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Virtual Reality and Social Phobia:
Recreating a social situation in Virtual Reality

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Abstract

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Title:
Virtual Reality and Social Phobia: Recreating a social situation in Virtual Reality

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Abstract:

Virtual Reality (VR) is a technology which allows a user to interact with a computer simulated environment and could offer a powerful tool in the future treatment of phobias. An application of VR is Virtual Reality Exposure Therapy (VRET) in which a phobia patient is exposed to a virtual environment containing the feared stimulus instead of being taken into a real environment or having to imagine the stimulus. This research aims to examine if the simulated social situation in the prototype virtual environment, especially developed for this purpose, is able to provoke the same behavioral response as the real life situation. If this is the case, it would be a step towards implementation of VRET in social phobia treatment. Two cases were examined in the prototype virtual environment to assess whether it was able to recreated social behavior of people. First, we examined if participant who enter a crowded room in the virtual environment prefer to take a seat in a chair that is close to them. Secondly, we investigated if participants in the virtual environment have the tendency to physically distance themselves from strangers when choosing a seat in a room full of strangers. We covered the prototype design of a social situation in a virtual world, the implementation of the prototype, the applied software and techniques and the results of a pilot experiment with the virtual world. We concluded, based on the two cases we examined during our experiments, that a social situation can be recreated in a virtual world.

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1.   Introduction

This chapter gives an overview of the thesis with the research goals, research cases and the thesis outline.

According to the Diagnostic and Statistical Manual of Mental Disorders [1] (DSM-IV) social phobia is a persistent fear of one or more social or performance situations in which the person is exposed to unfamiliar people or to possible scrutiny by others. The individual fears that he or she will act in a way (or show anxiety symptoms) that will be humiliating or embarrassing. Traditional exposure therapy (exposure in vivo) typically consists of confronting the feared situation in imagination or in real life [2]. Research has proven that Virtual Reality (VR) technology can be successfully implemented in clinical therapy [3][4]. Clinicians are using Virtual Reality Exposure Therapy (VRET) to treat anxiety. The exposure therapy takes place in the therapist's office in a computer generated world of the feared situation. The VR gives the therapist greater control over the feared situation, which results in the most effective exposure.

In 1999, the Delft University of Technology and the University of Amsterdam started collaborating in the frame of the research project "Virtual Reality and Phobias". The Delft University of Technology, department of Human Computer Interaction (HCI), which studies the relation between human and computer technology where the human acts as the user, is responsible for:
- The technical aspects of Virtual Reality (VR)
- The topics of Human Computer Interaction

The University of Amsterdam, faculty of Psychology, is concerned with:
- The Virtual Reality Exposure Therapy (VRET)
- Psychological aspect of Virtual Reality.

The Delft University of Technology has developed several virtual environments for phobia treatment, however a specific virtual environment for social phobia exposure therapy had not been created yet. This research aims to examine if a social situation can be recreated in a VR world and if that virtual world is able to generate the same response as the real world.

The whole process of designing this prototype of a social situation Virtual Environment (VE), the implementation of the prototype, the applied software and techniques and the results of a pilot experiment with the virtual world is described and structured in this thesis.

1.1 Research goals and research cases

The aim of this thesis is to create a realistic VR social environment that can generate the same response that social phobia patients would experience in the equivalent real life situation. If successful, this would be a first step towards the implementation of VRET in the treatment of social phobia.

The work consisted of the following main research goals:

- Conducting a literature study on social phobia and the use of VRET for its treatment
- Evaluation of the software and techniques to be used for the implementation of a prototype virtual environment for the treatment of social phobia
- Design and implementation of the prototype virtual environment
- Conducting and evaluating the experiment with the prototype virtual environment

In the prototype virtual environment, the preference of the participant for certain chairs in a room with several chairs is measured under different circumstances. In order to verify if the prototype virtual environment is recreating the real life situation successfully and is able to provoke the same human response, two test cases were investigated. The following two test cases are assumed to be representative behavior of social phobia patients, based on the literature study [5] [1][6] [7], and were used for the experiment with the prototype virtual environment.

A. People who enter a crowded room want to sit down as quickly as possible to avoid being the center of attention; they would prefer a chair which is close to them

B. People have the tendency to physically distance themselves from strangers when choosing a seat in a room full of strangers; they would prefer a chair with no one sitting around them

People with social phobia, get more than a little nervous in social situations. The majority of non sociophobic people will to a certain extent have experienced a nervous or awkward feeling in particular social situations, but when this feeling becomes extreme and intense, it can be classified as a social phobia. The participants in our experiment were for ethical reasons not selected from a group of social phobia patients. However, since social phobia patients show an extreme form of the responses that people without social phobia experience, we can conclude that a real life social situation has been successfully recreated in the VR environment, if the participants in the experiment indeed show the responses described in cases A and B.

1.2 Thesis outline

In Chapter 2 our research method is discussed. Chapter 3 contains background theory on phobias, Virtual Reality, the concept of presence and VRET. In Chapter 4 an overview is given of the current VRET systems of the TU Delft and the proposed system. Chapter 5 discusses the implementation of the prototype. Chapter 6 describes the experiment with the prototype, and discusses the results. In Chapter 7 the conclusion of the thesis is provided.

2.   Method

This chapter presents the method and the research approach that lead us to achieve the research goals and find answers to the research cases.

We started with a literature study to gather relevant information on the subject, e.g. from articles, internet sites and phobia patient forums. In addition, an overview of the current systems of the TU Delft, the presence parameters, and (dis) advantages are analyzed and the requirements for the new proposed prototype were made. From all collected material, the information necessary to facilitate the design of an anxiety provoking virtual environment for the treatment of social phobia was extracted. Three main elements of social situations that are known to cause fear in social phobia patients were selected to be implemented in the prototype virtual environment. The first element is the exposure to unfamiliar people. The entrance in front of a group which makes them being the center of attention is the second element. Third, the presence of a window into the virtual room, to induce social phobia symptoms such as anticipated anxiety.

To realize this virtual environment we have to go through a few stages. The design method that was chosen was used by Van der Mast [7]. This design method (see Figure 2.1) is based upon behavioral or user centered design, in which the user and the user interaction with the system can take a central position.

The stages of the method:

- The first stage is the requirements analysis
- Secondly an analysis is constructed, where we sum up the functionality that the proposed system has to include.
- In the third stage a global design is drawn up, which meets the specifications.
- Next stage, i.e. the implementation.
- Finally, the system will be evaluated. Evaluation is actually done during the whole process. Our final evaluation is an experiment of the prototype

Our evaluation approach is controlled by an experiment and the measures by questionnaires. The evaluation objectives of our system are to test whether the new system meets the requirements and specifications and whether the virtual environment can serve as a useful prototype for the future projects.
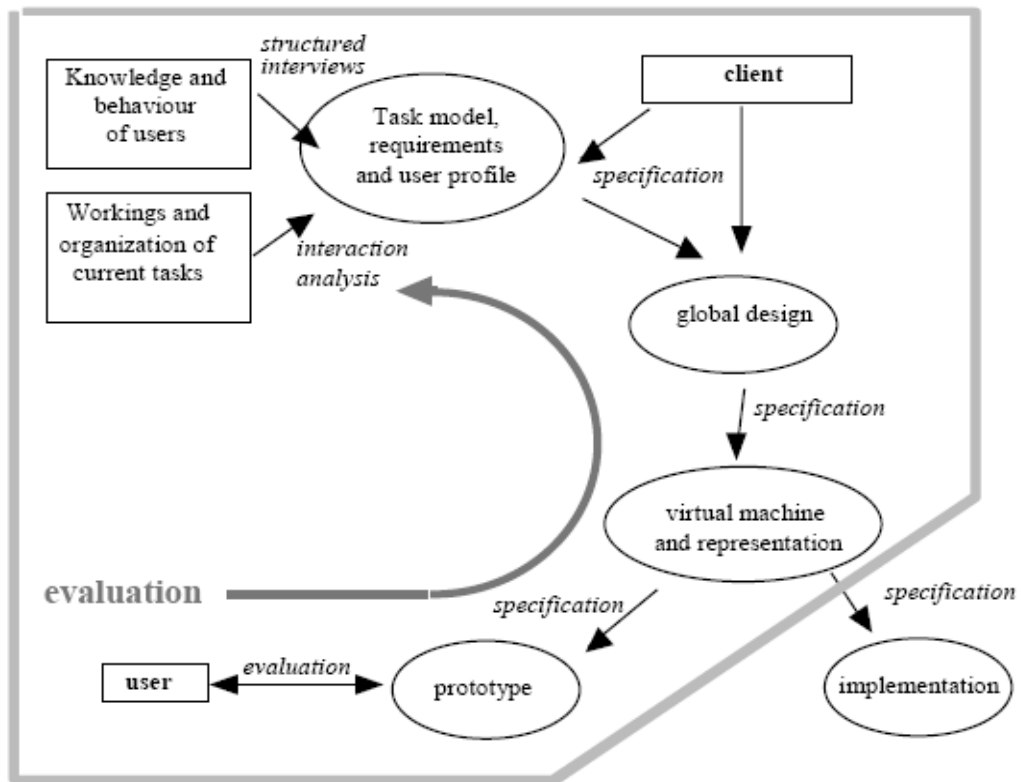
Figure 2.1 – Human Computer Interaction design process

3.   Background theory

In this chapter, the background theory acquired during the literature study is described. This background information is to elucidate our research approach

3.1 Phobia

> *A phobia is defined as an irrational, marked, and persistent fear of a specific object, activity, or situation, which is actively avoided or endured with intense anxiety or distress* [1]

A lot of people know the feeling of being anxious and tense of threatening or stressful situations. Such feelings are normal reactions to stress. Anxiety is considered not normal when it occurs in situations that the majority of people can handle with little difficulty.

Anxiety disorder include a group of disorders in which anxiety either is the main symptom or is experienced when the individual attempts to control certain maladaptive behaviors.

A person responding with intense fear to a stimulus or situation that for most people do not consider particularly dangerous is said to have a phobia. The individual usually realizes that her or his fear is irrational but still feels anxiety that can be relieved only by avoiding the feared object of situation.

A Fear is usually not diagnosed as a phobia unless it interferes seriously with the person's daily life.

3.1.1. Types of phobia

People can develop phobias of many things. The Diagnostic and Statistical Manual of Mental Disorders (DSM), published by the American Psychiatric Association [1], is the standard classification of mental disorders used by mental health professionals in the United States.

The most common of the DSM-IV-TR phobias, are persistent and exaggerated fear of particular objects or situations (see Table3.1). Most people with phobias go out of their way to avoid the thing they fear, even if such avoidance is inconvenient and disruptive. The DSM-IV-TR distinguishes among three subtypes of phobias:

1.   Specific phobia
2.   Social phobia
3.   Agoraphobia

All phobias, especially social phobia and agoraphobia, may be associated with decreased social functioning and lower vocal communication and are important disorders to be identified.

Table 3.1: Diagnostic Criteria for Phobias Adapted from the DSM-IV-TR, APA, 2000

Persistent, irrational fear of a specific object or situation.
Exposure to the feared object or situation usually provokes an intense anxiety reaction
The person recognizes that the fear is excessive or unreasonable.
The phobic object or situation is avoided or else endured with intense anxiety or distress
The avoidance, anxious anticipation, or worry about the feared object or situation interferes significantly with normal everyday functioning or there is substantialdistress about having the phobia.

3.1.2. Social phobia

An anxiety disorder characterized by a persistent, intense, and chronic fear of being watched and judged by others and of being embarrassed or humiliated by one's actions[1]*.*

Social phobia is not categorized as a specific phobia because, rather than fearing a specific object or situation, people with social phobia fear being judged or embarrassing themselves in front of other people. Social phobia also differs from the specific phobias in that it is more likely to severely disrupt a person's daily life [8]. It is easier for people to avoid snakes, heights or spiders than it is to avoid social situations in which they might embarrass themselves.

People with social phobia are well aware of the irrationality of their feelings, but nevertheless feel great apprehension when facing the feared situation. Therefore they will do anything to escape it and will start avoiding all sorts of social situations, with the result that the avoidance inhibits the person's functional character. In these feared social situations the social phobic will be constantly worried that other people might think they are anxious, weak, silly or strange.

One of the main characteristics of social phobia is the strong anxiety felt before the feared events take place, known as "anticipated anxiety". People start worrying and getting a feeling of fear before confronting the feared situation, once they actually face it, and due to their nervousness, it comes out worse, this leading to an increase in the level of "anticipated anxiety" next time they confront the same situation. A vicious circle is created and which is self generating.

Social phobia is much more common problem than we the most of us believe. Many people get a little nervous when speaking in front of a group of people or when they must join group of people already engaged in conversation

Some people report having had humiliating experiences that triggered their social phobia but others having felt extremely uncomfortable in social situations all their lives. Social phobia often co-occurs with mood disorders, other anxiety disorders

and antisocial personality disorder [9][10]. Once develops, social phobia tends to be a chronic problem if untreated. Most people with a social phobia do not seek treatment for their symptoms [8].

Table 3.2: Diagnostic criteria for social phobia, adapted from Diagnostic and Statistical manual of mental disorders, 4th Ed, primary care version (DSM-IV-PC).[1]

A persistent fear of one or more social or performance situations in which the person is exposed to unfamiliar people or to possible scrutiny by others. The individual fears that he or she will act in a way (or show anxiety symptoms) that will be humiliating or embarrassing. Exposure to the feared social situation almost invariably provokes an immediate anxiety response, which may take the form of a Panic Attack. The person recognizes that the fear is unreasonable or excessive and the phobic situation is avoided or endured with intense anxiety. The avoidance, anxious anticipation, or distress in the feared social or performance situation interferes significantly with the person's normal routine, occupational (academic) functioning or social activities or relationships with others, or there is marked distress about having the phobia.
Specifier:
Generalized (used if the fears include most social situations such as initiating or maintaining conversations, participating in small groups, dating , speaking to authority Figures, attending parties.)

3.1.2.1.   Symptoms

People with social phobia, get more than a little nervous in social situations. Physical symptoms may begin trembling and perspiring, feel confused and dizzy, have heart palpitations, "mind going blank", blushing, stomach ache, and eventually have a full panic attack.[11]

Patients with social phobia have a marked and persistent fear of one or several social or performance situations such as attending social functions, dating, participation in small groups, using a public lavatory or even initiating simple social conversations. As a result, these individuals have great difficulty attending class, working alongside others, eating in public, shopping or even coming to medical attention. They often live alone and work at solitary jobs.

Social phobia has significant comorbidity (effect of such additional disorders or diseases), including abuse of alcohol and other substances, which may be used to self-medicate symptoms [12]

They are sure that others see their nervousness and judge them as inarticulate, weak, stupid or "crazy". People with social phobia may avoid eating or drinking in public, for fear they will make noises when they eat, drop food, or otherwise embarrass themselves. People with social phobia tend to fall into three groups.

- People with only fear of public speaking.

- People moderate anxiety about a variety of social situations.
- People who have severe fear of many social situations, from speaking in public to having a conversation with another person, they all are said to have a generalized type of social phobia.

3.1.2.2.   Treatment of Social Phobia

It has been shown that two forms of treatment may well be of value in social phobia [13]:
- Drugs[14]
- Cognitive-behavioral therapy (CBT) [15]

Drugs exist that are helpful in depression (antidepressants). A certain class of antidepressants is also effective in social phobia. Physical symptoms of tension can be redacted with drugs known as beta blockers. These are often prescribed for occasional use in situations it is feared that physical symptoms may occur (fear of trembling when giving a speech ect.). The chances of achieving lasting positive effects by the use of antidepressant drugs are increased by supplementary behavior therapy.

