Research Assignment

Presence in Virtual Reality Exposure Therapy for Agoraphobia

Frans S. Hooplot
Master programme Media & Knowledge Engineering

Delft University of Technology
Supervised by Charles van der Mast
Delft, December 2004
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INTRODUCTION</td>
<td>4</td>
</tr>
<tr>
<td>Research Goal</td>
<td>4</td>
</tr>
<tr>
<td>Research Approach</td>
<td>5</td>
</tr>
<tr>
<td>Research Outline</td>
<td>5</td>
</tr>
<tr>
<td>2. VIRTUAL REALITY</td>
<td>6</td>
</tr>
<tr>
<td>Introduction</td>
<td>6</td>
</tr>
<tr>
<td>VR Technologies</td>
<td>7</td>
</tr>
<tr>
<td>3. PRESENCE</td>
<td>11</td>
</tr>
<tr>
<td>Theories</td>
<td>11</td>
</tr>
<tr>
<td>Subjective and Objective presence</td>
<td>11</td>
</tr>
<tr>
<td>Exclusive presence</td>
<td>11</td>
</tr>
<tr>
<td>General theory of presence (Mental models)</td>
<td>12</td>
</tr>
<tr>
<td>Measurement of Presence</td>
<td>13</td>
</tr>
<tr>
<td>Subjective measures: Questionnaires</td>
<td>13</td>
</tr>
<tr>
<td>Objective measures: Behavioral</td>
<td>13</td>
</tr>
<tr>
<td>Causes of Presence</td>
<td>13</td>
</tr>
<tr>
<td>Conclusion</td>
<td>14</td>
</tr>
<tr>
<td>4. ANXIETY DISORDERS</td>
<td>15</td>
</tr>
<tr>
<td>Panic disorder</td>
<td>15</td>
</tr>
<tr>
<td>Agoraphobia with panic disorder</td>
<td>16</td>
</tr>
<tr>
<td>Agoraphobia without panic disorder</td>
<td>16</td>
</tr>
<tr>
<td>Gradations of agoraphobia</td>
<td>17</td>
</tr>
<tr>
<td>Anxiety provoking situations</td>
<td>17</td>
</tr>
<tr>
<td>5. VIRTUAL REALITY EXPOSURE THERAPY (VRET)</td>
<td>18</td>
</tr>
<tr>
<td>Traditional treatment</td>
<td>18</td>
</tr>
<tr>
<td>Exposure</td>
<td>18</td>
</tr>
<tr>
<td>Treatment with VRET</td>
<td>19</td>
</tr>
<tr>
<td>6. VRET SYSTEM CHARACTERISTICS</td>
<td>20</td>
</tr>
<tr>
<td>Department of Human Computer Interaction at the Delf University of Technology (Netherlands)</td>
<td>20</td>
</tr>
<tr>
<td>Universidad de Valencia, Universidad Jaume I de Castellón, Previ group (Spain)</td>
<td>21</td>
</tr>
<tr>
<td>ATN-P lab, Istituto Auxologico Italiano, Verbania (Italy)</td>
<td>23</td>
</tr>
<tr>
<td>Biomedical Engineering Department, Hanyang University (Korea)</td>
<td>24</td>
</tr>
<tr>
<td>Virtual Reality Medical Center (VRMC) San Diego, Los Angeles, Palo Alto (USA)</td>
<td>26</td>
</tr>
<tr>
<td>Clark Atlanta University (USA)</td>
<td>27</td>
</tr>
<tr>
<td>Conclusion</td>
<td>28</td>
</tr>
<tr>
<td>7. REQUIREMENTS FOR VRET OF AGORAPHOBIA</td>
<td>29</td>
</tr>
<tr>
<td>Characteristics of VRET of Agoraphobia</td>
<td>29</td>
</tr>
<tr>
<td>The functionality of the user interface towards the therapist</td>
<td>30</td>
</tr>
<tr>
<td>8. CONCLUSIONS</td>
<td>31</td>
</tr>
<tr>
<td>9. REFERENCES</td>
<td>34</td>
</tr>
<tr>
<td>10. ABBREVIATIONS</td>
<td>37</td>
</tr>
</tbody>
</table>
1. Introduction

Throughout the years interesting research has been done on Virtual Reality Exposure Therapy (VRET) of phobias. Virtual Reality Exposure involves exposing the patient to a virtual environment containing the feared stimulus instead of taking the participant into a real environment or having the participant imagine the stimulus. This way of treatment has a lot of advantages. For example when treating participants that have a fear of flying it is less expensive to treat them with VRET than really making several flights. Yet still a lot of research has to be done on the effectiveness of VRET. It has been proven that VRET is effective for participants with acrophobia (fear of heights), arachnophobia (spider phobia) and fear of flying. The effectiveness of VRET in other anxiety disorders like claustrophobia, fear of spiders, fear of public speaking, fear of driving, posttraumatic stress disorder, and agoraphobia also holds promise for the future [7]. At the Delft university of Technology, in close cooperation with the University of Amsterdam, a generic system for treatment of phobia is being developed, taking into account specific Human Computer Interaction issues. In order for VRET to work properly it is very important that the Virtual Environment contains (almost) the same feared stimulus as the real environment. The participant has to feel the arousal of the anxiety that forms the basis for the specific phobia. In order to feel this, the participant has to feel a certain amount of presence. Because presence is one of the key aspects for successful VRET and VR as a whole, a lot of research is done on this subject.

Research Goal

In this document we focus on a specific phobia: agoraphobia. Agoraphobia is one of the more complex phobias. It literally means ‘fear of open spaces’, but later on we will see that it means more than just that. There has been several research projects on the efficacy of VRET in treating agoraphobia. Out of three studies, two concluded promising future expectations for VRET in treating agoraphobia. One study however showed negative results. The main problem in this study was, that the participants were not able to feel present in the virtual environment and thus didn’t experience any feared stimulus[7]. In this document we will try to find an answer to the following problem definition:

“Which parameters are necessary for creating a valid and anxiety-provoking virtual world for the treatment of agoraphobia”

Besides answering this question another (side) goal of this research is to determine which type of worlds should be build for the VRET treatment of agoraphobia.
Chapter 1. Introduction

Research Approach

In order to answer our problem definition research has to be done. There are many research methods out there to get the job done (e.g., Appreciative Inquiry, Case Study Design, Questionnaires, Surveys etc.). For this research we attended the following research methods:

1. The first step in our approach was literature study, collecting all suitable and relevant data on the subject. This meant finding relevant literature, articles, internet sites and other sources of information.
2. Secondly interviews where done with therapists. This was done mostly for evaluation of our thought process and for additional ideas and views. We choose to interview therapists, because this research is based on technical as well as psychological knowledge and because therapists will become the end users of the system for which this research is done.
3. We also looked at similar projects of other VRET researchers to find pitfalls and solutions related to the subject.
4. After the data collection and the additional interview all the information was structured, in order to find relations and draw conclusions.

