (Joystick)

- **Left thumbstick**: Control of the character.
- **Buttons “Start”, “X” or “A”**: Start/continue in the menu/options screens.
- **Button “A”**: Jump.
- **Button “LT”**: Move the camera to the left.
- **Button “RT”**: Move the camera to the right.
- **Button “Back”**: Quit the game.

Time

The maximum time to play each level will be 5 minutes and there is no minimum time. After each level you will have the time you require before starting the next one.
Appendix C - Questionnaire

Age: [ ]

Please complete the following questionnaire by placing a CROSS in the appropriate box.

<table>
<thead>
<tr>
<th>Please rate:</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Frequently</th>
<th>Everyday</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you play video games?</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Please rate:</th>
<th>Very low</th>
<th>Low</th>
<th>Normal</th>
<th>High</th>
<th>Very high</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. My level of fear of heights <strong>before the test session</strong> is:</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>2. My level of fear of heights <strong>after the test session</strong> is:</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First Level</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Uncertain</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I noticed that I was at a high altitude.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>2. I could feel fear of heights.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>3. I enjoyed playing the game.</td>
<td>[ ]</td>
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<td>[ ]</td>
</tr>
<tr>
<td>4. I would like to play the game again.</td>
<td>[ ]</td>
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<td>[ ]</td>
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</tr>
<tr>
<td>5. I did not feel motion-sickness.</td>
<td>[ ]</td>
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</tr>
<tr>
<td>6. I became more comfortable with heights after playing the level.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>7. I would recommend the level for acrophobia treatment.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
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</tbody>
</table>
### Second Level

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Uncertain</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I noticed that I was at a high altitude.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2.</td>
<td>I could feel fear of heights.</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>I enjoyed playing the game.</td>
<td></td>
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<tr>
<td>4.</td>
<td>I would like to play the game again.</td>
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<tr>
<td>5.</td>
<td>I did not feel motion-sickness.</td>
<td></td>
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<tr>
<td>6.</td>
<td>I became more comfortable with heights after playing the level.</td>
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<tr>
<td>7.</td>
<td>I would recommend the level for acrophobia treatment.</td>
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</tbody>
</table>

### Third Level

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Uncertain</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I noticed that I was at a high altitude.</td>
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<tr>
<td>2.</td>
<td>I could feel fear of heights.</td>
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<tr>
<td>3.</td>
<td>I enjoyed playing the game.</td>
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<tr>
<td>4.</td>
<td>I would like to play the game again.</td>
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<tr>
<td>5.</td>
<td>I did not feel motion-sickness.</td>
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<tr>
<td>6.</td>
<td>I became more comfortable with heights after playing the level.</td>
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<td></td>
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</tr>
<tr>
<td>7.</td>
<td>I would recommend the level for acrophobia treatment.</td>
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</tr>
</tbody>
</table>

Please use this box if you have any comments and/or suggestions:

Thank you for your help 😊
## Appendix D - Data collected from PG group

### Questionnaire

**My level of fear of heights after the test session:**
- 2 2 2 3 3 2 2 2 2 2 2 2 2
- 2 2 2 2 2 3 4 2 3 3 3 3 3

**My level of fear of heights before the test session:**
- 3 3 3 3 3 3 3 3 3 3 3 3 3
- 3 3 4 3 4 4 4 4 4 4 4 4 4

**How often do you play videogames?**
- 4 2 4 4 3 3 3 4 4 4 3 3 3
- 5 4 4 4 4 4 4 4 4 4 4 4 4

**PG8:** I believe the test will be more immersive with the next version of the Oculus Rift.

**PG4:** Merry-Go-round of sickness!

### Comments

- I would recommend the game for acrophobia treatment.
- I became more comfortable with heights after playing the level.
- I did not feel motion-sickness.
- I would like to play the game again.
- I could feel fear of heights.
- I would recommend the game for acrophobia treatment.
- I became more comfortable with heights after playing the level.
- I did not feel motion-sickness.
- I would like to play the game again.
- I enjoyed playing the game.
- I could feel fear of heights.

### TIME AND HEAD POSITION ON BRIDGES (SECONDS)

#### First Level
- Looking ahead: 16 6 23 20 41 13 9 7 33 15 40 2 226 19
- Slightly inclined downwards: 18 37 55 8 1 11 20 37 10 58 16 5 276 23
- Looking down: 2 4 2 4 4 4 5 5 5 5 4 4 4 4 4

#### Second Level
- Looking ahead: 17 20 18 6 75 68 29 1 76 10 30 2 352 29
- Slightly inclined downwards: 45 42 96 43 14 4 28 101 14 67 47 17 516 43
- Looking down: 6 20 38 6 0 0 2 16 0 0 8 0 96 8

#### Third Level
- Looking ahead: 18 25 11 6 102 10 20 5 28 9 57 73 364 30
- Slightly inclined downwards: 149 81 36 22 228 52 47 50 2 10 130 5 886 74
- Looking down: 130 164 56 12 353 78 6 0 24 14 210 6 1054 73

#### Total
- Looking ahead: 300 299 218 167 259 279 299 233 277 198 232 265 171 2972 248
- Slightly inclined downwards: 232 160 187 73 297 67 83 188 27 135 192 27 1678 140
- Looking down: 138 185 77 22 153 78 9 23 0 24 75 0 1054 73

### Heart Rate (Beats per minute)

- Before the experiment (Mean): 58.59 62.61 45.40 76 401.00 579.20
- Before the experiment (Max): 81.69 76.75 63.68 98 530.00 715.00

### Mean (Three Levels)

- First Level: Mean: 88 76 65 84 94 75 99
- Second Level: Mean: 67.33 65.33 65.67 68.67 87.50 75.00
- Third Level: Mean: 75.60 61.51 70.71 75 402.00 67.00

### Difference Mean (Mean Experiment - Mean Before Experiment)

- First Level: Mean: 88 67.33 65.33 65.67 68.67 87.50 75.00
- Second Level: Mean: 18.33 20.00 8.00 13.67 24.00 29.00
- Third Level: Mean: 7.33 1.67 8894 13.67 24.50 7.00

### Comments

PG4: Merry-Go-round of sickness!
PG8: I believe the test will be more immersive with the next version of the Oculus Rift.
## Appendix E - Data collected from PS group

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>PS1</th>
<th>PS2</th>
<th>PS3</th>
<th>PS4</th>
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<th>PS6</th>
<th>PS7</th>
<th>PS8</th>
<th>PS9</th>
<th>PS10</th>
<th>PS11</th>
<th>PS12</th>
<th>TOTAL</th>
<th>MEAN</th>
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<td><strong>TIME AND HEAD POSITION ON BRIDGES (SECONDS)</strong></td>
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<td>First Level</td>
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<td>69</td>
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<td>270 263 25</td>
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<td>19</td>
<td>39</td>
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<td>238</td>
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<tr>
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<td>63</td>
<td>13</td>
<td>49</td>
<td>2</td>
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<td>0</td>
<td>2</td>
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<td>10</td>
<td>21</td>
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<td>417</td>
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<td><strong>HEART RATE (BEATS PER MINUTE)</strong></td>
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<tr>
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<td>86</td>
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<td>WGE3: It could be faster in terms of the walking. Thank you! I enjoyed to participate.</td>
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