Cognitive- behavioral therapy is a form of treatment that is strongly oriented towards reducing symptoms. A careful investigation is always made to determine how symptoms have arisen and what keeps them going. Treatment is then giving according to a structured plan. The behavior therapist chooses methods and techniques that studies have shown to be effective in combating such symptoms. Three aspects must be distinguished in the cognitive-behavioral therapy of social phobia [16]:

1. **Dealing with anxiety-provoking thought**: The first step is to track down negative thoughts that are then examined to see whether they are justified. If possible, they are replaced by more realistic and often more positive thoughts
2. **Acquiring social skills:** It has been shown that some people with a social phobia become anxious because they defective social skills. The risk of rejection is greater if someone does not know how to initiate a conversation or turn down a request. Acquisition of social skills is usually carried out in groups. Social behavioral options are discussed, demonstrated and practiced by role-playing.
3. **Overcoming avoidance:** Behavioral therapy cannot be successful unless avoidance is overcome. A highly effective approach is the use of exposure exercises [17],[18]. The patient is exposed o situations that arouse anxiety. Mostly the patient starts with something easy and is then followed by increasingly difficult situations.

Cognitive behavioral therapies act in three different ways [16]:

- Through a regular and prolonged confrontation of the participant to anxiety producing (*exposure therapy*)

- Through a modification of the subject thoughts and of her/his assessments of social situations (*cognitive therapy*)
- Through the learning of more efficient relational behaviors (*assertiveness therapy*)

Studies cannot exactly determine which of these three components is the most efficient to reduce the social anxiety of phobic subjects. However, it seems that the exposure to feared social situations, especially if the participant learns how to modify is/her thoughts and certain of his/her behavior is fundamental to obtain an improvement of the anxious symptoms [19]

3.2.   Virtual Reality

"Virtual reality (VR), integrates real-time computer graphics, body tracking devices, visual displays and other sensory input devices to immerse patients in a computer generated virtual environment"[20]*.*

The words "Virtual Reality" originally describe experiments in the simulation of artificial generated elements that could fool the human perception. The first virtual world was founded by Ivan Sutherland in 1968 and is popularized by Lanier in the 1980s.

In the beginning, when the virtual world was introduced, the costs of a virtual world were very high but with the rapid growth of the technology, the costs decreased and the virtual world became affordable for more users. The VR systems have been developed more and used for various applications.

The technology development will always continue for hardware and software used in a VR world, that will result in lower cost and more use in different fields, also for psychotherapy. Users now are active participants in a three-dimensional (3D) virtual world and no longer external observers of images on a computer screen.

3.2.1   Types of Virtual Reality

The two main categories of VR systems are immersive VR and non-immersive VR.
  1) Immersive VR:
Immersive VR immerses people into a Virtual Environment (VE). It makes users feel present in the computer generated world. They perceive the VE as real because their eyes and ears are shut out from the outside world. This is mostly done with a Head Mounted Display (HMD) or a Computer Automatic Virtual Environment (CAVE) construction.

A category of immersive VR is *Simulation-Based VR.* In Simulation-based VR the user takes a seat inside a simulator that resembles a real-life object. The user input and feeding back corresponding visual, motion, gives the user the impression actually being there. The simulation based VR system is often used when usage of the object in real-life is extremely expensive for educational use or if there are too many risks involved testing it in real life.

2)   Non immersive VR (Desktop based VR):

With a non immersive VR, the (3-dimensional) virtual world is displayed on a (2-dimensional) desktop display in front of a user. Non-immersive VR is also known as Desktop based VR. The user does not make use of any specialized movement tracking equipment or a HMD, which is limiting the user ability to know what is happening around him.

The user is not fully immersed in the virtual environment but can navigate and move through the world using customary input devices (mouse, joystick or a keyboard). Though the user is not wearing HMD or tracking devices in non immersive VR technology, the user nevertheless can feel deep involvement in the virtual environment.

Categories of non immersive VR are *Augmented Reality, Artificial Reality, Fish Tank VR* and *Simulated Reality*.

Augmented Reality *(AR)* is a system that combines real world and computer-generated data. The user observes an environment with both virtual reality and real-world elements [21]. Argument Reality supplements reality rather than completely replacing it.

AR as systems that have the following three characteristics [21]:

1) combines real and virtual
2) Interactive in real time
3) Registered in 3-D

Artificial Reality*: "An artificial reality perceives human actions in terms of the body's relationship to a simulated world. It then generates sights, sounds, and other sensations that make the illusion of participating in that world convincing".* **Myron W. Krueger**. Artificial reality was the term Myron W.Krueger used to describe his interactive immersive environments based on video recognition techniques that put the user in full contact with virtual world.

In the years from 1974 to 1985, Myron Krueger established an artificial reality 2D-Videoplace medium and he used it as an interface to both two and 3D applications [22]. His idea with the Videoplace was the creation of an artificial reality that surrounded the users, and responded to their movements and actions, without being encumbered by the use of goggles or gloves.

This category of Virtual Reality does not have a real-world application yet.

Fish Tank VR*:* Fish Tank VR is used to describe desktop systems that display stereo image of a 3D scene, which is viewed on a monitor using perspective projection coupled to the head position of the observer [23]. The user of Fish Tank VR sees the entire volume on-screen and rotated it to view it from different perspectives. Response time and accuracy are used to measure performance.

Simulated Reality (SR)*:* **The Fraunhofer-Gesellschaft, who introduced the term Simulated Reality, define** simulated reality as "*an approach that combines scientific*

/ technical simulation and optimization techniques with modern visualization and interaction methods".[24]

Simulated Reality is the reality that could be simulated to a degree that the computer simulated world could not be distinguished with to the real world. Virtual reality is easily distinguished from the experience of 'true' reality; participants are never in doubt about the nature of what they experience. Simulated reality, by contrast, would be hard or impossible to distinguish from 'true' reality.

3.2.2. VR technologies

The three most used technologies are: [25]

- ▪ **Desktop VR**

This technology the three-dimensional world is reflected on an ordinary computer monitor. Using special shutterglasses it is possible to present the picture stereoscopic. Each eye captures its own view and the two separate images are sent on to the brain for processing. The two different views are fused together by the brain in a complex way that creates the visual perception of depth

- ▪ **Head mounted Display (HMD)**

HMD is a display device worn on the head or as part of a helmet. It basically consist a display, optics and supporting device. The HMD used in virtual reality mostly has an ear-phone which results that the user not only can see the virtual world but also can hear the sounds. Often a tracking device is added so head motion and orientation of the user can be used to control the view and give the right perspective of the world.

The three main types of HMD's are
- • Monocular: have only one display source
- • Biocular: have two displays with separate displays and optics paths, but show only one image
- • Binocular: provide stereoscopic viewing.

The HMD have colour or monochrome options, in a variety of visual and display resolution.

- ▪ **Computer Aided Virtual Environment (CAVE)**

A CAVE, room sized cubic, is an immersive virtual reality environment where projectors are directed on some walls and the floor where the virtual world is projected on. Like the Desktop VR in a CAVE shutter glasses can also provide stereoscopic viewing. Using head tracking the computer ensures that the user sees the virtual world always from the correct perspective.

3.3.   Presence

Presence, ''a psychological state or subjective perception in which, although part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience. Except in the most extreme cases, the individual can indicate correctly that s/he is using the technology, but at *some level* and to *some degree*, her/his perceptions overlook that knowledge and

objects, events, entities and environments are perceived as if the technology was not involved in the experience'' [26]

Many authors have tried to elaborate a consistent theory about presence. Several attempts to define the concept and advances with some measurement proposals have been done however researchers from different areas must still be working on it.

A review of the literature produced until now shows already certain consistencies but it seems almost impossible to give one definition or theory of presence.

Virtual Reality Exposure Therapy is based on the assumption that people feel "present" in the virtual environment. Because of the individual experience, presence is a subjective participant and hard to measure.

When a user experiences a more present in the virtual environment, the user can also develop fear in response to simulated anxiety provoking stimuli. Many authors assumed that there is a connection between presence and interactivity [27]

3.3.1   Theories of presence

In "presence" research various definitions and theories, owing to the wide field of research, have been proposed. Lot of the researchers agree with the definition of presence as "the sense of being there" when it is related with virtual reality. Some of the theories of presence are as follows.

Lombard and Ditton [25] indentified six different conceptualizations of presence.

- Presence as *social richness*: the sense of presence is determined by the fact that the medium is perceived as sociable, warm, sensitive, or personal. The principles are intimacy and immediacy.
- Presence as *realism*: the sense of presence depends on whether the representation of objects and persons in the medium can seem perceptual and/or socially realistic.
- Presence as *transportation*: the sense of presence will depend on the intensity of this transportation. In this sense, transportation is understood as "you are there"; "it is here" and "we are together".
- Presence as *immersion*: the sense of presence is engaged by the mediated environment. This immersion is not only perceptual (the virtual environment involves all senses of the user) but also psychological (it implies that the user feels being absorbed).
- Presence as *a social actor within medium*: the sense will be that the user responds socially to a representation of a person through a medium.
- Presence as *a medium as social actor*: the sense implies that the medium itself is perceived as a social actor.

After revising the six different conceptualizations of presence, Lombard and Ditton underline that all these conceptions have a main idea. They propose this as new definition of presence:"the perceptual illusion of non-mediation"**.** Although people

are always conscious of being using a medium, always can distinguish between mediated and direct stimuli, nevertheless at some level the illusion of non mediation can be perceived. [25]

The general theory of presence is described in the paper of **Thie and Wijk** [28]. General theory of presence (mental models), when interacting with a virtual environment is:
1) The model of the Real World (RW)
2) The model of the Virtual World (VW)

Presence refers to the distinction between RW and VW according to the user. The model of the Real World as well as the model of the Virtual World can be divided in a model of the individual him or herself ("Self") and in a model of the environment as the individual experiences it ("Non- Self").
The environment as the individual experiences can be divided further into a social model and an environmental model (see Figure 3.1)
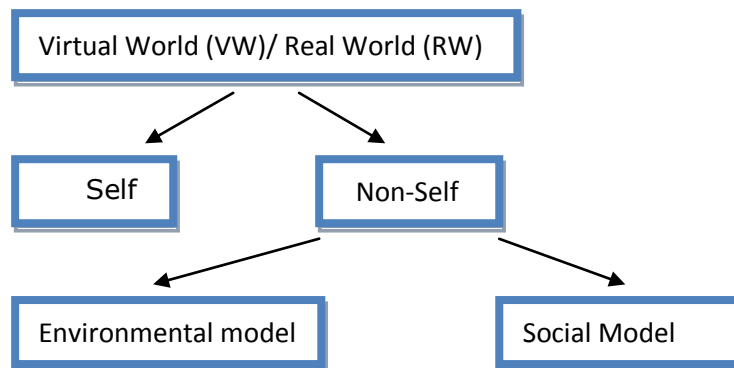
Figure 3.1: Mental model in a VR

Heeter distinguishes three different dimensions of present, personal, social and environmental presence [29] which can be defined for each lower level of Figure 3.1.

- Personal presence is related to the 'Self'. It is the measure of extent to which a person feels like being a part of the virtual environment.
- Social presence relates to the social model as part of the Non Self.
  It is the measure of extent to which other people (living or synthetic) are in the virtual world that is more evidence that the world exists
- Environmental presence refers to the environmental model and indicates the extent to which the environment reacts on the person or seems to know that the person is there.

Schuemie et al. [30] discusses several theories regarding presence, also the theory of **Schloerb** who distinguishes only two types of presence, subjective and objective presence, that are completely empirical.

- Subjective presence is the probability that a person perceives that he or she is physically present in the given environment.

- Objective presence is the probability that the specified task is completed successfully.

Sheridan makes the distinction between presence and telepresense. With presence is referred to the sense of being in a computer-generated world and with telepresence the sense of being at a real remote location.

A theory of presence by **Slater** is Exclusive presence[31].
The users sense of "being there" in the virtual environment and point out that a high sense of presence in a virtual environment requires a simultaneous low level of presence in the real world and vica versa.

Presence by involvement by **Witmer and Singer** is a theory that states that both involvement and immersion are thought to be necessary for experiencing presence. By focusing attention a person will get more involved and experience a higher sense of presence.[32]
Slater and Wilbur make the difference between immersion and presence[30].

- Immersion: an objective description of aspects of the system such as field of view and display resolution
- Presence: a subjective phenmenon such as the sensation of being in a virtual environment.

3.3.2. Measurement of presence

Measuring presence is difficult to because it is a subjective concept. The level of presence differs between people and that makes it a difficult task.
The two different approaches to measure present are objective measures and subjective measures.

- Objective measures

This type of measurement is by examining behavioral and psychological reactions of the person immersed in a virtual environment.
The behavior of the person as a response to mediated stimuli is measured (for example avoiding objects) and psychological measures (for example heart rate).
The results of this type of measurement are not very reliable because the highly personal judgment of people reactions to same situations.

- Subjective measures

This type of measurement is commonly used and examined by questionnaires
The patient immersed to the virtual environment gives ratings through questionnaires (subjective). The questionnaires can consist questions of different subjects related to the virtual environment they are immersed in. The questions in the questionnaire have to give the impression for example if the user feel present, does the user have the feeling of "being there".

3.3.3. Causes of presence

Researchers have tried to find factors that contribute to presence. In the article of Schuemie[30], several researchers have already made some categorizations of these factors. The factors that contribute to presence (table 3.3)

Table 3.3 : Factors that contribute to presence [30]

1. **Slater and Usoh [33]**
High quality, high resolution information
Consistency across all displays
Interaction with environment
Virtual body, the representation of the users' body in the VE.
Effect of action should be *anticipated*
2. **Witmer and Singer [32]**
Control factors: degree of control, immediacy of control, anticipation of events, mode of control, physical environment modifiability
Sensory factors: sensory modality, environment richness, multimodal presentation, consistency of multimodal information, degree of movement perception, active search.
Distraction factors: isolation, selective attention, interface awareness
Realism factors: scene realism, information
3. **Sheridan[34]**
Extent of sensory *information*
Control of relation of sensors to environment.
Ability to *modify physical environment*
4. **Lombard and Ditton[25]**
The *form* in which the information is presented.
The *content* of the information.
User characteristics
5. **Steuer [35]**
Vividness refers to the ability of a technology to produce a sensorial rich mediated environment.
Interactivity refers to the degree to which users of a medium can influence the form or content of the mediated environment.
User characteristics refer to the individual differences in users.

3.4. Virtual Reality Exposure Therapy

"*Virtual Reality Exposure Therapy (VRET) places the client in a computer-generated world, where they "experience" the various stimuli related to their phobia"* [1]*.*

According to the DSM-IV simple phobias consist of persistent fear of a circumscribed stimulus and consequent avoidance of that stimulus, the patient having this fear knows it is excessive or unreasonable [1].

Research had proved that virtual Reality technology can be implemented in clinical therapy [3]. Clinicians are using exposure therapy to treat anxiety. The exposure therapy takes place in the therapist's office in a computer generated world of feared situations, so not in a public place.