Research Outline

In this chapter we gave an introduction to the research, the research goals and the research approach. In the next chapter an introduction to virtual reality is given and different virtual reality techniques will be explained. In the third chapter, theories regarding presence are being introduced and the measurements and causes of presence will be given. The fourth chapter gives an explanation of anxiety disorders and specifically Agoraphobia and anxiety provoking situations. Chapter five discusses VRET and its effectiveness with respect to traditional treatment. Chapter six discusses the characteristics of VRET and showcases other research projects on this subject. In chapter seven an overview of the requirements of VRET of agoraphobia is given. Finally a conclusion is drawn in chapter eight.
2. Virtual Reality

Introduction

There is still a lot of discussion on what Virtual Reality really means. We can tell this by the numerous definitions that exist. To name a few:

Computer simulated environment within which humans are able to interact in some manner that approximates interactions in the physical world. [33]

An artificial environment created with computer hardware and software and presented to the user in such a way that it appears and feels like a real environment. [30]

A human-computer interface in which the computer creates a sensory-immersing environment that interactively responds to and is controlled by the behavior of the user. [31]

A computer simulation that closely resembles reality. [32].

The term virtual reality is sometimes used more generally to refer to any virtual world represented in a computer, even if it's just a text-based or graphical representation. The term virtual reality (VR) was proposed by Jaron Lanier only a few more than one decade ago. In these years the progression of virtual reality has been tremendous. In the beginning the costs were very high. But as the technology grew, the costs decreased so VR systems are not only affordable for governments. The term VR may be quite recent, the tool however isn’t. As early as 1966, Ivan Sutherland built a HMD (Head Mounted Display) which was connected to the computer. All that it showed was a simple wire-frame cube which could be looked at using the HMD. The first generation of VR platforms that where really immersive, had to be limited to industries and research centres, where the high cost of the hardware and software development was justified. However, at the beginning of the eighties VR was ready to be acknowledged as a feasible technology. In the nineties the technology matured. This resulted in better, more realistic virtual environments and economical systems. Now that the costs of VR systems are decreasing, it is available for more users. There are still things to do for this technology to make it available for everyone. But we are already moving to a situation where VR workstations will be available at work or at home, allowing us to do virtual transactions, shopping, games, trips etc. Because of the interesting aspects of virtual reality and the decreasing costs humans are looking for many ways to apply this technique. One area where virtual reality could be very useful is psychotherapy, which we will discuss later on in this document.

It is difficult to delimit a general concept of VR that includes all the applications that have been designed up to now under such designation. Nevertheless, it is possible to define VR by the basic concepts that characterize it. Pioneering researcher in this field, Burdea, gave a very useful definition: “Virtual Reality is a complex user interface that includes simulations in real time through multiple sensorial channels. These sensorial modalities are visual, auditory, tactile, olfactory etc.” From this definition we can filter that there are two important characteristics of VR.
First, VR is Immersive, because through special devices the user gets the feeling of being physically present in the virtual world.

Second, VR is Interactive, because the user isn’t visualizing the virtual world in a passive way. The user is actually interacting with the virtual worlds by touching, moving and changing objects.

We can distinguish two types of virtual reality.

**Immersive virtual reality**
Here the user is really immersed into the virtual environment. Most extern stimuli are cut out. This means that the users feels as if he/she is actually in the virtual environment. This is mostly done with an HMD or a CAVE construction. With HMD the user puts on the helmet and sees the virtual world through two displays (one for each eye) that are mounted inside of the helmet. The helmet has a tracker, which keeps track of the head-movement and head orientation of the user in order to show the right perspective of the world to the user. With CAVE (Computer Automatic Virtual Environment) the users stands in a cubic like structure, where the virtual world is projected on the walls.

**Non immersive) Desktop virtual reality**
This is the more conventional way of virtual reality. Here the virtual (3D) world is shown on a conventional (2D) Monitor. The user isn’t immersed into the virtual environment, but can actually navigate and move through the world by using conventional inputs like a (3d) mouse, a joystick or a keyboard.

Another kind of virtual reality that’s worth mentioning is augmented reality. Augmented reality is the use of transparent HMD’s to overlay computer generated images onto the physical environment. Precisely calibrated, rapid head tracking is required to sustain the illusion. An observer’s experience of an environment is augmented with computer generated information. Usually this refers to a system in which computer graphics are overlaid onto a live video picture or projected onto a transparent screen as in a head-up display.

**VR Technologies**

**HMD and CAVE**
These two techniques are most commonly used to immerse participants in to the virtual world. A HMD (Head Mounted Display) is worn by a user. Through the displays of the HMD the user sees the virtual environment. A tracking system is needed to follow the users’ head-movement in order to show the right perspective of the virtual environment. An HMD is made for individual use, but the real-world can be totally shut out. That last thing is slightly different with the CAVE (Computer Automatic Virtual Environment) that consists of a cubic like structure in which the participant (and the therapist) can take place. The virtual environment is projected on the four to six sides of the cubicle. The participant wears shutter glasses. These shutter glasses lighten and darken in synchronization with the images on the screens. This way the left and the right eye see the same image from a different perspective.
that corresponds with the positions of the eyes. This way they see the projections on the screens in 3D. Also a tracking system keeps track of the position of the shutter glasses. A sensor is attached to the participants shutter glasses to generate a correct perspective view. In figure 2.1 we find an example of a CAVE. The main difference with HMD is that the CAVE can be used with multiple users at once, while the HMD is made only for single usage. Then again when using the HMD the real world can be totally shut out, which isn’t the case when standing in a CAVE. According to Alcaniz [5], one of the main advantages of the CAVE construction is a wider Field of View. This means that the user has a wider angle from which he or she perceives the virtual environment. Study also showed that the effectiveness of treatment using HMD is the same as using a CAVE, while HMD’s are much cheaper and easier to use than CAVE’s.[34]

![Figure 2.1 Example of a CAVE construction](image.png)

**Tactile feedback**

The last couple of years a lot of research is done on the field of tactile stimuli. Tactile stimuli can really contribute to the feel of presence. Imagine feeling the railing of a balcony, standing on the 12th floor of a building in a virtual environment during a VRET session for fear of heights. Or the vibrations of an airplane during take of. Lane and Smith [18] give an overview of commercial force feedback systems. Since, so much can be conveyed by our senses, integrating them into a virtual environment would yield great rewards. However, the difficulty is great in dealing with the complex problems of creating such stimuli. Therefore the prototypes that do exist are used only in specific functions. To find an answer to our problem definition it would be very useful to see which hardware can be used to stimulate the feel of presence in order to make the virtual world more anxiety-provoking.
**Hand-sensing glove**

A Hand-sensing glove like we can see in figure 2.2 is a glove with small vibro-tactile stimulators on each finger and the palm of the glove. Each stimulator can be individually programmed to vary the strength of the touch. The array of stimulators can generate tactile stimuli such as pulses or sustained vibration or a combination of these stimuli to produce complex tactile feedback patterns. The hand-sensing glove can be used to have a better interaction with objects in a virtual environment.

