Research and prototyping of a Multiple Patient Virtual Reality Exposure Therapy system

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Abstract:
For more than ten years numerous studies have been conducted on virtual reality exposure therapy, because of the successes obtained in the treatment of differs types of anxiety disorders; thereby overcoming problems associated with traditional treatments such as limited control therapists might have over the exposure, logistics, costs, and the willingness of the patient undergoing exposure treatment. During this type of treatment, a patient is exposed to stimuli in virtual reality. A therapist monitors and provides treatment to the patient while allowing the anxiety to diminish. VR treatment may provide substantial improvement in efficient use of therapist resources and accessibility by delivering the treatment over the internet, to multiple patients simultaneously. This motivated initial exploration into the possibilities of a multiple patients Virtual Reality Exposure Treatment (VRET) system. With such a setup, one therapist can monitor and treat multiple patients simultaneously, each having their own personal VR treatment at their own personal location. The approach taken was (1) a scenario-based investigation with six therapists that had extensive experience in treating patients with VRET, and (2) a controlled lab experiment with 27 (students) participants to examine the effect of an automated assistance function on the therapists' workload and performance when treating three computer-simulated patients over the internet.

In the scenario-based investigation, three short films were created that presented the envisioned system being used by a therapist illustrating specific design claims, such as the possibility of treating a patient remotely, treating multiple patients simultaneously, and the possibility of using an automated assistant function that could take over part of the VR session. At the start of the in-depth interviews, the films were shown to a therapist, after which underlying claims were discussed. The interviews revealed that almost all the therapists were in favour of the remote communication setup as proposed using a video and intercom channel to monitor the patient as well as using physiological measurement such as heart rate and galvanic skin response. In addition, to reduce the therapists' workload it was suggested to use pre-programmed exposure scenarios with various anxiety evoking levels. In addition, to assist the therapist in monitoring and treating multiple patients, an auto-assist function was proposed. This function could be set up by the therapists themselves for each individual patient by using simple if- and then- statements. When a session is running, the system would give a warning to the therapist if one of the if-conditions had occurred. The option would then be presented to the therapist to let the auto-assist handle the situation or to take over manually. If the therapist would not react after a set amount of time, the auto-assist would take over, applying the then-rule, for example to switch to a les anxiety provoking VR scenario if the measured anxiety level was above a pre-set value. In addition, the therapist should always have the option to press a 'call for remote assistance'–button, thereby signalling an assistant in the immediate vicinity of the patient, who will then physically go up to the patient and provide local assistance.

Based on these preliminary specifications, a prototype was constructed that was used in a controlled lab experiment to explore the effects of the proposed auto-assist function on therapists' workload and their performance, and to explore the use of the 'call for remote assistance' function. In the experiment participants had to treat three computer-simulated remote patients, which they could see and hear. Varying the amount of attention needed by patients allowed for controlling the therapist workload. The experiment was set-up with a within-subject design exposing participants to four workload conditions (low, medium, high, and impossible to handle manually) when using the system with or without the auto-assist functionality. The result of the experiment showed a significant workload reduction caused by the auto-assist function. Furthermore in the high workload condition the auto-assist function also led to a significant error reduction in the execution of the treatment protocol. As the literature suggests that high workload could lead to a so called cognitive lock up situation, an important finding was that the participants did call for remote assistance when needed, and did not forget about it or were not reluctant to hand over the responsibility to another (in this case a simulated) person.

The findings of both the interviews and lab experiment are encouraging. They imply that a tele-delivered multi patient VRET system might be possible in the future, thereby providing treatment at remote locations and making efficient use of therapist resources.

Keywords:
Virtual reality exposure therapy, tele-treatment, cyberpsychology, cognitive ergonomics.

Contents

1 Introduction

Delft University of Technology is conducting research and develops technology to cure patients with phobias by using virtual reality exposure therapy. During this type of treatment, the patient is exposed to stimuli in virtual reality. A therapist monitors and provides treatment to the patient while allowing the anxiety to diminish. Various virtual worlds can be created to cure people with various phobias, for example the interior of an airplane for people with fear of flying and a fire escape staircase to help people with fear of heights.

With current configurations of virtual reality exposure therapy, it is possible for the therapist to treat one patient at the time. This thesis explores a system that allows one therapist to treat two or more patients simultaneously. There are numerous reasons why research on a multiple patient system could be useful. Therapies are expensive and it seems to be possible that one therapist is treating multiple patients in parallel. This way the cost of the treatment can be reduced. It may as well be possible that fewer therapists can assist more patients and thus increasing the efficiency and accessibility of the treatments. In addition, tele-delivered multiple patient VRET could have the benefit of being more accessible to the patients, because it could provide broader options to where en when to the patients could have their therapy.

To provide multiple patient therapy, alterations and extensions have to be made to a current VRET system. Communication between the therapist and patient in a multiple patient setup might need to be changed. The workload of the therapist could change and additions of the software may be needed to warn the therapist if another patient might ask for immediate attention. It could be necessary to develop a more complex system where the computer provides an option to take over certain tasks from the therapist. All these elements should be considered while designing such an extended system.

To be able to produce the specifications of a multiple patient VRET system, theory on how people can monitor parallel tasks were examined. Human factors like workload and situation awareness had to be taken into consideration. Different types of technology that might be necessary, like remote communication, VR-scenarios and adaptive automation were explored. When an initial vision was created, experienced therapists were asked to give their feedback. Subsequently a prototype was constructed to explore how participants reacted to the proposed multiple patient VRET system.

1.1 Background

Phobias are described as a persistent fear of specific objects or situations. Phobias are the most common form of psychiatric disorders. Bouman et al [1] describes how these phobias can be treated by exposing patients to anxiety-producing stimuli while allowing the anxiety to attenuate. In conventional treatment, these stimuli are generated by presenting the patient actual physical situations, so called in vivo therapy. There is a second option, in vitro, where the patient imagines these stimuli. Nowadays, virtual reality offers a third option.

Virtual reality (VR) is a technique where a computer creates a view from a three dimensional *virtual environment* (VE) and displays this on screens or inside a VR-helmet or Head-Mounted Display (HMD). VR gives the user the feeling of actually being inside this virtual environment, this is specified as *presence*. This presence can be used to induce anxiety on phobia patients much the same as in vivo therapy. This *Virtual Reality Exposure Therapy* (VRET) has already been shown to be effective with a great number of case studies and several controlled studies [2,3,4] with various phobias like acrophobia, claustrophobia and agoraphobia. The advantage of VRET over in vivo therapy is that there is full control over the environment the patient is experiencing. In addition, the therapy can be performed anywhere, because there is no need for physical locations. Another advantage, pointed out by Garcia-Palacios et al [5], is that patients were more willing to expose themselves to VR then in vivo.

Delft University of Technology has been working with VRET since 1996 and has conducted research in collaboration with Amsterdam University (UVA), Stichting Valk and PsyQ. With current VRET systems, it is possible for one therapist to treat one patient in the same room. Further research is being conducted on the development of VRET, to keep improving and extending its capabilities. This thesis will focus on the research questions, if it will be possible to provide treatment to multiple patients simultaneously with a future VRET system.

1.2 Research questions

The main research question of this thesis is: *Is it possible and what specifications are required, to extent VRET, so that one therapist can monitor and assist multiple patients in parallel?* These patients all run their own personal virtual reality exposure treatments at differs locations. Assisting multiple patients simultaneously may provide substantial improvement in efficient use of therapist resources and accessibility by delivering the treatment over the internet, to multiple patients simultaneously.