VR gives the therapist greater control over the feared situation, which results in maximally effective exposure. Exposure therapy typically consists of confronting the feared situation in imagination or in real life (in vivo exposure).[2]

VRET is still in an experimental stage but the system has been shown to be effective for patients with acrophobia, arachnophobia and fear of flying. Closer research will show the effectiveness of VRET in other anxiety disorders like claustrophobia, fear of public speaking and agoraphobia [36] in the future.

3.4.1   The advantages and disadvantages using VRET

The use of a virtual reality exposure therapy has advantages and also a disadvantage. Studies have already proved that with VRET the same results can achieved as the cognitive behavioral therapy.

However the VRET system can never surpass the CBT, because more aspects of CBT are important besides exposure.[37][38].

The technology can support a therapist to treat a patient in a for the therapist completely controlled environment. The amount of diversion can be decided and reproduced, which results that therapist can compare the behavior of the patients, by recording and replaying sessions in the virtual world.

The **advantages** of VR in treatment according the paper of Schuemie and Van der Mast [39]:

- *Time effectiveness*: The therapist can use the time more effective, they don't have to travel to a specific location for a exposure therapy.
- *Privacy*: The patient can be treated in privacy without leaving the therapist's office.
- *Variations of virtual environments*: The therapist can use different virtual environments and can adapt the therapy to the situation of the patient. Environments which normally lie difficult or precious be to reach, such as a plane for treatment of fear of flying, are not a problem anymore.
- *More control*: The therapist has total control of the phobic experience of the patient.
- *More safe:* The therapist can control the therapy on responses from the patient and can stop the exposure simple which gives the patient a high safety level.
- *Low threshold*: The patients feel less against a treatment in VR then against a treatment in reality. This results that a treatment will start sooner.

- *Physiological measuring*: The patient is in the office so physiological measuring such as pulsation can be measured which can help the therapist with the treatment.

Some other advantages in conducting exposure therapy according to the paper of Hodges, Anderson, Burdea, Hofman and Rothbaum are:

- *Cost:* The costs are considerably less than the use of real situations for exposure therapy
- *Repeated:* The exposure therapy can be repeated, the patient is able to confront the fear numerous times.
- *Gradual:* The patient can confront the fear in steps, beginning with the least fear provoking situation
- *Prolonged:* The patient can stay in the feared situation until anxiety subsides.

The disadvantage of the use of VR in treatment is that after a while the patients feel sick and dizzy, "simulator sickness". [39]

4 Design of a VRET system for social phobia

This chapter gives an overview of the current VRET system of the Delft University of Technology and the proposed system. The proposed system of the virtual environment can serve as a prototype for virtual worlds that will be built in the future to treat social phobia with VRET.

4.1 The current VRET system

The Delft University of Technology and University of Amsterdam developed a generic system for the treatment of several phobias through VRET. The functional architecture of this system is based on task analyses of therapist (Figure 4.1)[38]
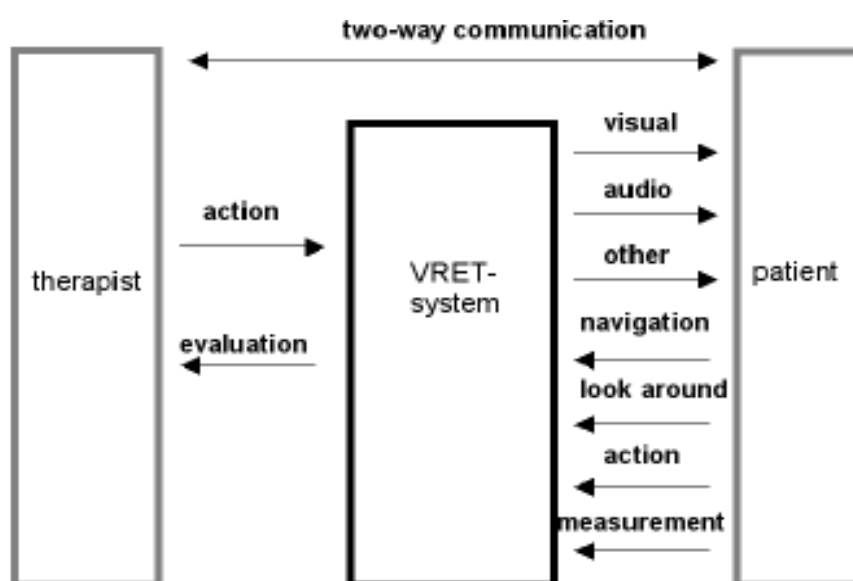
Figure 4.1: The functional architecture of the Delft VRET system.The two way communications of therapist and patient is direct if both are in the same room. An AV intercom connection is needed if both are not in the same room. The Delft VRET system is using 2 computers to be connected over the internet which supports tele-treatment [38]

The current VRET system uses the following virtual environments:

- Fear of heights (acrophobia) (Figure 4.2)
- Claustrophobia (Figure 4.4)
- Agoraphobia (Figure 4.5 and Figure 4.6)
- Fear of flying (Figure 4.7)

Several experiments has been performed with the Delft VRET system with real patients. The first experiment was with acrophobia. The patients were treated first with VRET and later on with in vivo exposure sessions. A second experiment was done with acrophobia where a copy of the real world (see below in Figure 4.2, 4.3 and 4.4) was built and this experiment was found as effective as the exposure in vivo.
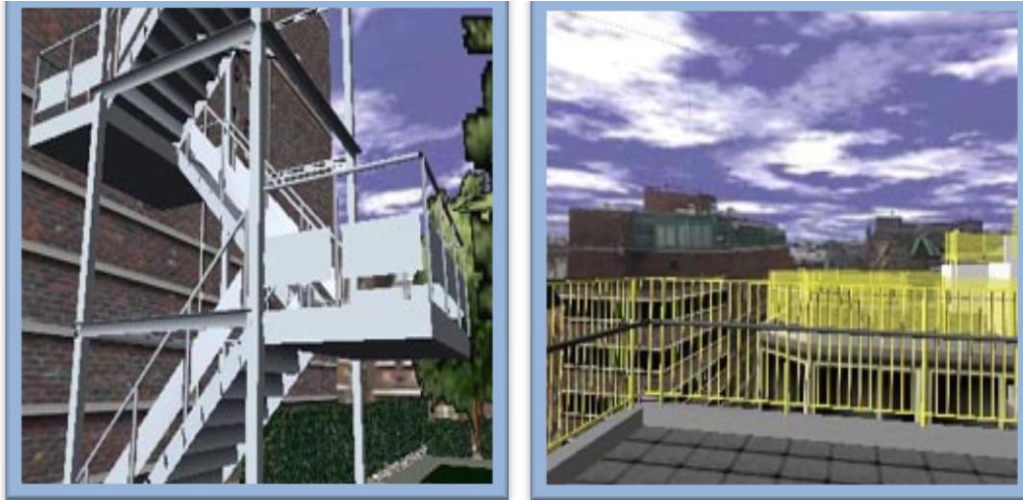
Figure 4.2: Fire escape and Roof garden (Acrophobia)

Some examples of virtual environments built for claustrophobia and agoraphobia are shown in Figure 4.3 and Figure 4.4.

The square in Delft is implemented for the treatment of agoraphobia. Many parameters can be changed by the therapist. This environment is still a prototype and will be improved in the near future.
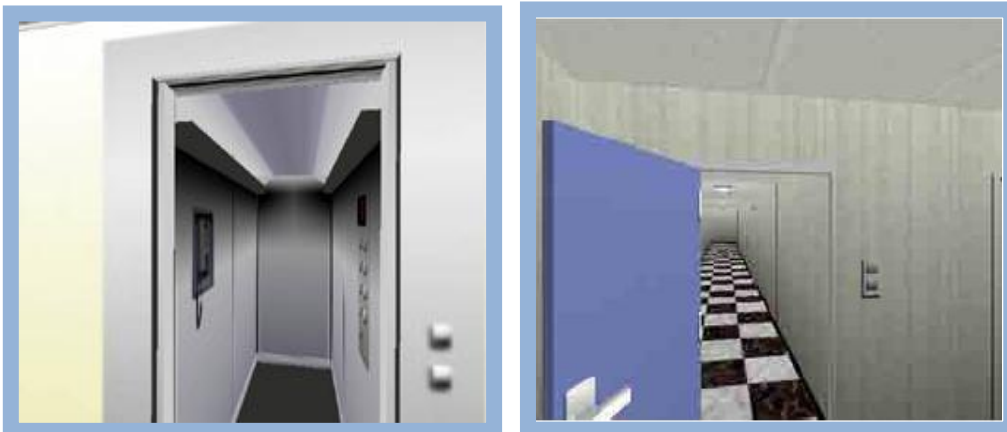
Figure 4.3: Lift and Small path (Claustrophobia)

Figure 4.4: Subway cabin (Agoraphobia)

Figure 4.5: Square (Agoraphobia)

The system of fear of flying is improved some months ago; this improved version is still a prototype and not in use by therapists. Google earth is used to show the view through the cabin window during the flight. This makes the environment more realistic (Figure 4.6).

Figure 4.6: Schiphol Airport and inside of an airplane (Fear of Flying)

Paul Emmelkamp and his group, the University of Amsterdam, are using the Delft VRET system now for new controlled experiments.
The Technical University of Delft is still investigating in using VR for the treatment of agoraphobia and fear of flying in close collaboration with the wishes of therapist.

We can observe that some of the virtual environments, that are already developed for the treatment of a phobia, can also be used for social phobia. For example the airplane environment; the seat can be preferred and the number of the static avatars can be changed. The square of Delft, which is designed for agoraphobia has walking avatars. The avatars walk around you and the number of avatars is also variable. This environment can provoke anxiety for people with a social phobia, but is not developed with the aim of treating people with a social phobia. The anxiety

provoking parameters for social phobia are not similar with agoraphobia or fear of flight. However the developed environments can be used when improved, since social phobia is a phobia that can take place in different environments.

The VRET systems components are as follows [40]:

	Therapist Computer	Patient Computer
Hardware	Dell Dimension 5150	Dell Dimension 5150
	Intel Pentium D-Processor with Dual Core-technology 820 (2,80 GHz, 2x1MB L2cache, 800 MHz FSB)	Intel Pentium D-Processor with Dual Core-technology 820 (2,80 GHz,2x1MB L2-cache, 800 MHz FSB)
	1 GB RAM DDR2 400-MHz SDRAM	1 GB RAM DDR2 400-MHz SDRAM
	160 GB Hard Disk Serial ATA	160 GB Hard Disk Serial ATA
	Intel Graphics Media Accelerator 950 graphics card	nVidia Quadro FX1400 graphics card
		COM-port, set to COM-3
Software	Windows XP Professional (operation system)	Windows XP Professional (operation system)
	Modeling and developing software	Modeling and developing software
	joystick (Logitech Attack 3)	Joystick(Logitech Attack 3)
	Mouse	Mouse
	Keyboard	Keyboard
	Monitor	Monitor
		Flock of Birds by ascension transmitter and control unit RS-232
		HMD Vissette pro Cybermind (stereoscopic, 70 degrees FoV, resolution 640x480)
		Bass shakers

The computer of the therapist and patient are connected through a local area network. The set up of the patient computer and the therapist are shown in Figure 47 and 4.8
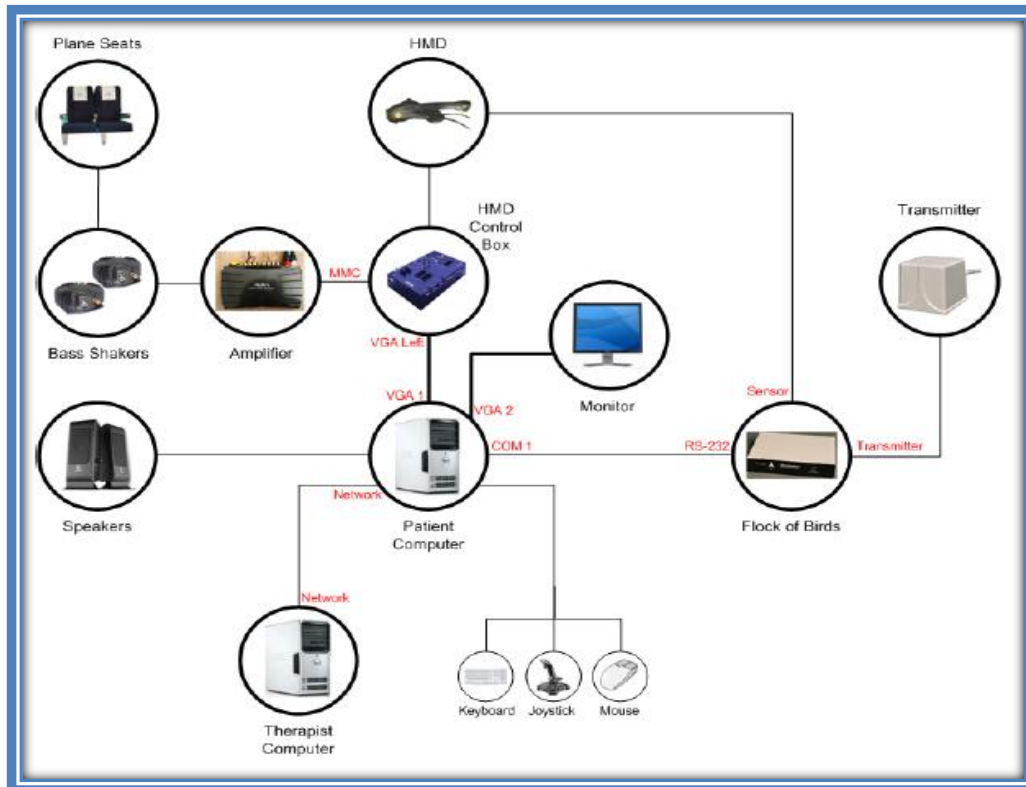
Figure 4.7: The patient pc set up [40]

Figure 4.8: The therapist pc set-up [40]
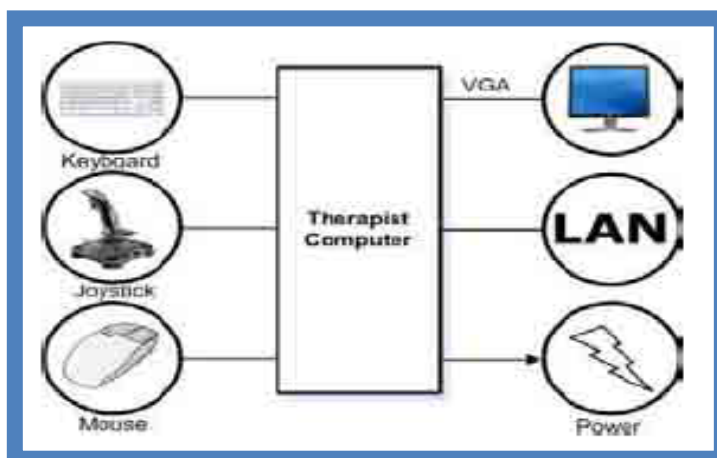
4.2 The proposed VRET system

The proposed system of the virtual environment serves as a prototype for virtual worlds that can be built in the future to treat social phobia with VRET.

If VR can be applied for social phobia, we expect that the patient, have to give the same reaction to the situation in the virtual world as they would react on the situation in the real world.

4.2.1 Requirements analysis

Foa and Kozak declare that an effective VRET system needs to satisfy three conditions [41].