![Figure 2.2 Hand-sensing glove](image)

**Tactile feedback chair**

The tactile feedback chair in figure 2.3 is a migration of the tactile feedback from other areas to a chair. The chair can give tactile feedback to the user in the form of vibration. This way the feeling of presence of the participant can be increased. For example, when simulating sitting in an airplane, the vibrations that the airplane produces can also be simulated.

![Figure 2.3 Tactile feedback chair](image)

**VR Simulators**

Virtual reality simulators are another way of providing tactile feedback to the participant. In figure 2.4 we see an example of such a simulator. This is a form of "mixed reality" (Milgram, & Kishino, 1994). Touching a virtual object improves the quality of the virtual experience. Compared to visual VR only, getting evidence from both visual and tactile senses increases the illusion of "being in a place" when experiencing the virtual environment. Tactile feedback from real objects enhances presence in virtual reality. When creating a virtual environment of sitting in a car, the feel of a real chair and real steering wheel can again enhance the feeling of being present. This technique has been used by TNO for creating a cost effective driving simulator. But this same technique could also be used to treat certain phobia’s. For the VR Exposure Treatment of people with ‘fear of heights’ a real life railing can be used that also is programmed into the virtual environment. This way the participant can see and feel the railing, therefore feeling more presence.
Chapter 2. Virtual Reality

Force feedback systems

Force feedback systems are another way of producing tactile feedback. For example, force feedback systems for your hands as we can see in figure 2.5, make it possible to grab (computer generated) objects in the virtual environment and feel a (force) resistance as you hold the object. Users are able to feel the size and shape of the computer generated 3D objects in a simulated virtual environment. Grasp forces are produced by a network of tendons routed to the fingertips via the exoskeleton. There are five actuators, one for each finger, which can be individually programmed to prevent the user's fingers from penetrating or crushing a virtual solid object. There are also force feedback devices for the whole arm. This makes it possible to actually “hang your hand” on a virtual steering wheel, sense weight while picking up a heavy virtual object or feel the resistance of a simulated wall.

We must not forget that computer generated force-feedback is much more expensive than input from real objects (mixed reality), and the physical textures of the real objects (e.g., the hairy feel of a spider) are still hard to reproduce in computer simulations.
3. Presence

Presence is an important concept in VR, but still there are a lot of theories regarding the nature of presence. This is mainly because presence is a rather subjective concept. Presence can be described as the sense of “being there”, especially when talking about a virtual environment. All these theories do not necessarily contradict each other, although they can be quite different. They all share some similarities. One common factor is that of attention. In fact ‘Presence’ and ‘Situation awareness’ are overlapping constructs. Many authors have assumed a strong relation between presence and the level of interactivity [13]. Below we will shed light on a few theories regarding presence.

Theories

Subjective and Objective presence

Schuemie [14] discusses several theories regarding presence in his article on Presence in Virtual Reality. One of the discussed theories is that of Schloerb. Schloerb distinguishes two types of presence:

Subjective presence, the likelihood that the person judges himself to be physically present in the remote or virtual environment; and

Objective presence, the likelihood of successfully completing a task.

This definition however is completely empirical and isn’t one of the most commonly used theories regarding presence.

Exclusive presence

Another theory is Exclusive presence by Slater. He stresses that the participant’s sense of “being there” in the virtual environment, and point out that a high sense of presence in a VE requires a simultaneous low level of presence in the real world and vice versa. So in this case it is only relevant to talk about the degree of presence in one environment. In figure 3.1 we see the visual presentation of this theory.

Figure 3.1. Exclusive presence
General theory of presence (Mental models)

This is the most general theory regarding presence. When interacting with a VE, we can distinguish two different mental models [14] as can be seen in figure 3.2:

1. The model of the Real World (RW)
2. The model of the Virtual World (VW)

![Diagram of the general theory of presence]

In this theory presence refers to the distinction made by the user between the RW and the VW. Like exclusive presence these two models overlap and being more present in one, means being less present in the latter. The Virtual as well as the Real World can be divided into the ‘Self’, which is the mental model that the person has of him or herself. The ‘Non-self’ is the environment as the individual experiences it. The non-self can even be further divided into a social model and an environment model. We now have a tree-like structure, where each leave represents a specific type of presence. Heeter[15].

- **Personal presence** is related to the ‘Self’. It is the measure of extent to which a person feels like he is really in the virtual environment.
- **Social presence** relates to the social model. Commonly this type of presence is described as the extent to which a medium is perceived as sociable, warm, sensitive, personal or intimate when it is used to interact with other people. Social presence can also be achieved using synthetic being (e.g., A creature that gives tips, talk with you or keeps coming back).
- **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.
Measurement of Presence

Because presence is a rather subjective concept, it is also hard to measure. We can however distinguish two types of measurements.

Subjective measures: Questionnaires

This type of measurement is most commonly used. The participants give subjective ratings through questionnaires. These questionnaires can be one or more questions on all sorts of variable themes. For example:

- The subjects sense of “being there”;
- The extent to which the VE becomes more “real or present” than everyday reality;
- The “locality,” the extent to which the VE is thought of as a “place” that was visited rather than just a set of images.

Objective measures: Behavioral

This type of measurement is done by studying the participants’ behavior as a response to mediated stimuli (e.g. heart rate, skin temperature, or skin conductance). But this type of measurement is rather tricky because of the noise in the signal. An increasing heart rate could also be caused by other factors than the stimuli from the virtual world. The heart rate could have increased because of arousal instead of feeling presence. And also the results are hardly comparable, because of user characteristics. Humans can have different behavioral reactions to the same situation.