When exploring this question, several sub questions appear. To provide treatment, communication between the therapist and the patient is required. The first sub question is how this communication should be handled, in a multiple patient VRET environment. Exploration is needed on the methods that are available and which therapists would prefer and feel comfortable with.

A second sub question that appears is what kind of setup and hardware is best to provide multiple patient VRET. In addition, there is the question of if it is possible to explore the impact on the workload of the therapist. Moreover, can computer assistance help the therapist in dealing with multiple patients? When dealing with multiple patients, a situation can occur where two or more patients need immediate attention simultaneously. What are proper methods to deal with these types of situations?

1.3 Research approach

The exploration of a multiple patient VRET system was unique in the sense that it proved itself to be a fairly new concept. Numerous ways to approach this exploration seemed possible. A key element of multiple patient VRET is that it supports both human-human and human-computer interaction. In addition, there might be a need for computer-controlled assistance. This defines multiple patient VRET as a *complex task environment*.

Situated cognitive engineering [6,7] as described by Neerincx and Lindenberg can provide an extensive approach to analyse complex task environments. Situated cognitive engineering is used to analyse human-computer interaction and improve computer-supported task performance. It follows an iterative development process in which a design, gains more-and-more detail in its specifications. In this process, the specifications are being assessed repeatedly to be refined, adjusted or extended. Situated cognitive engineering consists of four phases: (1) Derive, (2) specify, (3) testing and (4) refining (Figure 1.1). The goal of the derive phase (Chapter 2), was to gain a better understanding of theories and technologies that could play an important role in the design of a multiple patient VRET system. In this phase, the operational demand, human factor knowledge and envisioned technology for such a system were explored. This knowledge was subsequently used to create a *preliminary vision* of a multiple patient VRET system.

To verify and extent this preliminary vision, *scenarios and claims* as described by Carrol [35] were used. In this specify phase (Chapter 3), scenarios or stories were created which make claims on the use of the system. These scenarios and claims were subsequently reviewed and discussed with therapist who are experts in VRET. To make the scenarios more approachable movies were produced. In this movies actors play out how the therapist and the patients would use the proposed system. These interviews resulted in more refined *preliminary specifications*.

To further refine and test these preliminary specifications a *prototype* was constructed (Chapter 4) and an *experiment* was conducted (Chapter 5). With this experiment, it was possible to explore the impact of the proposed automated-assist system and "call for remote assistance"-function on the workload of the participants. The results showed that the proposed automated assistance had a significant effect on the metal effort of the participants and that all participants did use the "Call for local assistance"-option.
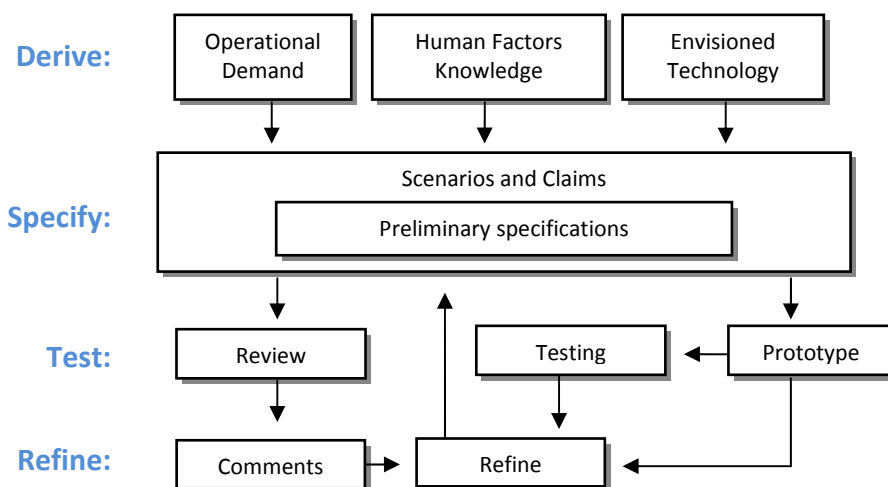

Figure 1.1: *Overview of situated cognitive engineering for a multiply patient VRET system, extended from Neerincx and Lindenberg [7].*

2 Derive: Background theory

The goal of the derive phase in situated cognitive engineering is to gain more knowledge about the theories and technologies that can play an important role of certain complex task environment. Multiple patient VRET can be seen as an extension of current VRET systems, therefore this chapter starts with a look at the current available single patient VRET. This includes a description of therapist-patient communication and a tasks analysis of the therapist and the patient. Subsequently there is a description of user-interface presented to the therapist to assist the patient.

Following situated cognitive engineering, section 2.2 explores the expected operational demand of a multiple patient VRET setup. Followed by information on human factor knowledge and envisioned technology needed for a multiple patient VRET system. All gathered knowledge is then used to generate an initial vision of the multiple patient VRET system, which is an initial description of the system that can further be explored to create preliminary specifications.

2.1 The current VRET system

Delft University of Technology has been working on virtual reality exposure therapy (VRET) since 1996. The current system is based on a description by Schuemie [8], which is being used in the field since 2003 and could be considered as a starting point for this research on a multiple patients VRET system. Before the exploration of a multiple patient VRET setup can start, there is a need to understand the current VRET setup.

2.2.1 Therapist and patient setup

In the single patient VRET, communication between the therapist and the patient is very direct. The therapist is in the same room as the patient (Figure 2.1). He or she can talk directly to the patient, gets direct vocal feedback and can watch the posture and movement of the patient to monitor their state of mind. The therapist can control the *virtual environment* (VE) of the patient by using either keyboard or joystick and can see the patient's view of the VE on his or her screen. The computer system can also generate sound, which both therapist and patient can hear. The patients can see their VE in the HMD and can change their viewpoint in the VE by moving their heads. A tracker will monitor these movements and adjust the virtual view of the patient (Figure 2.2).

Figure 2.1: *The current VRET situation, where the therapist and the patient are in the same room.*

Interaction can be split into two separate elements. First, there is therapist control; this is the interaction between the therapist and the virtual environment of the patient. The therapist can alter the state of a therapy session and manipulate the VE of the patients. The second element is direct communication, which can act bidirectional. In the current case, this exists of vocal communication and visual feedback. Changes in the posture of the patient are directly observed by the therapist and can be used to determine the patient's experience.
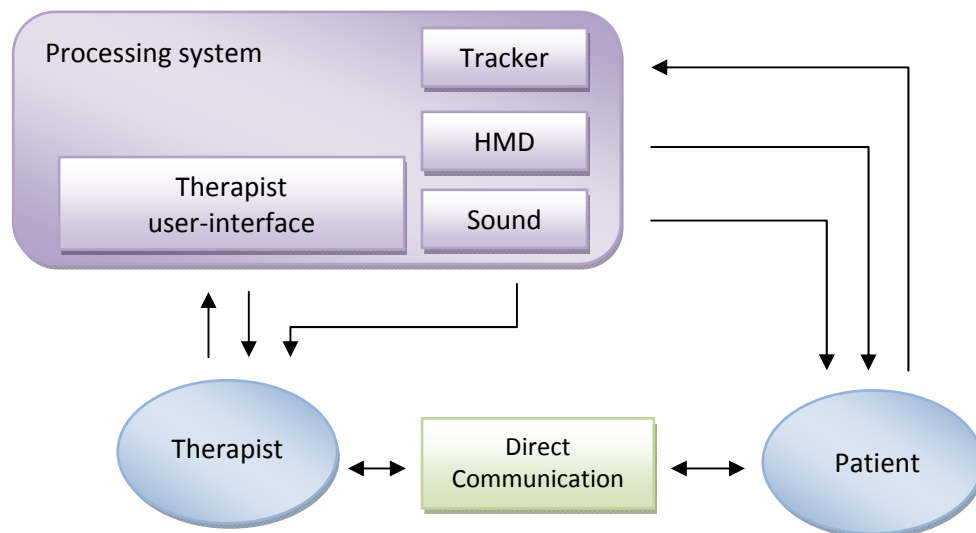
Figure 2.2: Overview of the communication methods available for the users in the VRET situation extended from Schuemie [8].