- The first condition is the sense of presence. The patient must get the feeling of being in the virtual environment.
- The second condition is that the virtual environment must be able to elicit emotions for a patient.
- The last condition is that the patient must see the connection between the real life and virtual environment; the success achieved with VRET must result in success in real life.

4.2.1.1 Parameters

During our research on the parameters that are necessary for creating valid and anxiety-provoking virtual environments for the treatment of social phobia, we came up with the following conclusions [5]

In treating social phobia with virtual reality exposure therapy it is important that the patient feels the right combination of the **presence experience parameter** and **the anxiety provoking parameter** in the virtual environment:

- Presence experience parameters that contribute to the feeling of presence, which are suitable for any phobia.
- Anxiety provoking parameters contribute to the level of fear that the patient experiences. This last group of parameters is phobia specific.

We have concluded that these two types are closely related to each other. For example:

- The patient experiences a high presence feeling in the VE but no fear provoking anxiety in the VE.
- The patient experiences a high level of anxiety provoking feeling in the VE but no experience of presence.

Another prerequisite is that the patient may not get used to the virtual environment, because this will reduce the level of fear. And this would undermine the effectiveness of the exposure therapy. Reducing the level of habituation can be achieved by changing or adjusting the VE.

Presence experience parameters:
To figure out if presence does indeed play an essential role in VRET, we must understand what factors can contribute to a sense of presence. Much research has been devoted to finding these factors. In fact, several researchers constructed different categorizations of these factors.

The different categorizations of the factors that can contribute to a sense of presence also have to be taken into account for the implementation of the world [30] . The factors are as follows:

- Level of realism: How more realistic the virtual room is, the more the feeling of presence.
- Number of sensorial modalities: The more sensorial modalities the system covers, the more presence feeling in the VE.
- The level of interaction with and existing of other creatures in the virtual environment: The more the patient can feel that they can interact with the avatars the more feeling of presence will increase.
- Level of interaction with the environment: The degree that the patient can interact with the environment, the more presence feeling.

Anxiety provoking parameters:
The parameters that can provoke anxiety for social phobia can be simulated in the virtual room. Typical symptoms of social phobia are as listed:

- Anticipated anxiety: Strong anxiety before the feared events takes place. [9]
- Unfamiliar people
- Avoidance of social situations
- Being the center of attention : Afraid being watched and judged by others and being embarrassed or humiliated[1]

The parameter we don't have to forget to take in account is the level of habituation. The patient may not get used to the virtual environment, because this will reduce the level of fear. Reducing the level of habituation can be achieved by changing and adjusting the VR.

4.2.1.2 Requirements

The parameters above have to be taken into account before the implementation of the virtual environment.

First, for the level of realism, research has shown [5]that patients do not need total realism to feel presence in a virtual world and provoke anxiety. Former projects of Delft University of Technology a resolution of 640x480 was used and has seemed to give a sufficient level of realism [42]. We are going to use visual and auditory modalities for full immerse and presence. The HMD has earplugs for the sound with this the sensorial modalities are covered.
The level of interaction with and existing of other creatures in the virtual environment can be implemented with the use of a lot of avatars. They must have face expressions, sometimes eye contact and not static. The level of interaction with the environment can be implemented by a normal pace in the room. The patient must be able to look around in the room with a HMD with tracking. They have to react upon the sound.

Second, we have to look to the anxiety provoking parameters for social phobia. One of the main characteristics of social phobia is the strong anxiety felt before the feared events take place, known as anticipated anxiety. People start worrying and getting a feeling of fear before confronting the feared situation [43][1]. Knowing this the design of the room can be modelled in a simple way. We do not need to consider specific furniture but have to focus on the room design which can create a feared situation.

The diagnostic criteria for social phobia [1] proved that people with social phobia have a persistent fear of one or more social or performance situations in which the person is exposed to **unfamiliar people** or to possible scrutiny by others. The individual fears that he or she will act in a way (or show anxiety symptoms) that will be humiliating or embarrassing situation for them. With this factual information we decide to seat avatars (built-in human face and body models) in the designed room to expose the patients with unfamiliar people. The rooms have to be designed in a way that the patient can take a look into the room before entering. The last parameter can be implemented in a way that the patient enters the room in the front of the people. The navigation is needed to let the patient navigate through the room preventing for getting habituated.

4.2.2   Techniques

Delft University of Technology used different applications for example Quest 3D for their former project. S. Roorda[44] has studied the question which virtual reality development application to use. He compared and rated applications on technical and non technical aspects. See Table 4.1 for his final conclusion.

Table 4.1: Comparison of eight virtual reality development applications on several subjects, in order to be able to choose the application used for further development of VRET[44].

	CAVELib	CaveUT	EON Reality	MetaVR	Multi Gen	Quest 3D	Virtools	Vizard
Hardware support	5	1	4	4	5	3	5	5
Software development	5	5	5	5	5	5	5	5
Scene development	3	5	3	3	5	5	5	4
Conversion and import	1	3	4	2	2	4	4	4
Price	3	5	1	3	2	5	3	4
Licensing conditions	1	5	1	1	3	5	2	4
Continuation	3	5	1	1	1	4	5	5
Total	**21**	**29**	**19**	**19**	**23**	**31**	**29**	**31**

The following four candidates showed to be good ones to use in the further development of VRET: Act3D's Quest3D, Virtools, and WorldViz's Vizard. All of these applications have the required basic functionality, but on certain criteria they differ from each other. The best two applications were Quest3D and Vizard. Delft University of Technology already had Quest 3D license and also gets the license of Vizard.

To model a virtual environment for social phobia it is important to use avatars for the social aspect. For this reason we decided to use the application Vizard, since Vizard has the complete characters library of 100 realistic human 3D Characters, especially created for real-time environments like computer games, simulations and other virtual worlds.

The room has to be modeled in Autodesk Maya 8.5, since several former worlds of the project are modeled with this high-end 3D computer graphics modeling software package and animation programmed in Vizard.

4.2.3   Design

We are starting with the design of the prototype. For the design of the virtual room we have to remember that we want to examine if a social situation can be recreated in a VR world.

The experiment participants are for ethical reason not social phobia patients because of the experiment is in a first trial phase. The participants of our experiment are PhD students, staff members or students of Delft University of Technology. For this reason we prefer to choose a situation which can be recognized by the participants.

The social situation we choose for the virtual world is a social event at a university. The participants have to join this social event. The social event is movie night that will take place in a class room of the university building.

The virtual environment scenario:
To clarify our design approach we give a broad outline of the situation during the experiment in the virtual environment.

The avatars are sitting on the chair watching a movie. The participant is entering the room too late (which is a feared situation for a social phobia patient), the movie is already playing. They take a look in the room before entering through the window. After standing in the room the participant is going to be navigated through the room, without knowing precise which direction. The participants do not have control on the situation after entering the room and cannot get habituated to the situation in the room, since their place in the room is changing continuously.

At certain points, they receive questions about the chairs. The participant has to answer the question. The virtual tour ends at the moment after the last question is answered.

The virtual room design of the prototype:
Virtual room design has to consist the requirements for provoking anxiety for people with a social phobia. The seating capacity of the room is twenty. There are four rows of five chairs. The rectangular room has a windowed room divider wall. The door of the room is closed (no escape is possible or avoidance of the situation). In front of the room there is a video screen (Figure 4.9).
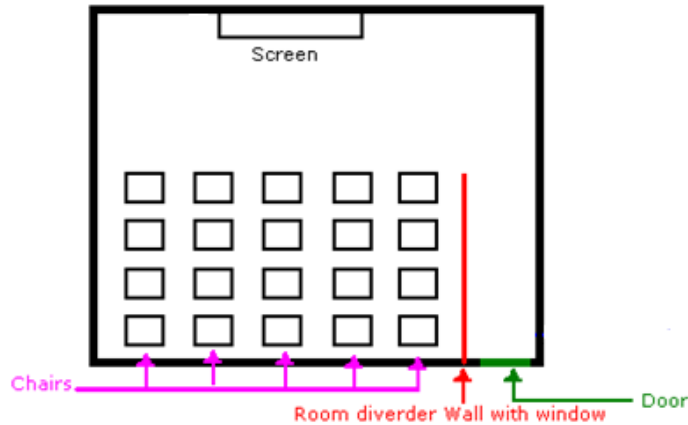
Figure 4.9 The sketch of the virtual room.

The chairs:

The chairs have to be arranged in a way that there are some chairs empty and that one chair is not surrounded with avatars(Figure 4.10). The 20 chairs are placed in the room and we assign different colors for 4 chairs (red, blue, green and yellow) the rest of the chairs are colored grey. We assume that the colors are neutral colors and do not influence the participants.

- The blue, green and yellow chairs are surrounded by avatars.
- The red chair does not have avatars in front, behind and left of the chair.
- The red and green chair has the same distance to the screen. The only difference is the avatars population. The red chair doesn't have avatars seating in front, left or behind the chair. The green chair is surrounded by avatars.
- The yellow chair is in the middle of the room in the last row.
- The blue chair is at the same position in the room as the yellow chair but the distance to the screen is less than that of the yellow chair. The blue chair is in front of the screen at the first row.
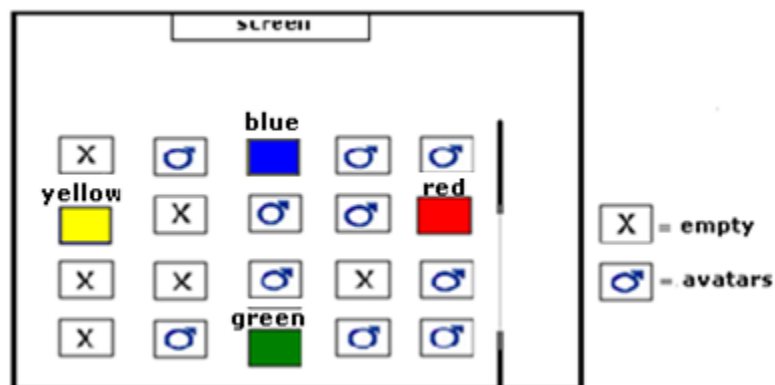
Figure 4.10:The sketch of chairs.

The room divider wall:

The room divider wall is used to create a corridor before entering the room. At the end of the corridor the participant stand in front of the group which is element that can provoke anxiety, since that makes them the center of attention.

The objects and programming for the virtual room for the treatment of social phobia is put together in Figure 4.11.

Figure 4.11: A design of the virtual room for treatment of social phobia.

5. Implementation of the prototype

With the background theory on social phobia, the requirement analyses, the techniques and design completed, the implementation of the virtual room can be realized. This is described in this chapter.

5.1 Virtual World

The first step of the implementation of the virtual world started with the question: How to create a 3D virtual room that can be used for VRET for social phobia?
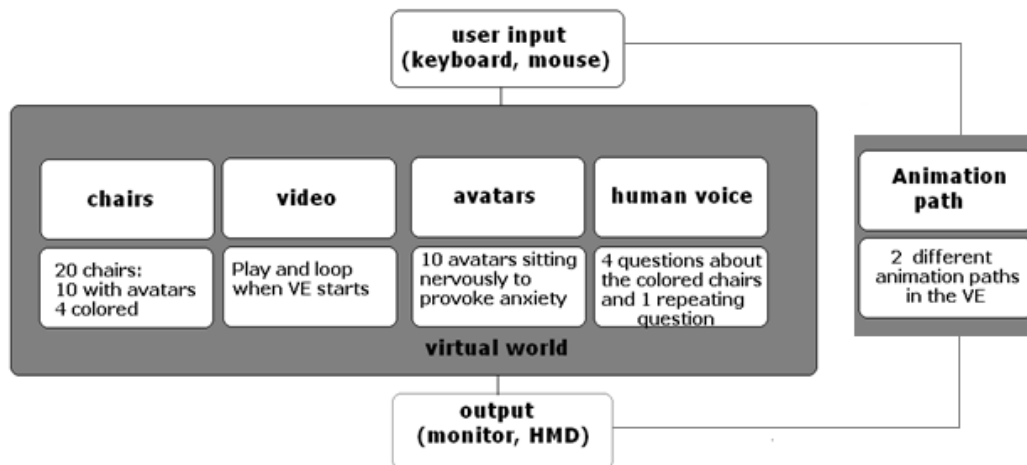
There are several methods of implementing the VR environment. We can choose for the immersive VR type or the non-immersive VR type. Our goal is to use this system for the treatment of social phobia. The patients must feel presence experience parameter in the computer generated world. They have to perceive the VE as real because and we have to try to shut out their eyes and ears from the outside world. Therefore, we choose for the immersive VR type. We can make the use of VR technologies like a Head Mounted Display (HMD) or a Computer Automatic Virtual Environment (CAVE) construction. We choose for the HMD because we want to limit what is happening in the real world around the patient. The HMD has an ear-phone which results that the user not only can see the virtual world but also can hear the sounds.

A method for modeling a room is using planes (as walls) with pictures as textures and modeling some 3D elements on the picture with Autodesk Maya 8.5 a high-end 3D computer graphics and 3D modeling software package. Another method is to build every object in the room totally in 3D.This is the time consuming way of modeling a 3D virtual room. Accordingly we preferred this method and start modeling with Autodesk Maya 8.5.

The interactive 3D content is build with Vizard Virtual Reality Toolkit. Vizard has built- in human and body models and can be inserted into an existing environment. The animations of the avatars are programmed in Python.

5.2 Autodesk Maya

We have decided to keep the design of the room simple, since the interaction build in the room is more important for social phobia. How can we design a room with elements that can create anxiety for people with social phobia?.
 We already know that people with social phobia start worrying before confronting the feared situation. The rooms have to be designed in such a way that before they are completely exposed to the feared situation, the patient can take a look into the room. We decided to realize this with a windowed room divider wall. The window provides a view of the room before entering and can be an element which is important for people having a social phobia.

The divider wall creates a corridor, at the end of that corridor the people stand in front of the room which is another element that can provoke anxiety. Entering a room and standing in front of the group, that makes them the center of attention.