Causes of Presence

Much research has been devoted to finding factors that contribute to presence. In the article of Schuemie [13], we see that several researchers have already made some categorizations of these factors. Following we give an enumeration of these factors.

a. Slater and Usoh [16]
   - 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

b. Witmer and Singer [21]
   - 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
Chapter 3. Presence

- **Realism factors**: scene realism, information

c. **Sheridan**
   - Extent of sensory information
   - Control of relation of sensors to environment.
   - Ability to modify physical environment

d. **Steuer**
   - *Vividness* refers to the ability of a technology to produce a sensorially 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* refers to the individual differences in users.

e. **Lombard and Ditton**
   - The form in which the information is presented.
   - The content of the information.
   - User characteristics.

**Conclusion**

There is still a lot of discussion going on regarding presence. It is almost impossible to give one definition or theory of presence. The main reason is that presence still relies on individual experiences. It is a subjective concept. This is secured by the fact that presence is hard to measure. Questionnaires for example are often not a reliable or validated. According to Schuemie [14], one important shortcoming for therapeutic applications is the lack of conclusive research on the relationship between presence and emotional responses such as fear. For this research we rely on the preceded most general theory regarding presence.
4. Anxiety disorders

Anxiety is one of the many human emotions. It is a normal reaction to stress. It helps to deal with a tense situation at work, keep focused on an important speech or workload. In general, it helps one cope. But when anxiety becomes an excessive, irrational dread of everyday situations, it has become a disabling disorder. The following information about anxiety disorders relies on professor Emmelkamp’s book ‘Anxiety Disorders, a Practitioner’s Guide’[10].

According to DSM-II-R (Diagnostic and Statistical Manual of Mental Disorders), Anxiety disorders can be divided into the following categories:

Table 1.1. DSM-III-R categories of anxiety disorders

<table>
<thead>
<tr>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panic disorder with agoraphobia</td>
</tr>
<tr>
<td>Panic disorder without agoraphobia</td>
</tr>
<tr>
<td>Agoraphobia without history of panic disorder</td>
</tr>
<tr>
<td>Social phobia</td>
</tr>
<tr>
<td>Obsessive-compulsive disorder</td>
</tr>
<tr>
<td>Post-traumatic stress disorder</td>
</tr>
<tr>
<td>Generalized anxiety disorder</td>
</tr>
<tr>
<td>Anxiety disorder not otherwise specified</td>
</tr>
</tbody>
</table>

In this document we focus on agoraphobia with panic disorder. The first thing we must understand is that there are two kinds of agoraphobia: agoraphobia with panic disorder and agoraphobia without panic disorder. The term agoraphobia has widely been misunderstood. It literally means fear of “open spaces”, but in reality it means more than just that. Before we go deeper into agoraphobia with panic disorder, we first focus on what panic disorder exactly means.

**Panic disorder**

Someone with a panic disorder has periodic panic attacks. A panic attack is an unexpected period of intense fear or discomfort. A person has to experience at least four attacks in a period of 4 weeks to be diagnosed with panic disorder. During at least one of the attacks four of the following symptoms occur within 10 minutes of the beginning of the first symptom with which the attack commences.

1. Shortness of breath (dyspnea) or smothering sensations
2. Dizziness, unsteady feelings, or faintness
3. Palpitations or accelerated heart rate (tachycardia)
4. Trembling or shaking
5. Sweating
6. Choking
7. Nausea or abdominal distress
8. Depersonalization or derealization
9. Numbness or tingling sensations (paresthesias)
10. (Hot) flushes or chills
11. Chest pain or discomfort
12. Fear of dying
13. Fear of going crazy or of doing something uncontrolled

These panic related symptoms however, can also be caused by other factors. For example restlessness, nervousness and increase heart-beat can also be caused by excessive use of coffee or other caffeine-containing products. This makes it difficult to determine whether certain symptoms are a result of a panic attack or not.

Persons that suffer from panic disorder are actually afraid of getting into the feared situation of loosing control. So in the moment of anticipation they already feel an increased arousal.

We may distinguish four types of loss of control.
1. Fear of somatic loss of control (fearing a heart attack, a stroke or fainting)
2. Fear of Psychic loss of control (fear of going mad or not being able to think properly anymore)
3. Fear of behavioral loss of control (fear of losing control over their own behavior)
4. Fear of social loss of control (fear of losing social respect because of signs of increased arousal such as nervousness, trembling, wanting to leave)

**Agoraphobia with panic disorder**

Agoraphobia with panic disorder is the most common form of agoraphobia. It happens when a person that suffers from panic disorder is afraid of being in places or situations from which escape might be difficult, or embarrassing, or in which help might not be available in the event of a panic attack. For example a person that has had several panic attacks in a crowded subway, can avoid the subway in order to prevent the panic attack. In the worst case a person might stay housebound, because he or she has has several panic attacks in several places (like the elevator, a crowded square or a subway) and avoids all of these places and situations. So in fact panic can be seen as the precursor of agoraphobia. Agoraphobia with panic disorder is a combination of panic attacks and avoidance behavior. The core element of agoraphobia is “the fear of the fear”.

**Agoraphobia without panic disorder**

The difference with “agoraphobia with panic disorder” is the motive of the avoidance. In the first case persons tend to avoid panic attacks and stay out of situations from which it is hard to escape or where there is no help at hand in case of a panic attack. But in the case of “Agoraphobia without panic disorder” there where no preceding panic attacks. These persons have the fear of suddenly emerging symptoms which may cause embarrassment to the person or make him or her in need of help. The most common fear is to lose control over the bladder or bowels, to have to vomit, depersonalization or derealization, and dizziness.
Chapter 4. Anxiety disorders

Gradations of agoraphobia

According to the Diagnostic and Statistical Manual of Mental disorders (DSM-III-R) there are gradations of agoraphobia. Mild agoraphobia means that a person has some avoidance, but can live a relatively normal life. The person is able to leave the house for necessary activities, but does not consider further traveling alone. In the case of Moderate agoraphobia the person is afraid of being more than a few kilometers away from home without company. These persons have a relatively restricted life style. Severe agoraphobia is the highest gradation of agoraphobia. In this case the person is totally housebound and hardly dares to leave his or her home. Agoraphobia appears more with women than with men.

Anxiety provoking situations

One of the most characteristic features of agoraphobia is the avoidance aspect. In the case of Agoraphobia with a history of panic attacks, the number of situations that cause anxiety are as diverse as the number of persons that suffer from agoraphobia, because it’s depends on the persons panic attack history. Agoraphobia is a fear of fear and not so much a fear of certain places. But the central theme is “not being able to leave” or “being stuck”. So for patients to feel present in the virtual world (or place) and really experience anxiety the patients have to get the feeling that they are not able to leave or escape the situation. Of course this is hard to do since the patient can take of the Head Mounted Display at any time. But the fact that the virtual world is imitating a place or situation from which escape is hard or impossible, will cause a sufficient level of fear for the agoraphobic.