2.2.2 Task analysis

The task analysis constructed by Schuemie [8] recognises the main goal of the therapist as to cure the patients by helping them cope with their phobias. Three subtasks were derived from this main goal (Figure 2.3). The way to deal with this task can differ per type of treatment, but all posses the same set of tasks. First, there is the subtask of determining the fear or anxiety of the patient. This can be achieved by asking the patient questions. One method is to ask the patients for a so-called *Subjective Unit of Discomfort* score (SUD score) [9]. This score can be used by a patient to communicate his or her personal level of discomfort on a scale between zero and ten. The second subtask is to change the virtual exposure of the patient. This can be achieved by instructing the patient or by letting the computer trigger effects within the patient's virtual environment and guiding the patient through their world. The last subtask is to solve ambiguity, make notes and collecting data.
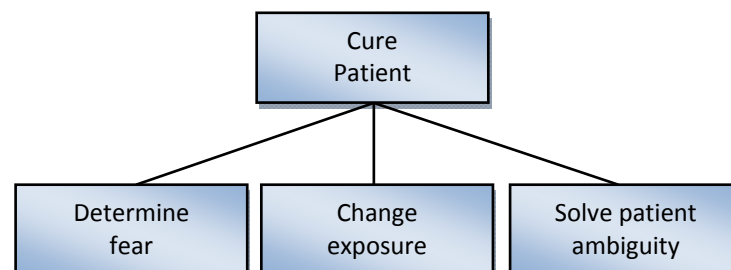
Figure 2.3: Therapist's goals, adapted from Schuemie [6].

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The main goal of the patients is recognised by Schuemie as to get rid of fear (Figure 2.4). To accomplish this they follow the instructions of the therapist. However, patients tend to have the tendency to avoid fearful situations, as described by Krijn et al [10]. To avoid fearful situations the patients can change their posture, for example clutching to a railing or the patients can change their VE by looking in another direction. Furthermore, the patient has the option to ask clarification on the therapy during a session. In the current VRET setup, the patient always has the possibility to talk to the therapist and to receive any additional verbal support.

Figure 2.4: Patient's goals, adapted from Schuemie [8].

2.2.3 Therapist User-interface

Multiple studies [9,11,12,13,14] have focused on the therapist's VRET user-interface. This user-interface keeps evolving as research is being continued. The therapist's interface redesign described by Gunawan [13] in 2004, consists of many separate elements (Figure 2.5). Main elements are session information, system status, patient's navigation control and the patient view, where the therapist can see what the patient's point of view of their virtual environment. There is also an element where the therapist can make notes and an element where the stress levels (SUD score) of the patients can be recorded.
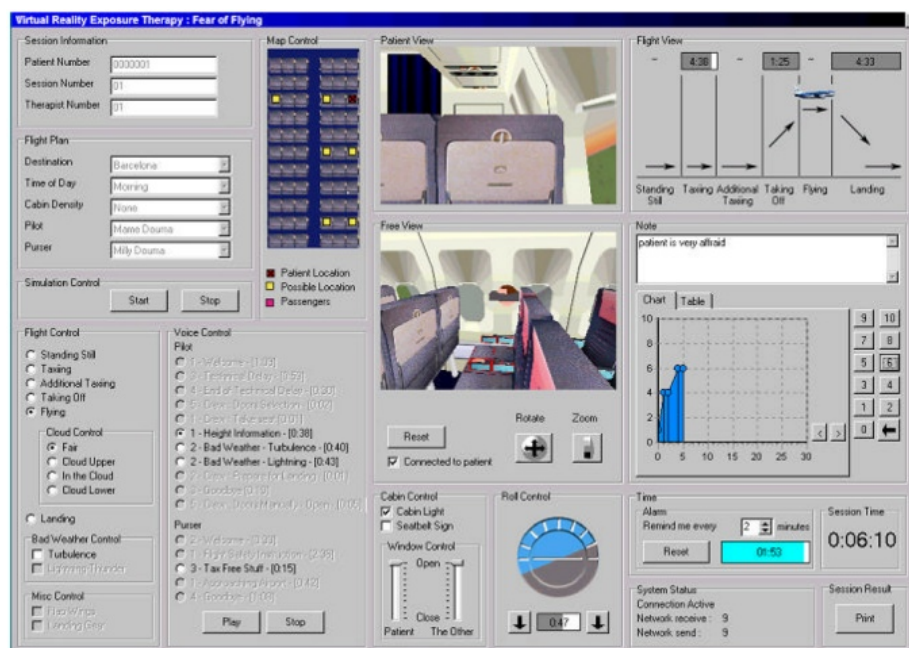
Figure 2.5: The therapist's user interface to monitor and control the airplane world for treating fear of flying as described by Gunawan [8].

For different types of therapy additional elements can be added. For example a map of the airplane-layout for fear of flight phobia treatment. In addition there are tools for the therapist to modify the VE and adapt the experience of the patient. In the fear of flying therapy these are flight control, voice control, roll control and cabin control.

2.2 Operational demands

To analyze multiple patient VRET there was need to explore operational demand within such a system. What makes a multiple patient setup more complex was the fact that most tasks had to be performed for every individual patient. This not only increased the amount of tasks and actions, it could also introduce completely new tasks and actions. Guiding two or more patients at once could mean that communication methods with the patients had to change; this could also introduce new tasks.

Because the new system was designed to assist patients and support human-human interaction, it was hard to predict how patients are going to behave during VRET sessions. The therapist cannot always predict how much attention the patients would require. This could lead to a *high variability in work demand*. By adding more patients this variability could grow even more. There could be situations where patients do not require attention at all. However, situations could occur where all patients desire assistance at the same time.

If a therapist would be working with multiple patients in parallel sessions, it is essential that the therapist is treating the right patient and does not mix-up the patients. The system should be designed to eliminate these so called *mode errors* [15], where a user thinks he or she is working in one mode but actually working on another. In a multiple patient VRET setup, this could mean that a therapist thinks he or she is talking to patient A but is actually talking to patient B. A method to eliminate mode errors is described by Sellen and Buxton [16] where in a videoconferencing setup each participant is represented by a separate camera/monitor. Therefore, the user of the system does not have one monitor showing four people but he or she has four separate monitors each depiction a single person. The advantage of such a system is that it is always clear with which person the user is communicating.

2.3 Human factors knowledge

Workload is a comprehensive concept with many aspects. Definitions of workload including the demand placed upon humans [17] or the portion of the operator's limited capacity required to perform a particular task [18]. The *task load* is an external workload, which is defined by the task environment. It is the number of problems that have to be processed in a given amount of time. *Mental workload* can be described as the demand placed on user's working memory during a certain task [19].