In front of the room there is a screen and there are 20 chairs which can be used to seat avatars on it. The room is modeled in Autodesk Maya according to the sketch(Figure 4.10). First, we started with an empty room and gave the walls and the floor a texture(Figure 5.1).
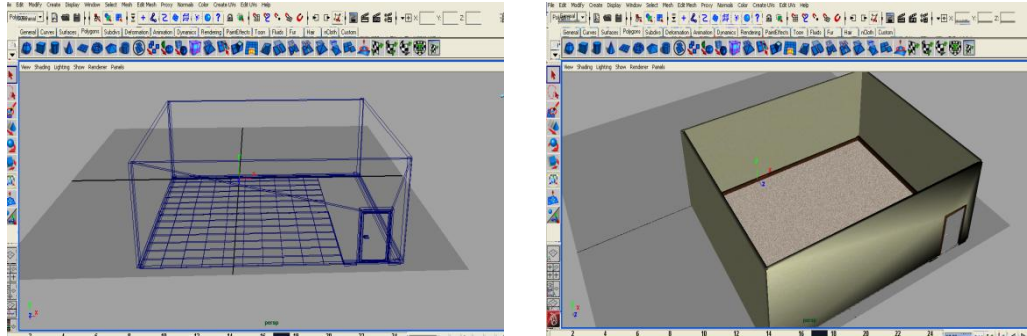
Figure 5.1: The room and room with the texture

The windowed room divider wall is used to create corridor(Figure 5.2). The start position is behind the door.
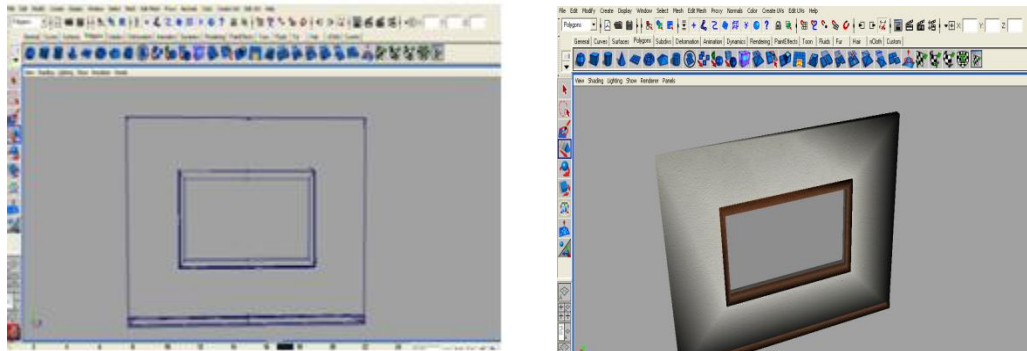
Figure 5.2: Room divider wall with window   Room divider wall with window and texture

The screen we need for the experiment to texture and the chairs to seat the avatars(Figure 5.3).
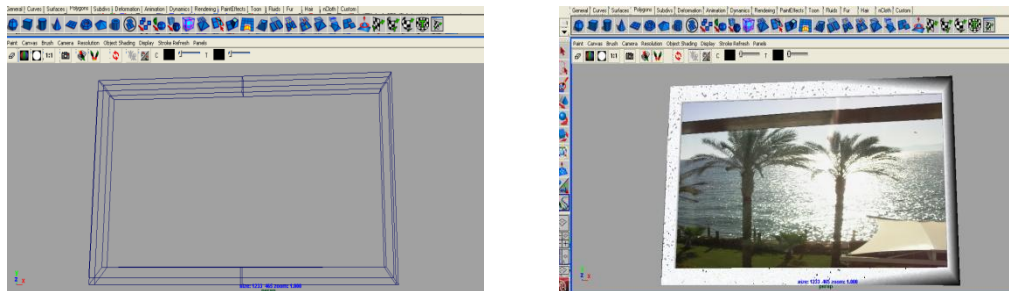
Figure 5.3: Screen without and screen with example texture.
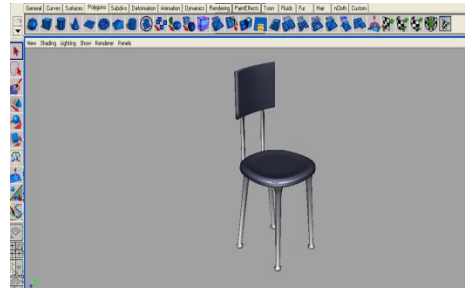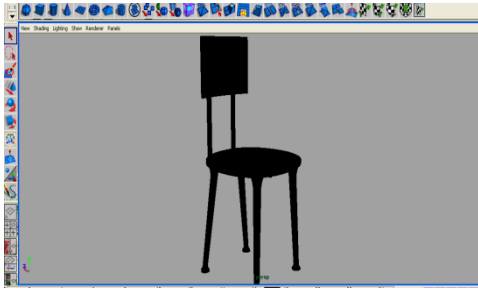
Figure 5.4: Chairs to seat the avatars.

Figure 5.5: The room almost completed.

Figure 5.6: Screenshot behind a the window of the roomdivider.

Figure 5.7: Screenshot from the last rows of chairs

The modeling part in Autodesk Maya is finished. We downloaded a converter for Maya 8.5 on the Vizard site [45], to export the maya .md file to a file which could be imported in Vizard. The converter did not work for our situation. The converter converted the whole room as one total and this was not useful, for example the video texture couldn't be realized. We had to find another solution.
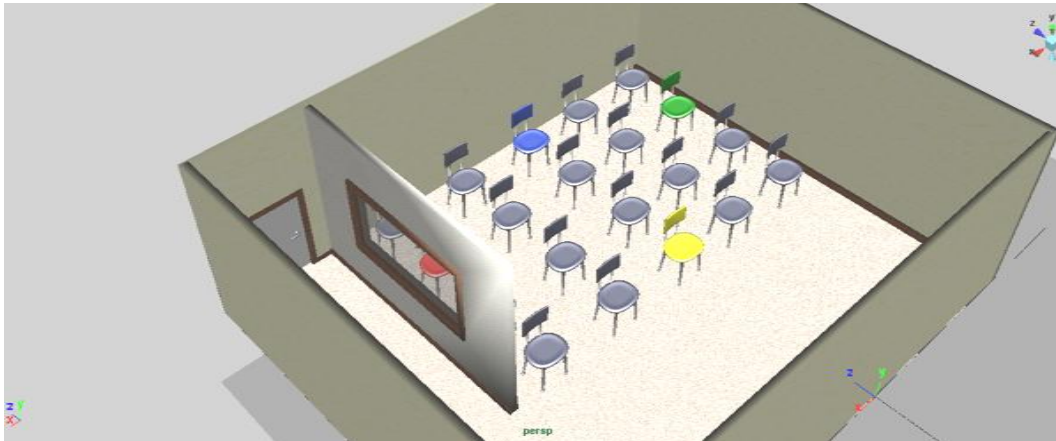
The objects, textures and lighting in Maya were exported to .OBJ files separately with Maya. The .OBJ files are converted with the use of Okino Polytrans to **.wrl** files. The .wrl file could now be imported into Vizard.

5.3 Vizard Virtual Reality Toolkit

Vizard VR Toolkit is a high level graphics toolkit that allows the development of high-performance graphics applications, including VR. With the use of the scripting language called Python, interactive 3D contents are building into the virtual environment. The toolkit guaranteed to support all head-mounted displays and avatars (built-in human face and body models) are also included.

The converted Maya virtual environment is imported into Vizard. However, we discovered a new problem. The room was modeled in Autodesk Maya for this reason the room was not centered in the in coordinates x= 0, y=0 and z=0 when it was imported into Vizard. We couldn't see the room inside but only a cube far away when we were running the application. We had to move the room to the center.

Finding the right coordinate to move the room seems like a simple problem to solve, since the toolkit Vizard doesn't have coordinates visible on the interface for that reason it was difficult to find the right coordinates to move the room to the center (0,0,0). We tried to find a solution for this problem on the Vizard forum, but it was not possible. Trying continuously to find the right coordinates was the best solution. After a lot of attempts we found the right coordinates (-45, 0.7, 50). We changed the properties of the room(Figure 5.10)to center the room in (0,0,0).

The room that is imported Vizard is shown below. We see that the textures are different in Vizard than in Maya in Figure 5.8. We tried to use texture baking for the textures, but the results did not differ a lot from the first result. We lost a lot of specifics of the textures during the converting between Maya and Vizard. Although, the converting is not successfully converted, the room is usable for the prototype.

Figure 5.8: Screenshot Vizard

Now the room is ready for the interaction to build into the world. We have to program the interaction with Python(Figure 5.9):

- Video texture on the screen. To give the people a 3D background sound during the whole immersion in the VR.
- 3D voice that asks some questions while walking in the virtual environment. The reason we choice for 3D sound and not a voice from the outside world is not to interrupt the session in the virtual world with the real world.
- The avatars, 20 chairs, 10 avatars are seated on. Not a static but an avatar that can move the head and body to provoke anxiety.
- An animation path, the people have to be navigated through the VR. Two different paths for the experimental part.
- The HMD, has to work on the system.

Figure 5.9: Vizard interface after programming.

5.3.1. Programming

Video texture:
We textured the screen with a video (Figure 5.10) . We have to avoid that the people immersed in the room are distracted by the video. The video has to be a background sound therefore the volume is low. The background sound can lead to a more presence feeling since there is no outside world sound.
The room and the screen were different .wrl files for this reason the implementation and programming with Python was easy to realize.

```
#VIDEO-TEXTURING:
scherm.appearance(viz.DECAL) #Set it's appearance to decal mode so that no shading
                             # of the video texture occurs
video = viz.add('D:/film.MPG')  #Add the video
video.volume(0.2)               # change the volume of the video
video.play()                    #start the video,
 video.loop()                   # loop the video
scherm.texture(video)           # Apply the video to the object
```
Figure 5.10: Python code for video texturing

3D sound:
We have two different sounds in the virtual room. The first is the sound of the movie playing (the background sound) and the second is the voice that asks some questions while walking in the virtual environment. We don't have to program the movie sound separately because the sound is programmed with the video texture. For the voice that asks some questions we choose for the text to speech software to copy a human natural voice. The reason we did not record a real human voice is because a real human cannot pronounce a sentence 4 times in the same way. We did not want the participants feel more sympathy for a voice and give a different rate for this reason. The wav.files are imported in Vizard with Python and they all get an unique key to activate the sound (Figure 5.11).

```
#Sound
mySound = viz.addAudio( 'lachen.wav' ) #Add the sound
red= viz.addAudio('red.wav')    #Add the sound red chair question
blue= viz.addAudio('blauw.wav') #Add the sound blue chair question
yellow= viz.addAudio('geel.wav') #Add the sound yellow chair question
green= viz.addAudio('green.wav') #Add the sound green chair question
grade= viz.addAudio('grade.wav') #Add the sound grade
vizact.onkeydown( 'p', mySound.play ) #play the sound MySound with key p
vizact.onkeydown('a', red.play) #play the sound red with key a
vizact.onkeydown('d', blue.play) #play the sound blue with key d
vizact.onkeydown('g', yellow.play) #play the sound yellow with key g
vizact.onkeydown('j', green.play) #play the sound green with key j
vizact.onkeydown('v', grade.play) #play the sound grade with key v
```
Figure 5.11: Python code for sound

The avatars:
We received an avatar package and build in animation with the Vizard Toolkit.

To give an impression of an informal meeting in the room we looked for casual looking avatars. We choose for 10 avatars with the same gender, male avatars. We did not want to use different genders in the room. The reason was that the gender preference could influence the participant's opinion.

The reason that we did not use female avatars was because the build in sitting animation had strange movements while sitting in the chair. Besides, the appearance of the avatars did not look natural. After selecting the male avatars we imported 10 different avatars into our virtual room (Figure 5.12).

Figure 5.12: the selected avatars

The avatars were added into Vizard with Python. The avatars were not visible. We discovered that the size of the room modeled in Maya was too large compared to the avatars. We solved this problem by scaling the world to 10% of the original size (see Figure 5.13).
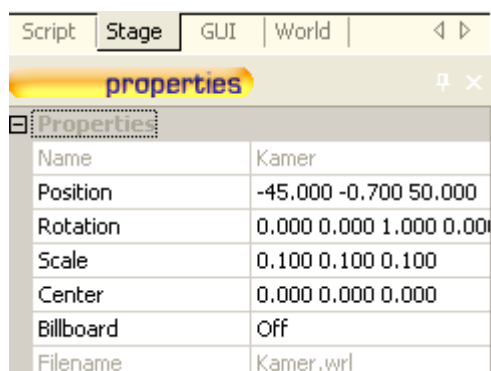
Figure 5.13: Screenshot of the properties of the room

We knew that all objects imported in Vizard were added in the coordinate (0, 0, 0). We tried to import the avatar to our world at the right place in the room just by

trying continuously to find the right coordinates next to the chairs they had to sit on. Again, after a lot of attempts we found the right coordinates for every avatar.

All the avatars were in the virtual world standing static with their arms wide open (Figure 5.14).

Figure 5.14: Avatar imported into Vizard

The avatars are seated on the chairs with the use of a build in animation of Vizard. The build in animation helped us programming the sitting position, but using ten times the same build in animation means that the 10 avatars had the same synchronic movements. All of them were moving their head the same way and are continuously moving while sitting on the chair. We solved this problem by changing the animation speed on 9 different ways.

Now the avatars are sitting on chairs and none of them made exactly the same movement. After the sitting animation was implemented we realized that the avatars had to be scaled, the coordinates on which point they are imported to the world had to completely match with chairs in the virtual room and the collision between the chair and the avatar had to be considered (Figure 5. 15).
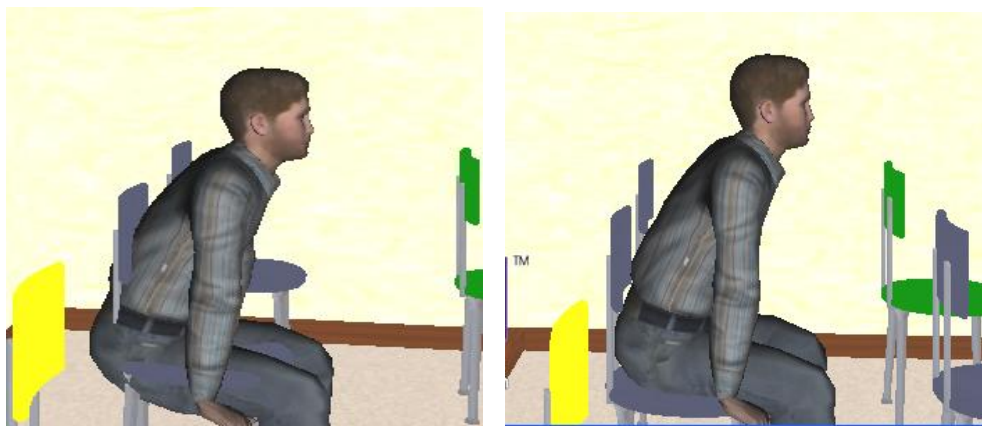
Figure 5.15: 1) not the right coordinates and collision 2) The right coordinates no collision

```
#Avatar 5_tolga= 4e rij 3e stoel
tolga= viz.add('D:\Wereld\Avatars\Male\casual02_m_highpoly.cfg')
tolga.setScale(11.0,11.0,11.0)
tolga.state(32)
tolga.setAnimationSpeed(0,0.1)
tolga.setPosition(-41.6,0,4.2)
```

Figure 5.16: The Python code for just one avatar

The result, a room with avatars sitting watching a movie. None of the avatars were static but moving continuously, looking around and sitting on different positions. We did not want static avatars, since anxiety can be provoke more with natural behavior.

The animation path:
The participants are navigated in the virtual environment. There are 2 animation paths. The black dots in Figure 5.17 are the coordinates of the points that can be activated with a key. The key which activates the animation is also given in the Figure 5.17 and programmed in Python.
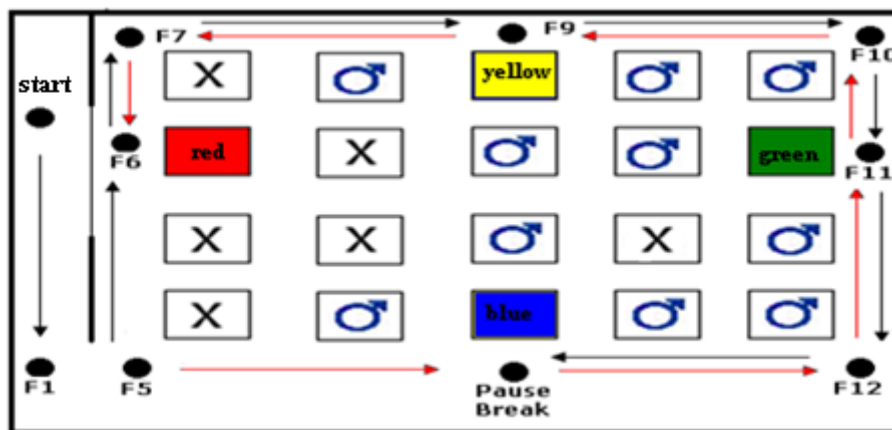
Figure 5.17: The animation paths
Both paths start in the dot above the "F1" dot (fig 5.17), the participant can look around and look through a window. The participant is navigated to "F5", again the participant gets time to look around, and the navigation goes on till "pause break". The participants get time to look around now they are standing in front of the group. The animation speed of the navigation is chosen as normal walking speed.
Then the difference in the navigation path starts.