Another aspect of Agoraphobia that has to be taken in account is that most agoraphobics are much more fearful when alone and not accompanied by a trusted person. So they often avoid being alone.

A few example situations are as follows:
- Standing in a queue
- Being in a large shop or shopping center
- Traveling by public transport (bus, train or aeroplane)
- Crowds, busy streets, large gatherings
- Driving a car on a motorway (the impossibility of turning on the road)
- Being in a traffic jam
- Crossing a bridge or being on a bridge
- Sitting at the barber’s
- Being in conversation with some person on the street
5. Virtual Reality Exposure Therapy (VRET)

Traditional treatment

Different methods are used in order to treat patients with certain phobias. Cognitive Behavioural therapy is one of the most common methods. It is a combination of Cognitive Therapy and Behaviour therapy. In cognitive-behavioural therapy, therapists recognise the maladaptive cognition and replace them with adaptive cognition [10]. It is based on the scientific fact that our thoughts cause our feelings and behaviours, not external things, like people, situations, and events. The benefit of this is the fact that we can change the way we think to feel / act better even if the situation does not change. Patients utilise imagery of anxiety-provoking situations to identify unrealistic thoughts, challenge these thoughts, and substitute more adaptive ones in their place.

Exposure

An important aspect of this kind of treatment is exposure. When people that suffer from a phobia are gradually exposed to the anxiety provoking situation, it helps them to create more neutral memory structures that ‘overrule’ the old anxiety provoking ones. We make a distinction between exposure in vivo and exposure in vitro. Exposure in vivo means that the phobia treatment is done in real life with real life situations. Exposure in vitro means that the treatment is done with the patient imagining the anxiety provoking situation. This technique leans on the imagination of the patients, which is different for each patient. Research showed that exposure in vivo is more effective in treating phobias, than exposure in vitro. A drawback of exposure in vivo is, that some patients might find these real life situations ‘too’ provoking and refuse treatment.

External and interoceptive exposure

According to Botella [1], panic disorder and agoraphobia sufferers usually avoid two different kinds of stimuli. External and interoceptive stimuli.

External exposure comes from being in the feared situation (e.g., When a person that suffers from claustrophobia is put in a elevator that person gets external stimuli and thus is exposed to a situation that it usually avoids)[4].

Interoceptive exposure consists of exposing the patients to the feared bodily sensations, similar to the ones experienced in panic attacks. (e.g., hyperventilation, blowing through a straw, running, jumping). In order to have more therapeutic benefits, interoceptive and situational exposure should be conducted at the same time. So in terms of VRET, not only should the patient be exposed to the world, but also to as much bodily sensations as possible (e.g., breathing difficulties, increasing heart rate, tunnel vision, blurred vison).
**Treatment with VRET**

Virtual reality (VR) is a technique that is progressing a lot, because the numerous research projects that have been done. It is still in its infancy, but we can already say that future prospects are very positive. VRET actually is the process of desensitization, for people with phobias, using virtual reality technology. It is quite like exposure in vivo, only the real life situation is a virtual computer generated environment. We can even say that it could be placed between exposure in vivo and exposure in vitro. The more realistic the virtual environment is the more it tend to be the same a exposure in vivo. VRET is still in an experimental stage. As the article of Foa and Kozak (1986) states, there are three conditions that should be met for VRET to be effective. First, participants need to feel present in the virtual environment. They need to have the feeling that they are really ‘in’ the virtual environment. Second, the virtual environment should be able to elicit emotions (e.g. anxiety). Third, extinction and co-occurring cognitive changes have to generalize to real situations so that real-life situations will not be avoided any longer or will be endured with less anxiety. Virtual Reality Exposure Therapy could be a interesting alternative for exposure in vivo, because it has many advantages. Botella 2004 [3] gives multiple advantages of VR for psychotherapy in general.

- **Time / Costs:** VR treatment can really help to overcome some of the limitations of one of the main therapeutic components to treat this problem and that is exposure. Exposure in vivo is more expensive and time consuming. Imagine what it would take to treat a person with fear of flying, by actually taking real flights or to take a patient with fear of heights to the top of a building.
- **Control:** Because the environment is virtual the therapist has high accuracy control over the environment. This allows to grade the situation in such a way that the patient can move forward from the easiest performances to the most difficult ones.
- **Repetition:** All situations can be repeated and for as long as needed. There is no need to wait for the events to be produced in the real world.
- **Scenarios:** The number of scenario’s that can be created is unlimited, due to the fact that the situation is virtual.
- **Safety:** Because the environment is virtual and controlled, this gives more safety to the patient and the therapist.
6. VRET system characteristics

Currently there are several research projects on VRET. They all use different techniques for the same purpose, namely the cure of phobic patients. In this paragraph we give an overview of some of the research projects that have been done or that are currently being done on VRET for agoraphobia. For each project we will give an overview of the used hardware components and virtual environments.

Department of Human Computer Interaction at the Delf University of Technology (Netherlands)

The Delft, Technical University and the University of Amsterdam developed VRET system that can be used for treating patients with several phobias, including fear of flying, claustrophobia, agoraphobia and fear of heights.

Hardware components Schuemie [2]

<table>
<thead>
<tr>
<th>INPUT</th>
<th>Tracker system</th>
<th>Ascension Flock of Birds with a transmitter and control unit. Connected to the computer using serial RS-232.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Physical control</td>
<td>Joystick</td>
</tr>
<tr>
<td>OUTPUT</td>
<td>Visual device</td>
<td>HMD Visette Pro (Cybermind) Stereoscopic, 70 degrees FoV, Resolution: 640x480</td>
</tr>
<tr>
<td></td>
<td>Haptic device</td>
<td>None.</td>
</tr>
<tr>
<td>SYSTEM</td>
<td>2 Pc’s with Pentium IV technology (2,66 GHz)</td>
<td></td>
</tr>
</tbody>
</table>

Virtual Environments

This project uses the following environments:
- Mall in Amsterdam (Acrophobia)
- Fire escape (Acrophobia)
- Roof garden (Acrophobia)
- Lift (Claustrophobia)
Chapter 6. VRET system characteristics

- Small path (Claustrophobia)
- Airplane (Fear of Flying) figure 6.1
- Subway cabin (Agoraphobia)
- Square (Agoraphobia [in progress])

Figure 6.1 Screenshot of the fear of flying system at TU Delft

The software that was used to develop the virtual environments is WorldUp R4 by Sense8 and Borland Delphi 5 is used for additional functionality.