2.3.1 The current task load model

To achieve a better understanding of the increase of a therapist's workload, the *Current Task Load model* (CTL) as described by Neerincx [20] can be used. This model distinguishes three main load factors that have a large effect on the workload (Figure 2.6). The first is the *percentage time occupied* (TO), which gives the actual time a user is working on tasks in percentages of the total time. A commonly made assumption is that people should not be occupied more than 70 to 80 percent of the total time available [21]. The second load factor is the *level of information processing* (LIP). This factor is determined by how fast the user can make decisions. This is done by using the skillrule-knowledge framework of Rasmussen [22] where the knowledge-based component involves a high load on the limited capacity of working memory. The last factor is the amount of *task-set switching* (TSS) which is being done. Many switches between different tasks will make the process much more demanding for the user.
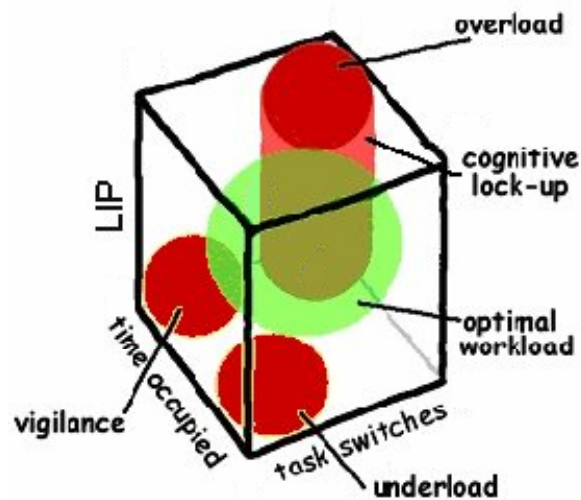
Figure 2.6: *The three dimensions of the task load model. Neerincx distinguished several critical regions [20].*

By plotting the factors above in three-dimensional space, the model distinguishes five cognitive states. Figure 3.1 shows a number of expected cognitive states. The five cognitive states are:

1. *Under-load*: When all three factors are low, the user can handle the tasks easily. There is the possibility that the user could lose attention and get bored.

2. *Optimal workload*: The factors are balanced and the user will be able to handle the situation.

3. *Vigilance*: If tasks take too much time it could happen that the user can handle the situation, but on every task, they can get a little behind, losing control in the end. Vigilance can result to stress due to the specific task demands (i.e. the requirement to continuously pay attention on the task) and boredom (carry-over effect) [22].

4. *Cognitive lock-up*: The user has fundamental problems managing their own tasks adequately. Humans are inclined to focus on one task and are reluctant to switch to another task, even if the second task has a higher priority. They are stuck to their choice to perform a specific task [23] and have the tendency to execute tasks sequentially [24].

5. *Overload*: The user will not be able to handle all the tasks given.

These cognitive states could occur when a therapist is working with multiple patients. When designing a system that supports the therapist, it seems needed to explore ways to avoid or deal with situations with vigilance, cognitive lock-up and overload. A way to improve the LIP of the therapists is to make sure the therapists have the correct and proper amount of information to make good and fast decisions. The TO is dependent on the number of tasks the therapist has to execute and how long much time each of the tasks will take. To lower the workload of the therapist, there is the possibility to make the computer take over certain tasks, if the therapist cannot handle them. The last factor is the number of task-set switching. This contains both the switching of tasks within the same patient treatment and the switching between different patients. It might be possible to lower the amount of task-set switching if a computer system can handle certain tasks so the therapist is not required to switch to a patient do a basic task and then switch back to the initial patient.

2.3.2 Situation awareness

If unexpected and time-critical problems occur, where time may be limited, it is important that a therapist can make fast and accurate decisions. A well-designed system should help the therapist by collecting and presenting relevant data [25], interpreting the data and provide advice to the therapist. Endsley [26] warns for factors that cause loss of situation awareness like; *tunnelling, memory trap, data overload, salience, complexity creep* and *out-of-the-loop*, all these factors should be considered when designing a multiple patient system.

2.4 Envisioned technology

2.4.1 Remote communication

For a therapists to be able to monitor and treat multiple patients, communication with these patients is needed. If you want to provide separate treatment per patience and if you want to ensure that patients do not interfere with one another is seems necessary for all patients to have their own personal treatment location. This means that the therapist cannot be physically present at the patients. If the therapist cannot be physically present at the patient, other methods than direct communication between the patient and the therapist must be found to ensure proper treatment.

Through better and more divers communication possibilities, the way therapy is provided is evolving. New remote variants are starting to be developed. Telephone therapy was already there but now sessions over the internet and even in online worlds are being established [27]. The growth of this so called E-Therapy or tele-treatment still has to be properly defined and has its own ethical and legal issues [28], but this shows there is room for therapy that uses other media then pure face to face communication.

During the current VRET sessions the patient is wearing a head mounted display, he or she cannot see the therapist. The communication between the patient and the therapist comprises of speech between the therapist and the patient. In addition, the therapist can visually observe the patient. If there is no physical interaction, the verbal communication could be replaced with a two-way voice stream over a network and the visual information could be replaced with a video stream and a monitor.

If remote communication is needed, suitable hardware and software for setting up a remote communication system is required. This translates in a system of microphones for both parties, complemented with headphones or a sound system for the therapist. The patient's HMD is already equipped with headphones, so it should be possible to add the therapists' comments and feedback to the sounds of the patient's virtual world.

2.4.2 Measuring the patients anxiety

The currently used indication the patient's anxiety level is the so-called SUD score (Subjective Units of Discomfort) [9], which gives a subjective anxiety level of the patient on a scale from zero to ten. Zero for no anxiety and ten indicates the highest level of fear the patient can imagine. This SUD score can also be used as an indicator for the computer system to determine if a patient needs assistance. In the current system, this score is determined by asking the patient. This method of obtaining SUD scores can still be used in a multiple patient setup, but it could be useful for the system to acquire SUD scores autonomic, without the need of the therapist, for example with a computer voice and voice recognition technology. The system can use this data to make intelligent decisions on how to assist the patients, or when to warn the therapist.

Anxiety or stress is a very complex emotion, but one that is possible to detect in humans. Using one type of measurement could provide unreliable results [29], but measuring additional indicators and then comparing those can generate a more reliable output. Research [30] is conducted on obtaining stress levels from voices. This software could be used to determine patient's anxiety-scores. For this to work it is necessary that the patient keeps talking to the system. There is also research on

software that can recognise stress levels from body posture and facial expressions [31]. Analyzing facial expression would be hard because the patient is wearing a HMD.

Another method to determine the patient's anxiety-score could be the use of biosensors [32]. Biosensors detect muscle and nerve activity. Currently, biosensors exists that measure physiological activity, muscle electrical activity, brain electrical activity and eye movement. Extracting accurate physiological data from biosensors can be a complex task and some biofeedback needs to be calibrated per patient. In addition, the patient monitoring sensors should be easy to attach and non-intrusive. A heart rate variability meter [33] and a galvanic skin response sensor could be good solutions, but additional research is needed to be certain.

2.4.3 Automated patient assist (VR-scenarios)

During a VRET session, the patient is situated in an anxiety provoking virtual environment. In the current VRET setup described by Schuemie [8], the therapist can alter the virtual environment of the patient to trigger more or less anxiety. It seems that not all patients react the same to different virtual environments [10]. What causes anxiety for some patients is not considered fearful by other patients. With the current setup, the therapist must do all alteration to the VR of the patient manually. If the therapist wants to provide more complex or interactive VE-situations for the patient, the therapist needs to create them manually. If there is a way to pre-programme these VR events as described by Brinkman et al. [14], the therapist could save a lot of time adjusting the virtual environment of the patients.

An additional benefit of having pre-programmed VR events can be that multiple versions of these *VR-scenarios* can be created within the same virtual world. Some VR-scenarios could be designed to gently let the patients get used to the situation. Others could be created to provide extreme anxiety-provoking situations, off course this can be subjective per patient. Therefore, the therapist should choose which scenario suits the individual patient. If these VR-scenarios can fluently merge from one into another a system of different expected anxiety provoking scenarios can be created. This could perhaps give a computer system the option to switch fluently to an easier VR-scenario in certain situations and to a harder VR-scenario in others.