- Animation path1 => red chair => yellow chair => green chair => blue chair.
- Animation path2 => blue chair => green chair => yellow chair => red chair.

```
#ROUTE PATH 1 en 2
def onKeyDown(key): #When the specified key is pressed down, the given function will be
#called with the passed arguments
        if key == viz.KEY_F1:
                viz.MainView.goto( [ 0,17.7,30],4)
        if key == viz.KEY_F5:
                viz.MainView.goto( [ -13, 17.7, 35 ],4)
        if key == viz.KEY_F6:
                viz.MainView.goto( [ -13, 17.7, 0 ],4) #red chair
        if key == viz.KEY_F7:
                viz.MainView.goto( [ -13, 17.7, -15],4)
        if key == viz.KEY_F9:
                viz.MainView.goto( [-42, 17.7,-15],4)  #yellow chair
        if key == viz.KEY_F10:
                viz.MainView.goto( [ -70, 17.7, -15],4)
        if key == viz.KEY_F11:
                viz.MainView.goto( [-70, 17.7,0],4) # green chair
        if key == viz.KEY_F12:
                viz.MainView.goto( [-70, 17.7,35],4)
        if key == viz.KEY_BREAK:
                viz.MainView.goto( [-42, 17.7,35],4)# blue chair
viz.callback(viz.KEYDOWN_EVENT,onKeyDown)
```

Figure 5.18: Python code for one of the navigation paths

HMD:

We had to write some commands in Python to let the HMD work with Vizard and also some adjusting to the graphic card are made.

We also have changed the eye height for the main view when the application starts. The person with HMD is walking around the avatars that are sitting; the eye height has to be as the real world situation(Figure 5.19).

```
#HMD
viz.go(viz.QUAD_BUFFER | viz.FULLSCREEN)
sensor= viz.add ('emagin.dls')
viz.link(sensor, viz.MainView)
```

Figure 5.19: The python code for the HMD

The prototype implementations are finished and ready for the experiment. The screenshots of the prototype are shown below. The start position the (0,0,0) position is visible in Figure 5.20. The participant can take a look in the room through the window. The first position they are navigated till is shown in Figure 5.21 and Figure 5.22. The participant can now see the movie playing and the whole group sitting. The participant is almost standing. The position when standing behind the yellow chair is in Figure 5.23.

Figure 5.20: screenshot of the implemented prototype at the start position
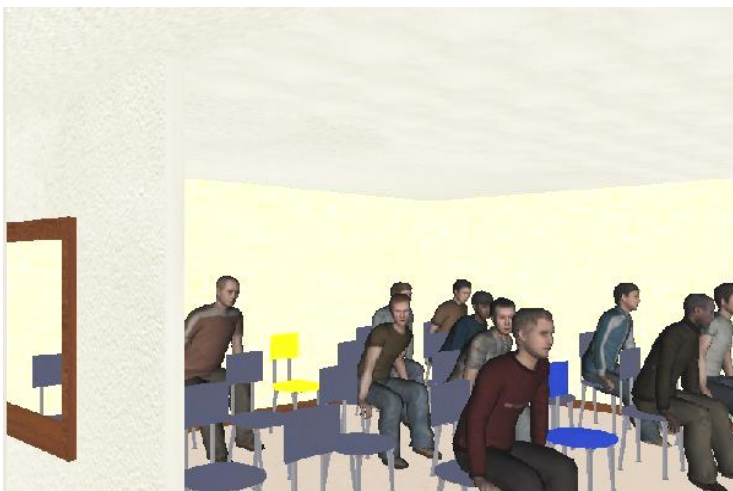
Figure 5.21: Screenshot of the implemented prototype at the position F1

Figure 5.22: Screenshot of the implemented prototype

Figure 5.23: Screenshot of the implemented prototype

The screenshots can give us a first impression of the prototype and can help visualizing the experiment described in the next chapter.

6. Experiment

This chapter describes the experiment that was conducted to verify the prototype.

6.1 Introduction

The virtual room modeled in Maya and programmed in Vizard is ready for the experiment. The next step is the experiment with the prototype.

The experiment results have to verify if the prototype virtual environment is recreating the real life situation successfully and is able to provoke the same human response. The following two test cases are assumed to be representative behavior of social phobia patients [1]:

A. People who enter a crowded room want to sit down as quickly as possible to avoid being the center of attention; they would prefer a chair which is close to them
B. People have the tendency to physically distance themselves from strangers when choosing a seat in a room full of strangers; they would prefer a chair with no one sitting around them

The assumed behavior in case A is based on the fear that people with a social phobia have of being watched and judged by others, which makes them want to sit down as fast as possible [1] . The assumed behavior in case B is based on the persistent fear of people with social phobia for unfamiliar people, which makes them prefer a physical distance between them and people unfamiliar to them[6].

6.2 Method

The method used is as follows:

6.2.1 Participants

For the experiment we asked Delft University of Technology students, staff members and PhD students as participants.
The participants did not get instructions about the experiment goal. Before the experiment they were asked to fill in the Liebowitz Social Anxiety Scale form.

6.2.2 Hardware

- Monitor: monitor resolution of 800 x 600 with a refresh rate setting of 60 Hz was needed
- Computer: The computer used for the proposed system is a Dell optiplex 755. An intel core 2 duo e6750 and 1.66 ghz with a quadro fx 1700 graphics card.
- HMD:For the proposed system we have the disposal of an eMagin - Z800 3DVisor HMD. The HMD is connected to the computer with a USB port,

Windows XP, CD-ROM or DVD drive, 10MB a hard drive space and a monitor resolution of 800 x 600 with a refresh rate setting of 60 Hz was needed. The eMagin Z800 3D Visor is a product to deliver an immersive 3D computing experience.

Figure 6.1: eMagin- Z800 3DVisor

The features of the HMD are:
- 360 degree horizontal head-tracking via a mouse emulation driver
- State-of-the-art head tracking device
- Full SVGA stereovision (800 x 3 x 600) OLEDs
- High contrast (>200:1) ratio
- Full colour (>16.7 million) pixels
- Low power (USB-powered) visor
- Lightweight, ergonomic (<8 oz) visor
- Built-in stereo sound and noise-cancelling microphone

6.2.3. Conditions

The animation path starts in front of the room; there are two different animation paths. The animation paths are chosen randomly. The 2 different animation paths, which are between-subject variables, are used for different group of participants.
Animation path1 => red chair => yellow chair => green chair => blue chair
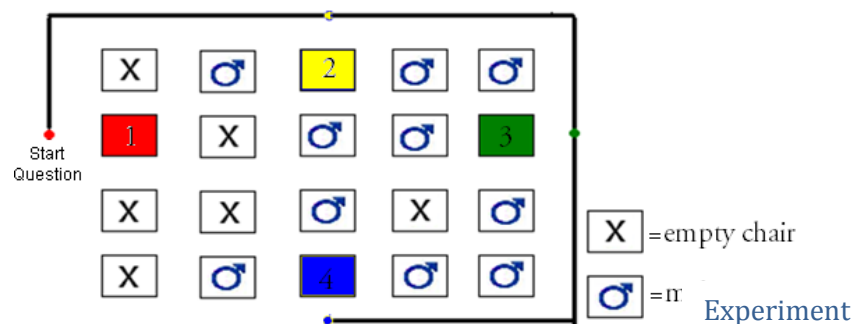
Figure 6.2: Animation path 1

Animation path2 => blue chair => green chair => yellow chair => red chair

Figure 6.3:   Animation path 2

6.2.4 Measures

We used four measures for our experiment:

1) The Chair preference rate during the experiment with the animation path:
The participants do not get information about the experiment goal before entering the room. They are navigated to certain points in the virtual world and when they arrive a colored chair they receive a question through their HMD integrate audio. They have to answer the question: "How willingly would you like to sit on the red/blue/green/yellow chair" and "please state your answer with the number between 1 and 7. They are informed of what the rates 1 till 7 means

Between 1 and 7 according to the likert scale:

Unlikely	1 extremely	2 quite	3 slight	4 neither	5 slightly	6 quite	7 extremely	Likely

They are navigated to the next point at the moment they say loudly what their grade is. This repeats for each colored chair till the end of the experiment

2) The preference order of the chairs:
The participant is asked which chair they would prefer first, second, third and fourth if they could walk to a chair when they are standing in front of the group, after navigated tour in the virtual environment.

3) Presence
We used the igroup presence questionnaire (IPQ)[46] to measure the presence. The Igroup Presence Questionnaire (IPQ) is a scale for measuring the sense of presence experienced in a virtual environment (VE). It was originally constructed in German, but is translated and also available in English and Dutch.

Figure 6.4: Immersion vs Presence [46]

People understand the *sense of presence* as the *subjective* sense of being in a virtual environment. Theoretically distinguish is made between immersion and presence.

- Immersion is a variable of the technology and can be described objectively
- Presence is a variable of a user's experience, therefore are measures obtained of the sense of presence from, self reports, subjective rating scales.

The scale development process of the current version of the IPQ identified one general item, three subscales. The three subscales can be regarded as fairly independent factors. They are:

1. Spatial Presence: the sense of being physically present in the VE
2. Involvement: measuring the attention devoted to the VE and the involvement experienced
3. Experienced Realism: measuring the subjective experience of realism in the VE

The current IPQ has a total of 14 items.

4) Social phobia

We used the Liebowitz Social Anxiety Scale (LSAS) to assess if our participants do have a social phobia [47].The more participants with a social phobia, the better we can confirm the effectiveness of our prototype.

The Liebowitz Social Anxiety Scale (LSAS) is a questionnaire (see Appendix B) by psychologist and researcher, Michael Liebowitz, whose objective is to assess the range of social interaction and performance situations which patients with social anxiety disorder may fear. It is commonly used to study outcomes in clinical trials. The scale features 24 items, 13 relating to performance anxiety and 11 concerning social situations. It is not intended for use as a self-reporting diagnosis. The LSAS differs from many of the other measures of social phobia in that it is explicitly situation-based. The participant have to rate his/her fear experienced in a broad array of social situations, as well as to rate the degree to which he/she avoids the situation.

The scoring scale
55-65 Moderate social phobia
65-80 Marked social phobia
80-95 Severe social phobia
Greater than 95 – Very severe sociale phobia

Figure 6.5: The scoring scale of the Liebowitz Social Anxiety Scale [6]

6.2.5   Data Analysis

The analyses of all the data collected from every participant were analyzed with the statistical analysis software SPSS version 16.0. We tested and search for comparisons or relations between the different chairs, animation path, LSAS data and IPQ data.

6.3 Experiment procedure

- **Step 1**: The participant start with filling in the Liebowitz Social Anxiety Scale.
- **Step 2:** The experiment is not started yet.The participants are informed there is a meeting going on and they are a bit too late (to provoke anxiety), the movie is already playing. They are told that they can look around and that they have to give a rate between one and seven when asked. They are informed of what the rates 1 till 7 means. The animation paths are chosen randomly. They are not informed about the goal of our experiment
- **Step 3**: The participant puts the HMD on, plugs the earplugs in and starts exploring the virtual environment room.
- **Step 4:** The animation path programmed in Vizard navigates them in a natural human pace towards the window in the divider wall. They can look around.
- **Step 5**: The participants is navigated to the front of the room. They can look around
- **Step 6**: The animation path to the different colored chairs is activated and the participant is navigated through the room at this moment. The participants get time to look around. The question: How willingly would you like to sit on the red/green/blue/yellow chair, please state your answer with the number between 1 and 7.
- **Step 7:** The grade given for the chair is recorded and they are navigated to the next chair.
- **Step 8:** This is repeated another three times until the last chair is graded.
- **Step 9**: The experiment stops at the moment the last chair is graded.
- **Step 1**0: The participant is asked to remove one earplug to hear sound from the real world and is navigated to the Pause Break point in Figure 5.15.
- **Step 11**: The participant is asked again to look around in the virtual world and asked which chair would be their first, second, third and fourth choice respectively. This is also registered.
- **Step 12**: The participant removes the HMD
- **Step 13**: The participant is asked to fill in an Igroup Presence Questionnaire.
- **Step 14:** The data is for the experiment is completed.

6.4 Results

The results of our experiment are:

Participants:
The experiment was performed in the multimedia lab at the EWI- faculty of the Delft University of Technology. The experiment is completed with 22 participants, 5 female and 17 male.
The 22 participant were master students (n=15), PhD students (n=5) or staff members (n=2). Some of the participants (n=9) already had virtual reality experience.
According to the LSAS scoring scale [6] the participants (n=19) did not have a social phobia and (n=3) a marked social phobia. More information about the frequencies can be viewed in appendix C.

Animation path
Both animation paths had different participants.
- 11 participants for animation path 1
- 11 participants for animation path 2

Measures:
The first step of the analysis was to transform the individuals' chair preference scores (x) into *z*-scores. This would remove individuals' use of the Likert scale. The *z*-scores were based on a participant's average (μ) and standard deviation of the chair (σ) rating.

$$z = \frac{x - \mu}{\sigma}$$

As the red chair and green chair are identical in distance to the film screen, but differ on the number of avatars position around the chair, analyzing preference rating of these chairs would give an insight in the effect of these avatars on participants' preference for these chairs. Next, participants were led pass the chairs in opposite routes, including this information in the analysis gives an insight on participants' preference on preferring a chair rather soon than later when moving through the room. Therefore a MANOVA with repeated measures was conducted. Chair and Animation Path were taken as independent within-subject variables, and preference *z*-score of the two chairs as dependent measure. The analysis found no significant main effect for the chairs ($F(1,20) = 0.13$, *p.* = 0.72) for the animation route ($F(1,20) = 0.80$, *p.* = 0.38). However, the analysis revealed a significant interaction effect between chairs and the animation route ($F(1,20) = 5,72$, *p.* = 0.027).
Examining Figure 6.5 with the mean z-score, it seems that the rating of the red chair was higher rated by participants starting with animation path 1: (red-yellow-green-blue),when red chair is asked in the beginning of the path. Participant following the animation path 2 (blue – green – yellow – red), for whom the red chair was the last one on their path, gave a lower score for the red chair. The same was visible for the green chair. The green chair gets a higher score is if the rate for the chair is asked

earlier in the path. For animation path 1, the green chair ratings are lower than in case of the animation path 2.
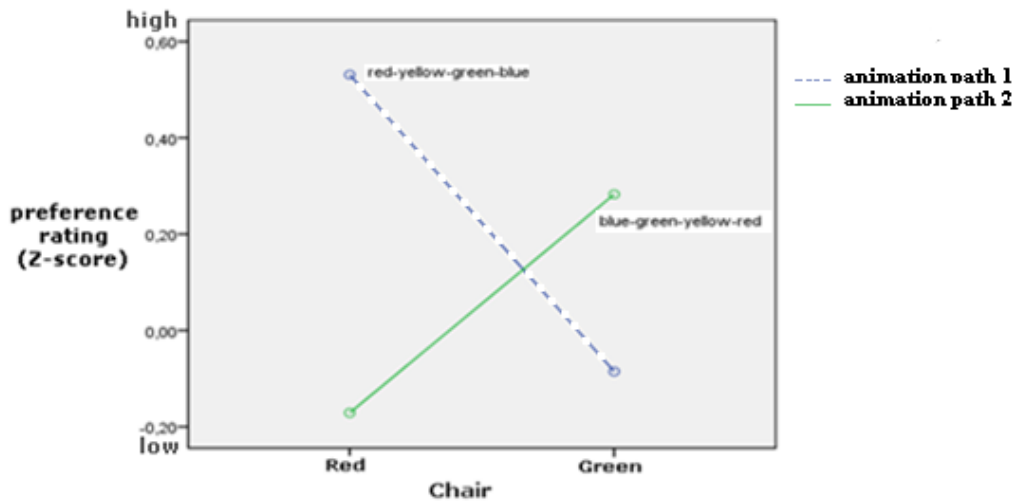
Figure 6.6: Preference rating chair in relation with the animation paths.