*Universidad de Valencia, Universidad Jaume I de Castellón, Previ group (Spain)*

VEPSY is a European-Union funded research project for Telemedicine and Portable Virtual Environments for Clinical Psychology that is done by the Previ Group (psychology and virtual reality). According to Botella [1], who is one of the investigators, their system is able to simulate bodily sensations (interosceptive exposure) that characterize Agoraphobia with panic disorder. Officially the project started on the 1st January 2001, VEPSY-updated will involve partners from an international network of academic institutions and industrial companies. The main objective of the project is to prove the technical and clinical viability of using Virtual Reality Therapy (VRT) in clinical psychology. Amongst other disorders, panic disorder with agoraphobia is one of the disorders that is part of their research [29]. Another interesting thing of this project is that it works with scenarios. The patient is not just standing in or navigating through an environment, but the patient is actually part of a story-like sequence.
Chapter 6. VRET system characteristics

Hardware components

<table>
<thead>
<tr>
<th>INPUT</th>
<th>Tracker system</th>
<th>Intertrax2 tracker with serial port connection, reset button and 3 DoF.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical control</td>
<td></td>
<td>None other than standard mouse and keyboard.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OUTPUT</th>
<th>Visual device</th>
<th>HMD V6 (Virtual Research)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haptic device</td>
<td></td>
<td>None.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>PentiumIII (1000HZ, 256 MB of RAM and CD-ROM drive)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AGP graphics card, 64 MB, with support for OpenGL and with support for a 60 Hz rest frequency at 640x480 resolution.</td>
</tr>
</tbody>
</table>

Virtual Environments

This project uses the following environments for the treatment of Agoraphobia:

- Training room
- Normal room figure 6.2
- The elevator
- The bus
- The subway figure 6.3
- The shopping mall
- The shopping mall, escalator first level
- The tunnel

The software that was used to develop the virtual environments is 3DIVE, and it runs in Microsoft Windows (95, 98, ME, 2000, or NT 4.0, with Service Pack 6) [29].

Figure 6.2 The room
ATN-P lab, Istituto Auxologico Italiano, Verbania (Italy)

The preceding treatment protocol for Panic Disorder and Agoraphobia was developed at the Applied Technology for Neuro-Psychology Lab of Istituto Auxologico Italiano, Verbania, Italy, in cooperation with the Psychology Department of the Catholic University of Milan, Italy. The actual version included the efforts of researchers from the Center for Advanced Multimedia Psychotherapy, California School of Professional Psychology, San Diego (CA), USA, and from the Seoul Paik Hospital, Inje University, Seoul, Korea. The research was done with real patients who were guided through the virtual environment by the therapists. The study showed extremely positive results. This was primarily because of the intrinsic effects of the VR tool. The feeling of actual presence offered by the realistic environments and by the involvement of all the sensorimotor channels enables the subject undergoing treatment to live the virtual experience in a more vivid and realistic manner than he could through his own imagination[27].

Hardware components

<table>
<thead>
<tr>
<th>INPUT</th>
<th>Tracker system</th>
<th>InterSense intertrax 30 tracker. Able to sense elevation, azimuth and roll with a sensitivity of 360 degrees/second. The response latency is 38 ms+/-2ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical control</td>
<td>Infrared two button joystick. Going forward and backward by pressing the upper or lower button. The direction of the movement is given by the orientation of the operator’s head.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data glove. Offering many degrees of freedom.</td>
<td></td>
</tr>
</tbody>
</table>
Visual device
HMD (sony glasstron PLM-A55), with two active matrix 7” color LCD’s. Display: 800 lines of 255 pixels to each eye.

Haptic device
None.

SYSTEM
Pentium III based immersive VR system (600mhz, 64MB RAM, graphic engine: matrox G400 Dual Head, 32MB WRAM) including two-button joystick-type motion input device.

Virtual Environments

This project uses the following virtual environments for the treatment of Agoraphobia:
- Elevator
- Supermarket
- Subway
- Large Square

The environments were developed using Superscape VRT 5.6 toolkit. The therapist is able to define the duration of the virtual experience and the number of virtual people (none to crowded).

Biomedical Engineering Department, Hanyang University (Korea)

At the Hanyang University, Korea many research is done on the field of social phobia. Besides, developing environments for social phobia like fear of public speaking, Hanyang University, Korea also developed the environment for agoraphobic patients. The exposure therapy experiments were done with 45 agoraphobics. To decrease the threshold the procedure of the experiment contained a relaxation phase, before subjects were immersed into the virtual environment. The subjects filled in a questionnaires survey after the experiment. The outcome of the survey, showed the environment(s) that were most frightening to the participants. As a result the most frightening environments were the tunnel with traffic jam, the elevator and the airplane. However this result is not significant, because each participant may have it’s own most frightening environment.
## Hardware components

<table>
<thead>
<tr>
<th>INPUT</th>
<th>Tracker system</th>
<th>FASTRAK tracker</th>
<th>Electromagnetic tracker from Polhemus Inc. Data update rate is 120 Hz. Dynamic and real time 6 DoF. Position is measured in X, Y, Z Cartesian coordinates and orientation is measured in pitch, yaw, and roll. The tracker is connected to the pc using RS-232 and USB. The tracker uses low frequency magnetic transducing technology so that the line of sight between receiver and transmitter does not have to be clear in order to transmit data well.</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUT</td>
<td>Physical control</td>
<td>Force Feedback steering wheel. Drive Simulator (TM Nascar Force Pro, Thrustmaster, Inc)</td>
<td></td>
</tr>
<tr>
<td>Haptic device</td>
<td>Force Feedback steering wheel. Drive Simulator (TM Nascar Force Pro, Thrustmaster, Inc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYSTEM</td>
<td>PC with Pentium processor</td>
<td>BooDoo (3D accelerator) for real time imagery</td>
<td></td>
</tr>
</tbody>
</table>

## Virtual Environments

This project uses the following environments for the treatment of Agoraphobia:
- Balconies
- Empty room
- Dark barn (with or without a black cat)
- Elevator
- Subway
- Tunnel with traffic jam
- Airplane
- Public speaking
- Theater

The software that was used to create these worlds is undisclosed, because of insufficient information.
Virtual Reality Medical Center (VRMC) San Diego, Los Angeles, Palo Alto (USA)

Virtual Reality Medical Center is a medical center that uses virtual reality to treat patients with certain phobias. Agoraphobia is one of the phobias that can be treated at this center. Their research is supported by the National Institute of Mental Health (NIMH) and by industry[26]. In figure 6.4 we see an example of a treatment at VRMC.