2.4.4 Automated therapist assist (Adaptive automation)

In a multiple patient VRET, situations could occur where therapists cannot cope with their workload. This might happen because the therapists cannot handle their workload due to vigilance, cognitive lock-up, or overload. A second reason could be that a therapist is completely occupied with one patient and therefore cannot assist another at the same time.

A possible solution to these problems would be to let the computer dynamically take over certain tasks. Research is available on *adaptive automation* (AA): "the dynamic division of labour between man and machine" [34]. It is based on the conception of actively aiding the operator only when human information processing limitations emerge and assistance is required in order to overcome bottlenecks and to meet operational requirements.

A possible next step is the use of *augmented cognition* (AC) that extends the AA paradigm by explicitly stating the symbolic integration of man and machines in a closed-loop system whereby the operator's cognitive state and the operational context are to be detected by the system [35]. For this, it is necessary to have systems that reliably augments the cognition of the therapist and is capable of coping with unreliability and knowledge about how humans use these systems [29]. Advice should be

provided in such a way that the user remain in the loop of the overall activity by interactive involvement in the process of action executions as part of a task procedure.

A situation of AA is described by Arciszewski et al [36]. This paper states that the user rather than the system designer should have the final say as to what level of automation the system is authorized to reach. It describes that you could see the user and the system work together as a team. There is an emphasis on the situation were the user can declare on forehand how the system should react in a case of high workload. Should this be applied to multiple patient therapy, it could mean that the therapist can make *working agreements* as described by Arciszewski. These agreements are made with the system per patient, telling the system how to act in situations with a high workload.

2.5 A preliminary vision of a multiple patient VRET system

To make claims on a multiple patient VRET system, a context or vision of such a system could be useful. This preliminary vision of the multiple patient VRET system can be used to provide an initial description of the system, which can be used as a base for further exploration. The results of this further exploration can be used to create preliminary specifications. This section describes this preliminary vision of the multiple patient system and the different elements of this system. It starts with an overview of the therapy structure and then explains the remote communication between the therapist and the patient. Finally it will give an overview of the multiple patient setup.

2.5.1 Therapy structure

If a patient begins with phobia therapy, he or she first has a consultation with a therapist. In this interview, the therapist determines what kind of treatment will suit the patient best. Treatments that consist of psychotherapy could be extended with virtual exposure therapy. If a therapist chooses to use VRET, he or she can decide to start with VRET at a location where the therapist and the patient are in the same room. At a certain point, the therapist can choose to sign the patient up for a remote session of VRET. The patient can have VRET at a location of their choice. In that situation, the patients will be assisted by the same therapist or specialised therapist by means of remote communication.

In this remote VRET setup the therapist sees the patient trough a video-feed from a camera at the location of the patient. The therapist and patient can communicate via an audio-feed over a network; both the therapist and the patient will have microphones. The therapist receives all the patient data via a network and can choose a proper VR-scenario for the patient. The remote therapist then monitors and assists the patient to achieve a proper treatment.

The patient could have this remote VRET session on different locations, for example a nearby mental health clinic, which has rooms equipped with a HMD and remote communication hardware. On these locations, an assistant has to be nearby so if anything goes wrong the therapist can warn this assistant to check up on the patient.

Because the therapists can always talk to the patient, they can always ask the patient for their level of anxiety; a computer can also do this. The possibility exist to extend this with the use of other fear or stress measuring methods, for example, stress recognition in voice, stress recognition in movement and posture, heart rate variability or galvanic skin response.

2.5.2. The setup

In a multiple patient setup, (Figure 2.7) the possibility exists for a therapist to assist multiple remote VRET patients at the same time. This could make the situation more complex as therapists must share their attention between multiple patients. Patients might need additional attention at the beginning of a session. One way to ensure this is in avoiding that patients start at the same time. This would mean appropriate planning for all VRET sessions of the day.

The system should be designed such a way that it reduces mode errors [15]. In which a therapist makes the error of attending a different patient he or she thinks. A way to avoid these errors is by providing the therapist with a separate monitor and input-system per patient as described by Sellen and Buxton [16]. This could assure that the therapist does not confuse the patients and their interfaces. To ensure that the workload of the therapist does not get too high and to compensate for emergencies, an automated assist system could be added. This system can monitor the anxiety levels of patients and warn the therapist, but also take over tasks if the therapist is too busy. This auto assist system can for example decide to give a patient an easier VR-scenario trying to calm him or her down.
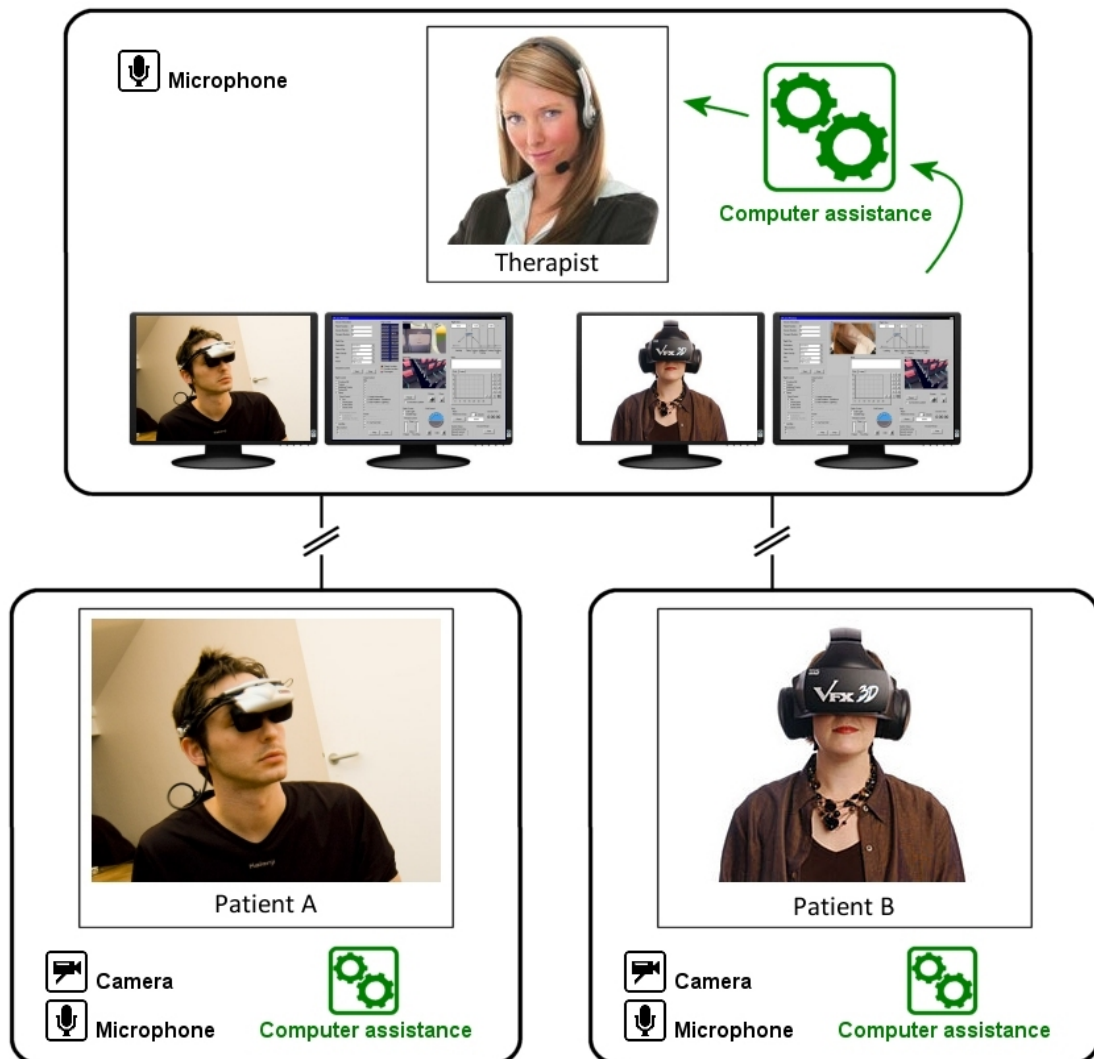