A difference between preferences in chairs was found in the participants preference ordering of the chairs at the end of session. The participants were asked to give a preference order for the colored chairs if they could walk to a chair independent of the animation path.

A Friedman Test on the ranking of all chairs revealed a significant difference (χ^2 (3, N = 22) =12.49, *p.* = 0.006) between the ranking of the chairs. Furthermore, a separate analysis of the ranking order of the green and red chair with a Wilcoxon Signed Ranks Test also found a significant difference (z = -2.56, *p.* = 0.011) in the ranking order of these two chairs. Examining table 6.1 and Figure 6.6 shows that the participants (n=13) prefer the red chair as their first choice and the blue chair (n=1) is totally not popular. The yellow (n=8) and blue (n=9) are popular as second chair in preference order.

Table 6.1: The frequency table of participant preference order

preference	red Frequency	yellow Frequency	green Frequency	blue Frequency
1	13	5	3	1
2	4	8	1	9
3	2	5	10	5
4	3	4	8	7
Total	22	22	22	22
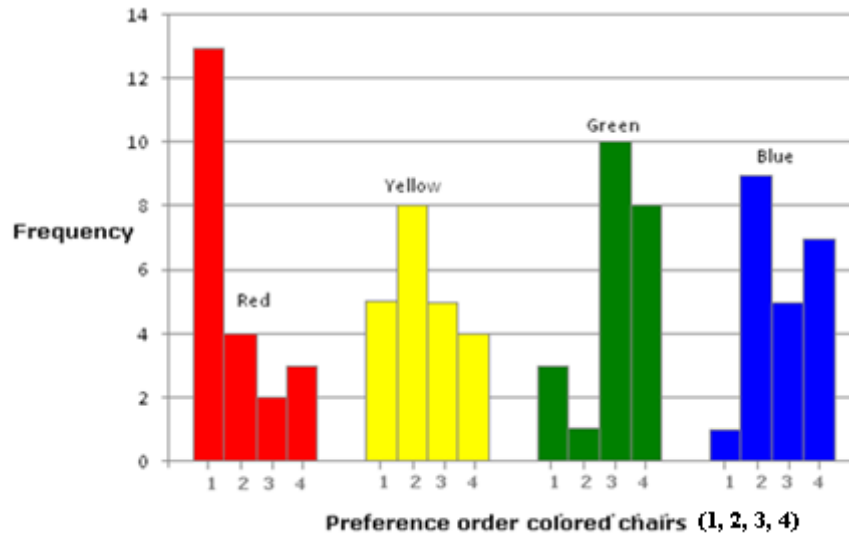
Figure 6.7: The participant preference order of colored chairs

The LSAS results did not have correlation with any chair preference. The 3 participants who had a social phobia according to the LSAS were not sufficient to make conclusions , still we examined their data and observed that two of the three participant gave the first chair of their animation path the highest rate when was asked how willingly they wanted to sit.
The social phobic participants prefered the yellow chair which was the physically the most distance chair and the red chair was twice the fourth preference (see table 6.2).

Table 6.2 The preference ranking for the colored chairs

Participant	Red Chair	Yellow chair	Green chair	Blue chair
1	4.0	2.0	1.0	3.0
2	1.0	3.0	4.0	2.0
3	4.0	1.0	3.0	2.0

6.5 Conclusion and Discussion

In our experiment we wanted to find out if social behavior of people in reality can be recreated in a VR world. The purpose was to test if the virtual environment can be used for VRET for social phobia.

In order to verify if the prototype virtual environment is recreating the real life situation successfully, and is able to provoke the same human response, two test cases were investigated. The following two test cases are assumed to be representative behavior of social phobia patients, based on the literature study[5] [1][6] [7] , and were used for the experiment with the prototype:

A. People who enter a crowded room want to sit down as quickly as possible to avoid being the center of attention; they would prefer a chair which is close to them

B. People have the tendency to physically distance themselves from strangers when choosing a seat in a room full of strangers; they would prefer a chair with no one sitting around them

The results for **research case A** showed that the rating of the red chair was higher when given at the beginning of the path, as was the case for animation path 1. Participants following animation path 2, for whom the red chair was the last one on their path, gave a lower score for the red chair.

The same is observed for the green chair which also gets a higher grade if is graded earlier in the path. For animation path 1, the grades of the green chair are lower than in the case of animation path 2. Therefore we can conclude that the participants prefer to take a seat on the chair that is nearest to them. This is in line with the hypothesed behavior for case A.

Some participants reinforced this conclusion by actually stating that they wanted to sit down as fast as possible, since they did not want to disturb the people already sitting down (avatars). This confirms that they had the feeling of actually being in the virtual room and wanted to sit as soon as possible and not being the center of attention.

In **research case B** we observed that the red chair was significant more present than the green chair (see Figure 6.1). Since the only difference with the green chair was the fact that the chairs surrounding the red one were empty, we can conclude that the participants prefer a chair with no avatars around them rather than the chairs with avatars surrounding it.

For our experiment we used students, staff or PhD students of the Delft University of Technology. The Liebowitz Social Anxiety Scale was not taken into account in our results because we only had a limited number (n=3) of participants with a social phobia. Although we observed different results for the social phobia participants, the number of social phobia participants was limited to draw any significant conclusions for that group. The difference in the results for the social phobia participants was that they did not have as strong a preference for the red chair as the other participants. A possible explanation for this behavior could be that the recreated room was not totally symmetric, and although the red chair was not surrounded with avatars, the fact that it was next to a window could have influenced the choice of the social phobia participants. We assumed that the colors used were neutral colors and did not influence the preference of the participant.

Since the assumed behavioral response were observed for both case A and case B, we can conclude that a social situation can be recreated in a virtual world.

7. Conclusion

In this last chapter the overall conclusions and recommendations are presented.

We designed and implemented a prototype virtual environment for the treatment of social phobia. The applied software and techniques were presented and used for the implementation of the prototype. We implemented three main elements of social phobia into our virtual environment to induce social phobia symptoms such as anticipated anxiety. We performed the experiment, evaluated the result and have reached our research goals for this thesis.

With the experiment we observed that people entering a room with strangers prefer to sit down on a chair close to them. We also observed that the participants preferred the chair with no avatars around them rather than the chairs with avatars surrounding it. The reaction of the participants to the implemented virtual situation was in accordance with the assumed behavioral response. Since social phobia patients show an extreme form of the responses that people without social phobia experience we can conclude that the real life social situation has been successfully recreated in the VR environment.

We can unfortunately not confirm that the prototype can be used for VRET for social phobia, because we had a very limited number of social phobia participants to draw that conclusion. However, we have recreated a social situation in VR and made a first step towards a virtual environment that can serve as a prototype for virtual worlds that will be built in the future to treat social phobia with VRET.

7.1 Recommendations

The prototype used in the experiment covers several requirements for social phobia. There are already two parameters implemented in the prototype that could be manipulated by therapist during exposure therapy, but still a lot of improvements can be made.
The design of the room can be more symmetric and the navigation could be changed, e.g. by making the participants walk through the room and between the chairs to provoke anxiety. For graded exposure, anxiety arousing sounds could be added into the virtual environment such as a whole group that starts laughing when the patient enters the room.
The number of avatars can vary, manipulated and be placed on different chairs. More interaction between the avatars and the patient can be built in the virtual environment such as a conversation and eye contact.
The objective measurements like heart rate and perspiration could be used to test if a situation has indeed provoked anxiety.
All of these aspects can be incorporated in the future in our prototype to achieve a more improved VRET for social phobia.

References

[1] Psychiatric Association, American. *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV).* Washington, 1995.

[2] L. F.Hodges, P. Anderson, G.C.Burdea, H.G.Hoffman, B.O. Rothbaum. „Treating psychological and psychological disorders with VR." (IEEE Computer Society Press) 21, nr. 6 (2001).

[3] Emmelkamp, P.G.M., M.Krijn, A.M. Hulsbosch, S. de Vries, M.J. Schuemie, en and C.A.P.G van der Mast. „Virtual Reality Treatment versus exposure in vivo;." *A comparative Evaluation in Acrophobia Behaviour Research & Therapy*, 2002.

[4] J. Wiersma, A. Greeven, E. Berrety, M. Krijn, P. Emmelkamp. „De effectiviteit van Virtual Reality Exposure Therapy voor hoogtevrees in de klinische praktijk." *Gedragstherapie (in dutch)*, 2008: 253-259.

[5] Inan, F. *Virtual Reality and Social Phobia.* Delft: Tu Delft, 2008.

[6] *The Anxiety Community.* 2000-2005 . http://www.anxietyhelp.org/information/leibowitz.html (geopend august 20, 2008).

[7] *Elaborated case for MKE project 1.* IN1810 (Faculty EWI, Delft University of Technology november 2004).

[8] Kessler, R.C. „The impairments caused by social phobia in the general population: - implications for intervention." (Acta Psychiatrica Scandinavica Supplement) 19-27 (2003).

[9] Neal, J.A., Edelmann, R.J. „The etiology of social phobia: toward a developmental profile." (Clinical Psychological Review) 23(6): 761-786. (2003).

[10] Wittchen, H.U., Fehm, L. „Epidemiology and natural course of social fears and social phobia." (Acta Psychiatrica Scandinavica Supplemen) 108(417): 4-18 (2003).

[11] http://www.socialfear.com/.

[12] Kessler RC, Nelson CB, McGonagle KA, Edlund MJ, Frank RG, Leaf PJ. „The epidemiology of co-occurring addictive and mental disorders: implications for prevention and service utillization." *Am J Orthopsychiatry*, 1996: 66(1), 17.

[13] R.G.Heimberg, D.H. Barlow. „New developments in cognitive behavioral therapy for social phobia." (Journal of Clinical Psychiatry) 52(suppl), nr. 21-30 (1991).

[14] M.R.Liebowitz, F.R. Schneier, E.Hollander and al. „Treatment of social phobia with drugs other than benzodiazepines." (Journal of clinical Psychiatry) 52(suppl Nov), nr. 10-15 (1992).

[15] Mersch, P.P. „The behavioral and cognitive therapy for social phobia." 1994.

[16] Lehman, D.H. Barlow and C.L. „Advanced in the psychological treatment of anxiety disorders." (Archivees of General Psychiatry) 53, nr. 727-735 (1996).

[17] G.Butler. „Exposure as a treatment for social phobia: some instructive difficulties." (Behaviour Research Therapy) 23(6), nr. 651-657 (1985).

[18] R.G.Heimberg, M.R. Liebowitz, D.A. Hope and F.R. Schneier. „Social Phobia: Diagnosis Assesment and Treatment." (The Guilford Press) 1995.

[19] Tanneau, P.Legeron and E. „Therapie comportementale et cognitive de groupe de la phobia sociale." (Journal de Therapie Comportementale et Cognitive) 3, nr. 84-94 (1998).

[20] Krijn, Merel. *Virtual Reality and Specific Phobias --Welcome to the real world.* Amsterdam: PhD thesis, University of Amsterdam, 2006.

[21] Azuma, Ronald T. „A Survey of Augmented Reality." *Presence: Teleoperators and Virtual environments*, August 1997: 355-385.

[22] Krueger, Myron W. „Environmental technology: making the real world virtual." *Special issue on computer augmented environments : back to the real world*, 7 july 1993: 36-37.

[23] Ware, C., Arthur K. and Booth K.S. „Fish tank virtual reality ." *Proceedings of the conference on Human factors in computting systems*, 1993: 37-42.

[24] *Fraunhofer- Gesellschaft.* http://www.fraunhofer.de (geopend 04 11, 2008).

[25] Ditton T., Lombard M. „At the heart of it all: The concept of Presence." *Journal of Computer Mediaded Communication*, 1997, 2 ed.

[26] m.lombard. „http://www.matthewlombard.com/." *Resources for the study of presence: Presence explication.* 2000. http://www.matthewlombard.com/.

[27] M.J Schuemie, C.A.P.G van der Mast. „Presence: Interacting in VR." Delft.

[28] Thie, Wijk. „A General Theory on Presence: Experimental Evaluation of Social Virtual Presence in a Decision Making Task." june 1998: 10-11.

[29] Heeter, C. „Being There: The Subjective Experience of Presence." *Teleoperators and Virtual Environments*, 1992.

[30] Martijn J. Scheumie, Peter van der Straaten, Merel Krijn and Charles van der Mast. „Research on Presence in Virtual Reality: A Survey." *CyberPyschology & Behavior*, 2001.

[31] Slater M., Usoh M., & Steed A. „Depth of presence in virtual environments." *Presence*, 1994: 130-140.

[32] Witmer B.G, & Singer M.J. „Measuring presence in virtual environments: A presence questionaire." *Presence*, 1998: 225-240.

[33] Slater M., & Usoh M. „Representation systems, perceptual positions, and presence in immersive virtual environments." *Presence*, 1993: 221-233.

[34] T.B, Sheridan. „Musings on telepresence and virtual presence." *Presence*, 1992: 120-126.

[35] J., Steuer. „Defining virtual reality: Dimensions determining telepresence." *Journal of Communication*, 1992: 72-93.

[36] P.M.G. Emmelkamp, M. Krijn, R.P. Olafsson, R. Biemond. „Virtual Reality exposure therapy of anxiety disorders: a review." *Clin Psychol Rev*, 2004, 24 ed.

[37] Emmelkamp, PMG. „Technological innovations in clinical assessment and psychotherapy." *Psychoter Psychomat*, 2005, 74 ed.

[38] van der Mast, Charles. „Technological challenges in the delft virtual reality exposure therapy system." *Int J Disabil Human Dev*, 2006.

[39] Martijn Scheumie, Charles van der Mast. „Virtual Reality in de therapie."

[40] B.Aslan. „A New VRET Framework, Fear of Flying." Delft, 2007.

[41] B., Foa E., en Kozak M. J. „Emotional Processing of Fear: Exposure to Corrective Information." *Psychological bulletin* , 1986.

[42] Hooplot, F.S. *Design and evaluation of a new system for VRET for agoraphobia.* Delft: Tu Delft, 2005.

[43] Turk, C. L., Heimberg, R. G., & Hope, D. A. „Social anxiety disorder." In *Clinical handbook of psychological disorders: A step by step treatment manual (pp114-154),*

door D.H. Barlow. New York: Guilford Press, 2001.