![Figure 6.4 HMD at VRMC](image)

According to their website, controlled clinical studies of virtual reality treatment as well as clinical services performed over the past seven years at the VRMC for specific phobias, panic disorder and agoraphobia reveal a success rate of approximately 92%.

Virtual Environments

This project uses the following environments for the treatment of Agoraphobia:
- Supermarket figure 6.5
- Subway figure 6.6

![Figure 6.5 Screenshot of The supermarket](image)
The hardware and software components that were used in this project are undisclosed, because of insufficient information.

**Clark Atlanta University (USA)**

This study investigated the effectiveness of a virtual environment desensitization (VED) in the treatment of agoraphobia. 60 subjects attended this experiment. Thirty subjects were placed in the experimental group and thirty subjects were placed in the control group. In order to make measurements two types of validation were used: Attitude Towards Agoraphobia Questionnaire and the Subjective Unit of Discomfort Scale (SUDS). The subjects in the experimental group, that were exposed to the Virtual Environment Desensitization, showed a decrease in the average SUDS during each session. The other thirty subjects that were in the control group, or no-treatment group, did not change significantly. [28]

**Hardware components**

<table>
<thead>
<tr>
<th>INPUT</th>
<th>Tracker system</th>
<th>Electromagnetic head tracker (Flock of birds and Ascension technology Corp.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical control</td>
<td>Data glove (Power Glove)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OUTPUT</th>
<th>Visual device</th>
<th>HMD (Stereoscopic HMD, Cyber eye, GRC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haptic device</td>
<td>None.</td>
<td></td>
</tr>
</tbody>
</table>

| SYSTEM                    | PC with Pentium processor Workstation (Silicon Graphics)                        |                                                                                |
Virtual Environments

This project uses the following environments for the treatment of Agoraphobia:
- Balconies
- Canyon with series of bridge scene
- Empty room
- Dark barn (with or without a black cat)
- Elevator
- Covered bridge

The software that was used to create these worlds is undisclosed, because of insufficient information.

Conclusion

The previous projects show a lot of similarities. They all use an HMD instead of a CAVE as visual device. This is very logical, as we stated earlier an HMD is cheaper than a CAVE construction, though the performance is the same. The worlds that were build in the projects are also quite identical. The elevator and the subway seemed very popular. In comparison to our project at the Technical University of Delft, we can also conclude that our used technologies are up to date. All projects use a PC based on Pentium technology, preferably a Pentium III or higher. As far as the HMD goes, we have an average but sufficient resolution of 640x480, that is compensated by a high FoV of 70 degrees. Humans have a total field of view between 160 to 208 degrees, about 140 degrees or so for each eye and by regular field of 120 -- 180 degrees [36]. According to Atkins a normal (acceptable) field of view is 40 degrees.
7. Requirements for VRET of Agoraphobia

VRET has been proven an effective treatment for patients who suffer from phobias. However each phobia has its own characteristics. Previously we saw an overview of VRET projects for the treatment of Agoraphobia with Panic disorder. From this previous work, we can conduct characteristics and requirements for VRET of Agoraphobia and worlds that should be build for the treatment. In addition to analyzing previous projects, an interview with professor Emmelkamp, from the University of Amsterdam was conducted in order to find even more specific requirements for VRET of Agoraphobia. The following is a result of this interview.

*Characteristics of VRET of Agoraphobia*

According to Emmelkamp[10] the procedure for exposure treatment of agoraphobia is:

- Explaining the rationale to the patient
- Constructing a fear hierarchy
- Carrying out and discussing exposure tasks

In the first step the therapist will explain the working of exposure in vivo in order for the patient to understand the principles of treatment. The second step is to construct a fear hierarchy. This forms the starting point of the treatment and means that the therapist constructs a hierarchy of situations in which the patient is afraid and of situations avoided by the patient. For Agoraphobia we came to the conclusion that the therapist should be able to have sufficient possibilities to change, manipulate and vary the virtual environment in order to create a fear hierarchy of different personalized worlds for the patient. When this is done properly the third step can be done and that is to actually expose the patient gradually to the different virtual environments.

Another issue was that an important anxiety provoking part for people who suffer from Agoraphobia is the fact that they are in a situation from which escape is hard or even impossible. From a practical point of view one would consider that with VRET the patient will know that he or she can take off the HMD at any point and thus escape the situation. This would have a negative effect on the patients level of fear. However, it seems that patients who suffer from agoraphobia will not see this as an option, because they are too focused on the virtual anxiety provoking world.

Sensorial modalities also cause more realism. It would be optimal if patients could touch objects in the virtual world (using haptic devices), or even smell objects. Imagine the smell of baked bread when passing by a bakery in the virtual world. This would also contribute to the realism of the virtual world and thus the feel of presence.
The functionality of the user interface towards the therapist

Another part of the interview was about the functionality of the user interface towards the therapist. In this case it is about a specific virtual environment, namely a large square with or without people. But many of the aspects do also account for other virtual environments.

- The therapist must be able to navigate the patient through the virtual world
- The therapist must be able to make the patient believe that the patient’s heart-rate is higher or lower than it actually is. This way the therapist can manipulate the patient's feeling of fear for the virtual world. Because when a patient becomes frightened his or her heart-rate will go up resulting in a catastrophic interpretation that even causes more anxiety and a higher heart-rate. When the therapist however makes the patient believe that his or her heart-rate is not increasing at all, the patient will calm down. This method could also be applied for other Agoraphobia specific bodily sensations like hyperventilation, shortness of breath etc.
- The therapist should also be able to make the ambience noise more intense or less intense. (E.g. the sound of talking people and cars). Especially the sound of the siren of an ambulance caused a higher level of anxiety with agoraphobics.
- The therapist should also be able to change the weather in the Virtual Environment (Rain, Thunder, Sunshine, Fog etc.)
- The therapist should also be able to choose between different types of squares. The patient may by no means get used to a certain environment, because this will decrease the level of anxiety.
- The therapist should be able to change the size of the square.
- The therapist should be able to influence the patients sight, applying ‘blurred vision’ and/or ‘tunnel vision’. These are agoraphobia specific bodily sensations, and will increase the anxiety level of the patient.
- The therapist should be able to change the number of people on the square. For example the therapist could have a choice between ‘empty’, ‘calm’ and ‘crowded’. The transitions between the different types of occupations should be animated. So when changing from ‘empty’ to ‘crowded’, people will gradually crowd the square. The most optimal situation is when people who are on the square, move, react and act in a realistic manner.
8. Conclusions

The above research has provided more insight into the parameters that are necessary for creating a valid and anxiety-provoking virtual world for the treatment of agoraphobia. In order to find the parameters to create an anxiety provoking virtual world for the treatment of agoraphobia we distinguish to types of parameters:

A. Presence parameters: Parameters that contribute to the feel of presence. These parameters account for any virtual environment and any phobia.