Figure 2.7: *An overview of a multiple patient VRET setup.*

3 Specify: An expert perspective using claims and scenarios

The initial goal of this thesis was to explore the specifications for a multiple patient VRET system. To create preliminary specifications *User-based scenarios* were used. According to Carrol [37] scenarios should be used in a design process because they can capture the consequences and divers trade-offs in a particular design. Because scenarios are narrative, they can help users, experts and designers to imagine user situations and contexts for the new technology. By creating scenarios, automatically assumptions are made on what a system can and cannot do. These assumptions can be turned into claims, which can be reviewed by experts. Because the whole concept of multiple patient VRET seemed new to most experts it was chosen to in addition turn the user-based scenarios into movies, thereby better visualising and explaining the scenarios.

After the initial written scenarios were reviewed by an experienced researcher of VRET. These scenarios were rewritten to a film script. This script was turned into a film using (amateur) actors to further visualize multiple patient VRET. This group of videos of a therapist assisting multiple patients was shown to therapist and end-users with experience with virtual reality exposure therapy. Because there was a limited number of available therapists who had experience with VRET users, there was a need to collect as much information per expert as possible. Therefore, the use informal or *semi-structured interviews* [38] seemed the best way to collect data. *Qualitative bases analysis* was used to extrapolate themes and specifications from these interviews. The results acquired were used to draw conclusions and generate preliminary specifications.

3.1 Scenario-based approach

To provide a better overview the exploration of a multiple VRET system was separated in five different aspects. First, there is the remote nature of the multiple VRET sessions. It would be impossible for a therapist to have face-to-face communication with multiple VRET patients at the same time. This means there is a need for a different setup and structure of the therapy. The second aspect was the communication between the therapist and patient. It was important to explore which communication methods are possible and which the therapist prefers.

The third aspect dealt with the gathering and presentation of data about the patient during a VRET session. How should a system ask for SUD scores and is physiological data useful? Furthermore, how can we present the patient's and session data in such way that the therapist can make quick and accurate decisions? The fourth aspect dealt with computer assistance for the patient. How can computer technologies assist the patient? This assistance can provide the therapist with more time to concentrate on the therapy. The last aspect dealt with computer assistance for the therapist. How should a system be designed in which a therapist gets assistance, making it easier and safer to handle multiple VRET patients at the same time?

The full scenarios were written in Dutch because all interviewees were Dutch (Appendix A). For every scenario corresponding claims were made. These claims were created as statements that were presented to experts during interviews, to explore if they would agree or disagree and to trigger a discussion. The next section will give a brief description of the four created scenarios and there corresponding claims.

Scenario 1: The start of the day for a therapist

The first scenario deals with the general setup of a remote VRET session. It describes how therapist Henrietta starts her day at a multiple patient VRET-center. It also states how she makes contact with her first patient that day. It describes how she interacts with the assistant on location and how each patient starts at a different time, giving the therapist time to welcome and personally address the patient before the VR session starts.

Claims:

- After an initial interview with a therapist, the patient can be redirected to other therapists for a remote VRET session.
- Ten minutes before the beginning of a VRET session is enough time for the therapist to welcome and assist the patient.

Scenario 2: Patient communication

The second scenario describes how the therapist and patient communicate with each other. The therapist can hear and see all patients on their own separate monitor and speaker set. The patient can hear the therapist with his or her HMD. The therapist can see what the patients' view is in their VR environment.

Before each session, the patients are connected to a heart rate variability measuring system and a galvanic skin response monitor, which measure the patients' physiological state. The system automatically asks a SUD score from the patients every two minutes and combines this score with the physiological data into a total anxiety-score. This score is presented continually to the therapist. This scenario also explains that a therapist can fluently switch to another VR-scenario in the same virtual environment.

Claims:

- It is not necessary in VR exposure treatment that the therapist and the patient have physical contact.
- The therapist can assist the patient completely with only verbal communication.
- For emergencies, an assistant on location is enough to provide backup assistance.
- The therapist will always like to hear all voices from all patients.
- The therapist will always like to see all patients on their own personal monitors.
- The therapist does not mind working with multiple monitors at the same time.
- Patients will accept that a computer system will ask them for their SUD score.
- The use of physiological measurement has a large benefit in the monitoring of a patient.

Scenario 3: The therapist sets up the VR-scenarios and the setup of the assist system

This scenario elaborates on how a therapist can choose the VR-scenarios for the patient. It shows how a therapist can combine different VR scenario phases to a complete scenario, for example the combination of takeoff, flight and landing into a complete fear of flight scenario. It explains that a therapist has the freedom to combine the scenarios to his or her own preference. Some VR-scenarios phases come in a variety of difficulties adding an option to the therapist to make session more anxiety or less provoking for the patient.

This scenario also explains that the therapist can manually setup the automated assist per patient. With a simple rule-set, the therapist can for example arrange that she wants an alarm at an anxiety-score of seven with patient A and that she wants the system to switch to an easier scenario if the anxiety-score of patient B goes over eight.

Claims:

- It is possible to create pre-programmed VR-scenario phases that can be varied from minimal anxiety provoking to maximal anxiety provoking.
- It is important that the therapist can link these scenario phases to a complete scenario.
- The therapist is capable, having all the background information of the patient, to select a fitting scenario for the patient.
- The therapist wants to be able to configure the automated assist him or herself.
- The therapist wants to be able to configure the warning system him or herself.

Scenario 4: Multiple patients need immediate assistance

The last scenario describes a situation where two patients need immediate attention from the therapists at the same time. It explains that the therapist will assist one patient and the automatic-assist automatically starts to calm the other patient down by switching to a les anxiety provoking VR-scenario.

Claims:

- An automated assist can autonomously switch to an easier VR scenario if the anxiety-score of a patient is too high for a certain amount of time.
- An automated assist can autonomously switch to a harder VR scenario if the anxiety-score of a patient is too low for a certain amount of time.
- An automated assist system can automatically operate if a therapist does not react within a certain range of time.

3.2 Script and filming

After the initial written scenarios had been discussed with a therapist who was an expert on VRET, they were further visualized. The strength of scenarios is to provide good means to communicate design ideas, this can be further exploited by visualizing these scenarios. A film-script was created for each of the movies (Appendix B). To ensure that the movies did not take too long to watch, the four original scenarios were compressed together into three short film-scripts taking about nine minutes together. The first script described the proposed remote communication. The second described the treating of multiple patients and setting up VR-scenarios. The third scenario described the proposed automated assists system. These three scenarios were filmed to produce three user-scenario movies.

In addition to the three user-scenarios movies, a promotional video was created with the intention to quickly explain the basics of multiple patient VRET and was posted publicly on YouTube[1]. This link could then be sent to parties who were interested, so they would easily understand the general idea of multiple patient VRET and to persuade them take part in the project. The other three videos, on average each taking about three minutes, showed a therapist assist three patients with multiple patient VRET (Figure 3.1). The first video shows the start of a session and making contact with the first patient. It also shows how an assistant on location helps the patient with equipping their HMD and sensors.