[44] S.Roorda. *Developing a general framework for the Delft VRET application.* Delft: TU, 2008.

[45] *WorldViz Home.* 2002-2008. www.worldviz.com (geopend june 15, 2008).

[46] *igroup presence questionnaire (IPQ) Scale Construction.* 1995–2004 . http://www.igroup.org/pq/ipq/index.php (geopend august 21, 2008).

[47] Richard G. Heimbert, Ph.D. and Robert M. Holaway, M.A. „Examination of the known-groups validity of the Liebowitz Social Anxiety Scale." *Depression and Anxiety*, 2006.

[48] *Virtual Reality and Phobias.* Tu Delft. 7 nov 2007. http://graphics.tudelft.nl/~vrphobia/vrpsych.html.

[49] Kessler, Stein & Berglund. „Social phobia subtypes in de National Comorbidity Survey." *American Journalof Psychiatry, 155*, 1998: 613-619.

[50] Heiser, N.A., Turner, S.M., & Beidel, D.C. „Shyness: Relationship to social phobia and other psychiatric disorders." *Behaviour Research and Therapy*, 2003.

[51] Lang AJ, Stein MB. J Clin. „Social phobia: prevalence and diagnostic threshold." (J Clin Psychiatry) 62(suppl 1):5-10. (2001).

[52] Connor, KM, Kobak, KA, Churchill,. „Mini-SPIN: a brief screening assessment for generalized social anxiety disorder. Depress Anxiety 2001 ." (John Wiley & Sons) 14, nr. 139 (2001).

Abbreviations

HCI – Human Computer Interaction

VR – Virtual Reality

VRET – Virtual Reality Exposure Therapy

CAVE - Computer Automatic Virtual Environment

HMD – Head Mounted Display

CBT- Cognitive Behavioral Treatment

DSM- Diagnostic and Statistical Manual of mental disorders

3D- three dimensional

VE- Virtual Environment

AR- Augmented Reality

SR- Simulated Reality

RW- Real World

VW- Virtual World

VRT- Virtual Reality Therapy

LSAS-Liebowitz Social Anxiety Scale

IPQ-IGroup Presence questionnaire

SAD- Social anxiety disorder

Appendix A: Igroup Presence Questionnaire (IPQ)

S U R V E Y   O N   E X P E R I E N C E S   I N   V I R T U A L   W O R L D S

Now you'll see some statements about experiences. Please indicate whether or not each statement applies to your experience. There are no rights or wrong answers, only your opinion counts.

You will notice that some questions are very similar to each other. This is necessary *for statistical reasons* . And please remember: Answer all these questions only referring to this *one* experience.

---

1)How aware were you of the real world surrounding while navigating in the virtual world? (i.e. sounds, room temperature, other people, etc.)?

extremely aware ○ ○ ○ ○ ○ ○ ○ not aware at all

-3 -2 -1 0 +1 +2 +3

moderately aware

---

2)How real did the virtual world seem to you?

completely real ○ ○ ○ ○ ○ ○ ○ not real at all

-3 -2 -1 0 +1 +2 +3

---

3)I had a sense of acting in the virtual space, rather than operating something from outside.

fully disagree ○ ○ ○ ○ ○ ○ ○ fully agree

-3 -2 -1 0 +1 +2 +3

---

4)How much did your experience in the virtual environment seem consistent with your real world experience ?

not consistent ○ ○ ○ ○ ○ ○ ○ very consistent

-3 -2 -1 0 +1 +2 +3

moderately consistent

---

5)How real did the virtual world seem to you?

about as real as an imagined world ○ ○ ○ ○ ○ ○ ○ indistinguishable from the real world

-3 -2 -1 0 +1 +2 +3

---

6) I did not feel present in the virtual space.

did not feel ○ ○ ○ ○ ○ ○ ○ felt present

-3 -2 -1 0 +1 +2 +3

7)I was not aware of my real environment.								
fully disagree	O	O	O	O	O	O	O	fully agree
	-3	-2	-1	0	+1	+2	+3	

8)In the computer generated world I had a sense of "being there"								
not at all	O	O	O	O	O	O	O	very much
	-3	-2	-1	0	+1	+2	+3	

9)Somehow I felt that the virtual world surrounded me.								
fully disagree	O	O	O	O	O	O	O	fully agree
	-3	-2	-1	0	+1	+2	+3	

10)I felt present in the virtual space.								
fully disagree	O	O	O	O	O	O	O	fully agree
	-3	-2	-1	0	+1	+2	+3	

11)I still paid attention to the real environment.								
fully disagree	O	O	O	O	O	O	O	fully agree
	-3	-2	-1	0	+1	+2	+3	

12)The virtual world seemed more realistic than the real world.								
fully disagree	O	O	O	O	O	O	O	fully agree
	-3	-2	-1	0	+1	+2	+3	

13)I felt like I was just perceiving pictures.								
fully disagree	O	O	O	O	O	O	O	fully agree
	-3	-2	-1	0	+1	+2	+3	

14)I was completely captivated by the virtual world.								
fully disagree	O	O	O	O	O	O	O	fully agree
	-3	-2	-1	0	+1	+2	+3	

Virtual Reality Experience: Yes   /   No

Gender : M / F

Age:

TUD :   O Student
              O Staff
              O Phd
              O Other

Appendix B: Liebowitz Social Anxiety Scale (LSAS)

Liebowitz Social Anxiety Scale (LSAS)

Situation	Fear 0= none 1= mild 2= moderate 3= severe	Avoidance 0= never 1= occasionally 2= often 3= usually
1. Using a telephone in public		
2. Participating in a small group activity		
3. Eating in public		
4. Drinking with others		
5. Talking to someone in authority		
6. Acting, performing, or speaking in front of an audience		
7. Going to a party		
8. Working while being observed		
9. Writing while being observed		
10. Calling someone you don't know very well		
11. Talking face to face with someone you don't know very well		
12. Meeting strangers		
13. Urinating in a public bathroom		
14. Entering a room when others are already seated		
15. Being the center of attention		
16. Speaking up at a meeting		
17. Taking a test of your ability, skill, or knowledge		
18. Expressing disagreement or disapproval to someone you don't know very well		
19. Looking someone who you don't know very well straight in the eyes		
20. Giving a prepared oral talk to a group		
21. Trying to make someone's acquaintance for the purpose of a romantic/ sexual Relationship		
22. Returning goods to a store for a refund		
23. Giving a party		
24. Resisting a high pressure sales person		

The subcategory for the analyses of the Liebowitz Social Anxiety Scale

Question nr	Question description
Social Interaction	
5	Talking to people in authority
7	Going to a party
10	Calling someone you don't know very well
11	Talking with people you don't know very well
12	Meeting strangers
14	Entering a room when others are already seated
18	Expressing appropriate disagreement or disapproval to people you don't know very well
19	Looking at people you don't know very well in the eyes
21	Trying to pick up someone
22	Returning goods to a store where returns are normally accepted
23	Giving an average party
24	Resisting a high pressure salesman
Public Speaking	
2	Participating in small groups
6	Acting, performing, or giving a talk in front of an audience
15	Being the center of attention
16	Speaking up at a meeting
20	Giving a report to a group
Eating and Drinking	
3	Eating in public places
4	Drinking with others in public places
Observation	
1	Telephoning in public
8	Working while being observed
9	Writing while being observed
13	Urinating in a public bathroom
17	Taking a written test

Appendix C: Tables SPSS

Data analysis with SPSS 16.0 of all data from the questionnaires and rates of the participants

Frequency Table of the data collected from the participants.

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	5	22,7	22,7	22,7
	Male	17	77,3	77,3	100,0
	Total	22	100,0	100,0	

TU Delft

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Student	15	68,2	68,2	68,2
	Phd	5	22,7	22,7	90,9
	Staff	2	9,1	9,1	100,0
	Total	22	100,0	100,0	

VR experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	13	59,1	59,1	59,1
	Yes	9	40,9	40,9	100,0
	Total	22	100,0	100,0	

Age Subject

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	22	3	13,6	13,6	13,6
	23	2	9,1	9,1	22,7
	24	4	18,2	18,2	40,9
	25	1	4,5	4,5	45,5
	26	2	9,1	9,1	54,5
	27	2	9,1	9,1	63,6
	28	3	13,6	13,6	77,3
	29	2	9,1	9,1	86,4
	31	1	4,5	4,5	90,9
	47	1	4,5	4,5	95,5
	48	1	4,5	4,5	100,0
	Total	22	100,0	100,0	

Liebowitz Social Anxiety Scale

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	15,00	1	4,5	4,5	4,5
	16,00	1	4,5	4,5	9,1
	21,00	1	4,5	4,5	13,6
	23,00	2	9,1	9,1	22,7
	25,00	1	4,5	4,5	27,3
	26,00	1	4,5	4,5	31,8
	30,00	1	4,5	4,5	36,4
	36,00	2	9,1	9,1	45,5
	39,00	1	4,5	4,5	50,0
	40,00	1	4,5	4,5	54,5
	43,00	2	9,1	9,1	63,6
	45,00	2	9,1	9,1	72,7
	46,00	2	9,1	9,1	81,8
	52,00	1	4,5	4,5	86,4
	68,00	1	4,5	4,5	90,9
	74,00	1	4,5	4,5	95,5
	80,00	1	4,5	4,5	100,0
	Total	22	100,0	100,0	

Appendix D: SPSS data

Subject	Gender	VR_experience	Animation_path	TUD	Age	VR_red	VR_yellow	VR_green	VR_blue
1	M	Y	2	1	23	7	2	4	3
2	M	N	1	1	28	7	7	7	6
3	M	N	1	1	31	7	7	1	5
4	F	Y	1	1	29	5	2	4	7
5	M	N	2	1	26	7	7	7	7
6	M	N	1	1	28	7	3	5	3
7	M	Y	2	1	24	2	5	6	4
8	M	N	1	1	29	5	5	5	5
9	M	Y	2	1	23	4	6	6	3
10	F	N	2	1	25	1	7	7	7
11	M	N	1	1	22	6	5	4	4
12	F	Y	2	1	22	5	5	6	7
13	F	N	2	2	24	7	7	7	4
14	F	Y	1	2	26	7	7	7	5
15	M	Y	1	2	28	3	3	4	6
16	M	N	2	1	24	7	2	4	1
17	M	N	2	1	24	1	3	3	7
18	M	Y	1	3	47	6	6	6	5
19	M	N	2	3	48	5	5	5	4
20	M	Y	1	1	22	5	1	3	5
21	M	N	1	2	27	6	3	5	6
22	M	N	2	2	27	1	1	1	2

Subject	1e_stoel	2e_stoel	3e_stoel	4e_stoel	Pref_order_red	Pref_order_yellow	Pref_order_green	Pref_order_blue
1	3,00	4,00	2,00	7,00	4	2	1	3
2	7,00	7,00	7,00	6,00	2	1	3	4
3	7,00	7,00	1,00	5,00	3	4	1	2
4	5,00	2,00	4,00	7,00	1	3	4	2
5	7,00	7,00	7,00	7,00	1	3	4	2
6	7,00	3,00	5,00	3,00	2	1	3	4
7	4,00	6,00	5,00	2,00	3	4	1	2
8	5,00	5,00	5,00	5,00	1	4	3	2
9	3,00	6,00	6,00	4,00	2	1	4	3
10	7,00	7,00	7,00	1,00	1	3	4	2
11	6,00	5,00	4,00	4,00	1	2	4	3
12	7,00	6,00	5,00	5,00	1	2	3	4
13	4,00	7,00	7,00	7,00	1	2	3	4
14	7,00	7,00	7,00	5,00	1	2	3	4
15	3,00	3,00	4,00	6,00	1	2	3	4
16	1,00	4,00	2,00	7,00	1	4	3	2
17	7,00	3,00	3,00	1,00	1	3	4	2
18	6,00	6,00	6,00	5,00	1	2	3	4
19	4,00	5,00	5,00	5,00	1	2	4	3
20	5,00	1,00	3,00	5,00	4	1	3	2
21	6,00	3,00	5,00	6,00	2	3	4	1
22	2,00	1,00	1,00	1,00	4	1	2	3

Subject	LSAS_total	LSAS_fear	LSAS_avoidance
1	80,00	45,00	35,00
2	52,00	28,00	24,00
3	46,00	29,00	17,00
4	30,00	18,00	12,00
5	40,00	6,00	34,00
6	39,00	19,00	20,00
7	23,00	8,00	15,00
8	21,00	5,00	16,00
9	45,00	25,00	20,00
10	74,00	38,00	36,00
11	46,00	19,00	27,00
12	25,00	9,00	16,00
13	36,00	14,00	22,00
14	15,00	4,00	11,00
15	36,00	18,00	18,00
16	16,00	10,00	6,00
17	23,00	9,00	14,00
18	26,00	16,00	10,00
19	45,00	22,00	23,00
20	68,00	33,00	35,00
21	43,00	24,00	19,00
22	43,00	16,00	27,00

Subject	IPQ_INV	IPQ_SP	IPQ_Real	m_pref	SD_pref	Z_red	Z_yellow	Z_green	Z_blue
1	1,00	-2,00	-2,00	4,00	2,16	1,39	-0,93	0,00	-0,46
2	2,00	10,00	1,00	6,75	0,50	0,50	0,50	0,50	-1,50
3	3,00	2,00	1,00	5,00	2,83	0,71	0,71	-1,41	0,00
4	3,00	-7,00	1,00	4,50	2,08	0,24	-1,20	-0,24	1,20
5	2,00	3,00	-1,00	7,00	0,00	0,00	0,00	0,00	0,00
6	5,00	-3,00	0,00	4,50	1,91	1,31	-0,78	0,26	-0,78
7	1,00	6,00	-1,00	4,25	1,71	-1,32	0,44	1,02	-0,15
8	-6,00	2,00	-2,00	5,00	0,00	0,00	0,00	0,00	0,00
9	-3,00	3,00	2,00	4,75	1,50	-0,50	0,83	0,83	-1,17
10	-1,00	4,00	-2,00	5,50	3,00	-1,50	0,50	0,50	0,50
11	-3,00	3,00	-3,00	4,75	0,96	1,31	0,26	-0,78	-0,78
12	-1,00	2,00	-2,00	5,75	0,96	-0,78	-0,78	0,26	1,31
13	-2,00	-14,00	0,00	6,25	1,50	0,50	0,50	0,50	-1,50
14	4,00	4,00	0,00	6,50	1,00	0,50	0,50	0,50	-1,50
15	-2,00	1,00	0,00	4,00	1,41	-0,71	-0,71	0,00	1,41
16	-1,00	-4,00	-5,00	3,50	2,65	1,32	-0,57	0,19	-0,94
17	1,00	5,00	-1,00	3,50	2,52	-0,99	-0,20	-0,20	1,39
18	-4,00	-4,00	4,00	5,75	0,50	0,50	0,50	0,50	-1,50
19	-4,00	-2,00	-2,00	4,75	0,50	0,50	0,50	0,50	-1,50
20	-8,00	3,00	0,00	3,50	1,91	0,78	-1,31	-0,26	0,78
21	-4,00	5,00	-3,00	5,00	1,41	0,71	-1,41	0,00	0,71
22	3,00	6,00	-1,00	1,25	0,50	-0,50	-0,50	-0,50	1,50