B. Anxiety provoking parameters: Parameters that contribute to the level of fear that the patient experiences. These parameters are phobia specific.

These two types are closely related. For example when the feel of presence is high, but the situation (in the virtual environment) is not provoking any anxiety, the effectiveness is low. (E.g. Someone with fear of heights that is put in a realistic virtual environment for claustrophobics where he or she feels really present.) Also when the virtual environment is a provoking situation, but the patient does not feel present, the effectiveness is also low.

A. Presence parameters

These are common parameters that increase the feel of presence. As we saw earlier, there are different categorizations of the parameters (factors) that cause presence. Below we give an overview of parameters that contribute to the feel of presence.

- **Level of realism**
  Of course the more realistic the virtual world is, the more the feel of presence will increase. However, patients who suffer from phobia, do not need hundred percent of realism in order to provoke anxiety. When we look at former VRET projects, a resolution of 640x480 has seemed to give a sufficient level of realism. And the field of view should have a minimum of 40 degrees. Also a stereographic HMD is preferred, because of the level of realism.

- **Virtual body**
  A representation of a user’s body in the virtual environment, contributes to the feel of personal presence.

- **Number of sensorial modalities**
  Sensorial modalities are visual, auditory, tactile (feel, touch) and olfactory (sense of smell). The more sensorial modalities the system covers, the more the user feels present in the virtual environment. Auditory sensations are very important and easily applied. A stereo headphone (build into the HMD) that simulates the sounds of the virtual environment is sufficient.

- **The level of interaction with and existing of other creatures in the virtual environment.**
  The more the patient is able to interact with other (virtual) people in the virtual environment, the more he/she will feel present in the environment. Avatars with
expressions and inferred-gaze could have a positive impact on perceptions of communication and thus on the feel of being present [25].

- **Level of interaction with the environment**
  This accounts for the degree to which users of the medium can influence the form or content of the mediated environment. We can divide this parameter into three sub-parameters.
  1. **Speed** – The speed with which the medium responds to user inputs.
  2. **Range** – Amongst others the number of inputs from the user that the medium accepts and to which it responds.
  3. **Mapping** – The degree of correspondence between the type of user input and the type of medium response.

**Level of distraction**
How much is the user distracted in the virtual environment.

**User characteristics**
Another parameters that we could take into account is the user characteristic. Since presence still remains a subjective concept, the feel of presence is dependant on the characteristics of the user.

**B. Anxiety provoking parameters**

These parameters contribute to the level of fear experienced by the patient. According to Botella [1], panic disorder and agoraphobia sufferers usually avoid two different kinds of stimuli. External and interoceptive stimuli. So parameters that contribute to the level of fear can also be subdivided into two types. Simultaneously conducting these parameters will show best results.

**Parameters that contribute to External stimuli**

- **Level of possible escape**
  This parameter accounts for the situation that is simulated by the virtual world. Agoraphobics fear situations from which escape is hard or impossible. So this parameter should be kept as low as possible. Below follows a list of situations where the level of possible escape is very low as we saw earlier on.

  - Standing in a queue
  - Being in a large shop or shopping center
  - Traveling by public transport
  - Crowds, busy streets, large gatherings
  - Driving a car on a motorway (the impossibility of turning on the road)
  - Being in a traffic jam
  - Crossing a bridge or being on a bridge
  - Sitting at the barbershop
  - Being in conversation with some person on the street
- Level of habituation

As we saw in the previous chapter, by no means may the patient get habituated to the environment, because this causes a decrease in the patients level of fear. The level of habituation must be kept as low as possible. This can be achieved with a virtual environment has as much variation as possible.

Parameters that contribute to Interoceptive stimuli (Bodily sensations)

- Number of (agoraphobia specific) bodily sensations

This is the number of agoraphobia specific bodily sensations that can be simulated with the system. Agoraphobia specific bodily sensations that can be simulated are [10]:

- Increasing/decreasing heart-rate
- Blurred vision
- Tunnel vision
- (Hot) flushes or chills
- Sweating
- Choking
- Trembling or shaking
- Shortness of breath (dyspnea) or smothering sensations

The above shows which parameters are necessary to create an anxiety provoking virtual world for the treatment of agoraphobia. We distinguished two types of parameters: the general presence parameters and the anxiety provoking parameters. As far as technical specifications for the system we found that a stereographic HMD with a resolution of 640 by 480 and a FoV of at least 40 degrees is sufficient. As far as the worlds that should be build we can say that the worlds must simulate a situation from which escape is hard or impossible. Preferably the world should be one of the situations previously listed. It is also of much importance that the patient stays in a new situation and does not get used to the virtual world. So the virtual world must be as variable and changing as possible. The patients body should also be represented in the virtual world. In the future we might be looking at applying more sensorial modalities like tactile and olfactory modalities and more agoraphobia specific bodily sensations.
9. References


17. Website: http://www.ncsa.uiuc.edu/VR/VR/cave_software.html
18. Website: http://www.hitl.washington.edu/scivw/EVE/IC.ForceTactile.html


26. Website: http://www.vrphobia.com/


29. Website: http://www.previsl.com

30. Website: http://www.rustybrick.com/definitions.php


32. Website: http://www.uhnres.utoronto.ca/ehealth/html/glossary/eh_glossary.shtml

33. Website: http://www.uhnres.utoronto.ca/ehealth/html/glossary/eh_glossary.shtml


35. Website: http://www.photo.net/learn/fov/
36. Website: http://www.artinarch.com/vp05.html
Chapter 10. Abbreviations

10. Abbreviations

CAVE - Computer Automatic Virtual Environment
DoF – Degrees of Freedom
FoV – Field of View
GUI – Graphical User Interface
HMD – Head Mounted Display
PDA – Panic Disorder and Agoraphobia
RW – Real World
SUDS - Subjective Unit of Discomfort Scale
VE – Virtual Environment
VED - Virtual Environment Desensitization
VR – Virtual Reality
VRET – Virtual Reality Exposure Therapy
VW – Virtual World