The second video shows how a therapist could choose the different VR-scenarios for a patient. The last video shows how a therapist can setup an automated assist system and how it is working in general. In the second and third video mock-ups of an interface were added. This was done to give a better visualisation on how the therapist would interact with the system (Figure 3.2). The main goal of these videos was to use them in interviews with therapists, so they got a better understanding of multiple patient VRET and inspire them to start an discussion.

Figure 3.1: Stills from the created videos. a) The therapist is making contact with the first patient. b) The assistant on location is helping a patient. c) The therapist is monitoring multiple patients.
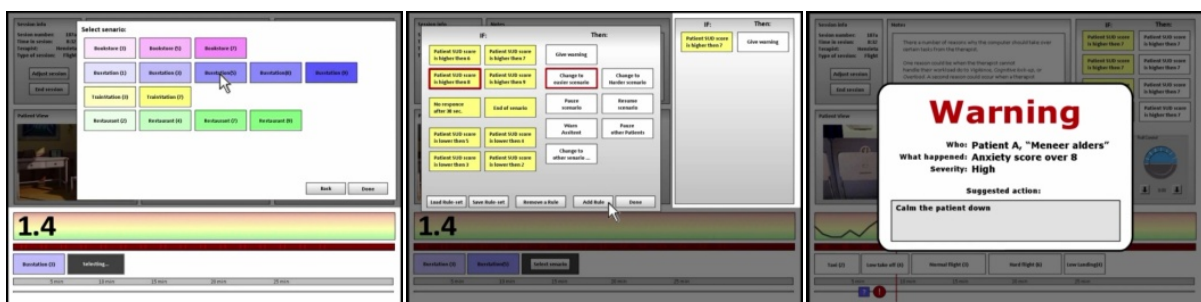

Figure 3.2: The mock-ups within the videos. a) Choosing a VR-scenario. b) Setting up the automated assists. c) Warning the therapist.

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[1] http://mmi.tudelft.nl/vret/index.php/Designing_a_Multiple_patient_VRET_system

3.3 The interview

To study the claims and scenarios, therapists who had experience with the current VRET system were interviewed. The disadvantage of this approach was that the amount of interviewees was very limited. It would be important to collect as much information as possible per participant. For that reason, informal or semi-structured interviews [36] were used. As a preparation for the interviews, the original claims were rewritten to a questionnaire with a more open structure, providing the interviewee room to voice their own opinion on the topics (Appendix C). The topics were divided in five segments: (1) Therapy structure, (2) remote communication, (3) patient data gathering and presentation, (4) patient assistant system and (5) therapist warning and assist system.

3.3.1 Participants

The collaboration between TU Delft and other organizations like Stichting Valk and PsyQ was very useful, because in those organizations therapist were using the current VRET system. Stichting Valk is a Dutch foundation specialised in treatment for people with fear of flying. They use VRET with certain clients as part of their treatment. Four therapists from Stichting Valk were available for interviews. PsyQ is a company that provides help for people with differs psychological problems. PsyQ is also experimenting with VRET and it was possible to interview one of their employees as well. The last interviewee had conducted her own research on VRET [10] and currently is working as a therapist. In total six participants were interviewed.

3.3.2 Material

The main approach of the interviews was to use the three created videos of a therapist using the proposed system and then discuss these videos and the appropriate claims that came with them. All interviews were showed in the office of the interviewee. To show the videos on location a laptop and speakers were used. The questionnaire based on the claims was used to ensure that all subjects were discussed. Pen and paper were used to make notes of the interviews.

3.3.3 Procedure

To prepare for the interviews we looked at the skills of a good interviewer as stated by Robson [39] namely question asking, good listening, adaptive and flexibility, grasp of the issues and lack of bias. Minimizing lack of bias was imported because we did not want to influence the view the therapists had on a multiple patient VRET system.

All interviews started by talking about the interviewees experience with VRET and some global background information. Then the first video was shown on a laptop and they were asked for their initial reaction. The therapist would make their remarks and there was a conversation about the video. During the interview, it was imported to ensure that all elements of the questionnaire were addressed. Then the second scenario was shown and discussed in detail as well. After the last scenario was discussed, the interviewee was asked to summarise all their remarks in a small paragraph. Finally the therapist had the opportunity to make extra remarks on the design of a multiple patient VRET system.

3.3.4 Measurements

During the interview, the interviewer made notes, describing all the comments the therapists made. If the comments were not clear, the interviewer would ask the interviewee to elaborate. After the interview, all notes were digitized for further analysis (Appendix D).

3.4 Data analysis

To analyse informal or semi-structured interviews *qualitative data analysis* [39] was used. Similar phrases, patterns and themes were identified within the interviews. Elements were groups in five categories: (1) Therapy structure, (2) remote communication, (3) patient data gathering and presentation, (4) patient assistant system and (5) therapist warning and assist system. This made it more manageable to identify and label similar remarks.

When during interviews completely new remarks or ideas were introduced, these were noted and presented to future interviewees asking their opinion about these remarks. This meant that the questionnaire of the interview developed over time. By identifying and labelling similar remarks, it was possible to regroup and prepare the comments to a complete summary of remarks. This summary was then compared to the initial claims.

3.5 Result of the interviews (complete summary of remarks)

Remote therapy

Of the six interviewed therapists, four initially reacted negative on the proposal of remote VRET sessions. They made it clear that the therapist-patient relationship is very imported in phobia treatment. Conditions which enable the intensification of trust between the patient and the therapist are very important, especially at the beginning of the treatment. Almost all of the interviewed therapists already use remote ways to assist their patients; by phone, e-mail or with exercises at home. When they perceive the remote VRET session not as a replacement for face-to-face psychotherapy, but more as an addition to existing therapies, like a monitored home exercise, all interviewees reacted very positive.

Some therapists do not see the benefit of having a VRET session on a different location then the therapist's office. One said that the commitment a patient makes by travelling to the therapist could be part of the therapy. All therapists do see a large usefulness, if the VR-equipment can somehow be delivered to the patient, so he or she can do VRET sessions at their own home. Especially people with agoraphobia and social phobia could benefit from this. In remote situations, all interviewees felt it was necessary to have some type of assistant at location. This person must be able to quickly come over and support the patient locally in case of emergencies.

Therapist patient communication

Almost all interviewees agreed that a computer monitor should be enough to keep an eye on the patient. One did mention that it could be hard to notice some little nuances in the behaviour of the patient, but proper training could take care of that. The therapists did realize that there is a general trend towards more web-cam based communication and this trend could, certainly within a decade, develop into a completely acceptable method of communication.

All therapists feel that using physiological measurements on the patient could be beneficial to the therapy. The therapists feel the more information they have, the better they can treat the patient. The results of the measurements should be presented clearly or be combined into a single patient anxiety-score. The interviewees stated that it is important that the measuring-equipment should not be intrusive to the patient.

Asking for SUD scores

All therapists ask patients for subjective anxiety-scores during VRET sessions. Some say they might forget to ask them every two minutes and others only ask for a SUD score when they feel it is necessary. The interviewees would like a system that could remind them to ask for a SUD, but they want the option to configure that system for themselves. Half of the therapists like the idea that a computer will ask the patients' SUD scores for them; it will then automatically recognise the spoken feedback and present the score to the therapist. Two therapists also suggested a slider or a dial, which the patient can use to continuously correspond their anxiety-score. In addition, a force gauge, which the patient can squeeze, was suggested, because patients tend to tighten their mussels if their anxiety level goes up.

Multiple patients

Almost all therapists saw the treatment of multiple patients with VRET as a bit of a futuristic concept. Most said that this would be a different way of providing therapy. They all stressed that it is very important that a patient has the full attention of the therapist. Spreading the therapists' attention over multiple patients could diminish the effectiveness of the treatment. All said it is very important for the treatment that the therapist has enough time before and after the VRET session. Before the session, the therapist needs to explain what is going to happen and what the patient could expect and how he or she should react in certain situations. Afterwards the therapist should evaluate how the patient did and what the patient has experienced.

Two therapists said that you need to be quick with the responses to a patient. The patient should never have the feeling that he or she is being ignored or that the therapist is too busy with another patient. On the other hand one interviewee remarked that the therapist has the option to tell patients he or she is attending another patient and put them on hold. Most patients will accept this if they have the sentiment that the therapist would do the same thing for them in return. Almost all interviewees remarked that multiple patient therapy is not recommended for all patients, the patient's therapist should decide if he or she is suitable for remote multiple patient VRET sessions.

Some interviewees said that the operator of such a system is more a monitor than a therapist. Others say it must be a very experienced therapist who can anticipate on patients' behaviour and possesses a great deal of experience with remote VRET. The operator should be able to recognise if a patient is about to get very frightened, and he or she should be able to explain why a patient feels certain fears and how this treatment can help them. It is key that the operator has good time-management skills and must be able to anticipate on complex situations. About half the therapists feel that it would be very hard for them to use a multiple patient system, the other half would be interested to try it out. However, all interviewees agree it has potential and it is important to continue the research.

The use of pre-programmed VR-scenarios

The interviewees state that using pre-programmed VR-scenario's can be very useful, especially if the VR-scenarios come in different anxiety inducing variants. They feel gradual exposure is an important part of a treatment and most therapists recognize that VR can do this in a controlled and predictable way. Most therapists would like the system to take care of the scenario's giving more time to the therapist to actually assist the patient.

The therapists do note that all VR scenarios should be designed by proper therapists and that that the anxiety level of patients can be very personal. A therapist must know that patients can react very different per VR-scenario. If one scenario is frightening for a certain patient, other patients could have no fear for it at all. It seems key that the therapist choosing the scenarios for the patients has the skills to determine which scenario is appropriate for each individual patient.

Therapist assist system

All interviewees recognize that assistance for the therapist is necessary for multiple patient therapy, even if this is a simple warning system. All therapists like the idea that they themselves can setup the assist system per patient per session. The functionally of gradual stepping to a less fearful scenario could be an essential part of that. It should however be made perfectly clear to the patient that an assist system could do that, so they know what to expect.

One therapist mentioned that if a patient or a therapist decides to step down to a less fearful scenario, it is important that over time the patient gradually gets back to the original harder scenario. This means that the patients should end up at the same level as where they were when they got frightened. If this does not happen, the treatment could be ineffective or even have a negative impact.

Almost all therapists saw no problem with the system automatically going to a harder scenario if there is a low anxiety-score, as long as the therapist is properly informed. Three therapists mention that the patients themselves could be in control of switching to a harder scenario, for some patients it could be adventitious for the treatment to feel in control.

Extra remarks

One interviewee suggested that virtual reality could be useful as a diagnostic tool. By exposing a client to different worlds and situations, the therapist can examine when or why a patient is starting to get frightened. Another therapist did mention that you have to be careful with this; because there is a chance, you can expose the patient to too much anxiety.

Two interviewed therapists mentioned that because you film patients and take their physiological measurements, it could be helpful to present this data to the patient itself. When you show the video of the session to patients, they can realize how they behave in certain situations. This could help them to understand their phobias better. In addition, if you present physiological data to the patient during a session the patients can realize how their bodies react to anxiety, this could help them understand and cope with their reaction to fear.

Lastly three interviewees mentioned that remote VR sessions could also be used for training purposes, for example speaking in public and solicitation training. This would have a much wider audience and could be more commercially viable. In addition, it has the advantage that there is no patient-therapist situation, which means that the users would need much less assistance.

3.6 Conclusion and discussion

The interviewees agreed on most of the claims that were derived from the creation of the scenarios. Some interviewed therapists did stress on the importance of the patient-therapist relationship. Some were afraid that the distance between the therapist and the patient could become too big when using remote communication methods. Therefore making this a tool, which could be not suitable for all patients or all therapists.

The therapists affirmed with the remote communication setup shown in the video and liked the idea that a computer system could ask the patients for their SUD score. They also liked the use of physiological measurement in generating more data of the patient.

For a good exposure treatment it seemed key that the patient has anxiety and a therapist can help the patient deal with this anxiety so the patient has the opportunity to overcome it. Some therapists feared that treating multiple patients could lead to a high workload for the therapist. In addition, some therapist felt that it could lead to situations where patients needed attention simultaneously. Most therapists agreed that some type of therapist assistance software could help them in assisting multiple patients. They all agreed it was necessary to have some system that could provide additional help on location in emergency situations.

The therapists liked the idea of pre-programmed VR-scenarios where they could choose an appropriate scenario for the patient. They welcomed the fact that different difficulties of the scenarios were available, making it possible to switch between a harder or easier scenario. The therapists did warn that not all patients would perceive a specific scenario as the same difficulty level. This is probably a personal matter. Lastly, the interviewees liked the idea that they could setup an automated warning and assist system for themselves, making sure they are in control of the therapy.

3.7 Preliminary specifications

The conclusions of the interviews were used to refine and extended the preliminary vision as described in section 2.5. Preliminary specifications for a multiple patient VRET system were created. The proposed therapy structure was refined to accommodate for the remarks of the interviewee. The therapist liked the communication setup as described in the user scenarios. This was extended with more ideas on how to present the patient data to the therapist. The therapist felt the need for an automated assist and the ability to call for remote assistance, so this was described in more detail.

3.7.1 Therapy structure

In addition to the start of a session, the therapist also needs personal time with the patient at the end of each session. This time is used to give extra guidance and provide time for the patients to process the anxieties they had during a session. A therapist working with multiple VRET has the option to tell patients that another patient needs immediate attention, so they are put on hold. A large group of patients will probably accept this if they have the feeling that the therapists would do the same thing for them in return. There could be an addition to the system where patients themselves are able to switch between scenarios. Some patients like to be in control and this option could help them during treatments. It is necessary to have an assistant at location. This person can quickly come over and support the patient locally in case of emergencies.

3.7.2 Remote communication setup

As described by the preliminary vision, the patients use a microphone to talk to the therapist and are filmed by a camera so the therapist can keep monitoring them. The therapists use a microphone to talk to the local assistant and the patients. They can view all the patients on their separate monitor and have a second monitor per patient that shows the user-interface and patient's data. For every patient the therapist has a mouse and keyboard for input and speakers to hear the speech of the patients.

3.7.3 Patient data presentation to therapist

Therapists concurred that virtual reality exposure therapy could benefit from taking physiological measurements from the patients. These measurements need to be presented to the therapist. The main variable is the anxiety-score of the patient. This can be calculated by a weighted average of the different stress measurement methods. Some of these methods can be two minute interval asking for SUD score, hart rate variability, galvanic skin response, squeeze meter or a deal or slider operated by the patients. In addition stress recognition software can be used to analyse the patient's voice or body movement.

Two types of data from the patient can be distinguished. Personal and historical data of the patient and the data generated during a VRET session. Personal data can be viewed before the session and is showed on the monitor. The data generated during a session is directly visualised on screen giving a real-time overview of the patient's status during a session.

The anxiety-score can be visualised in a variety of ways. A possible way could be a timeline, which will immediately give an overview of the complete VRET session (Figure 3.3). In this timeline, other data can be incorporated as well, like the VR-scenario the patient is following and the placement of flags and notes.
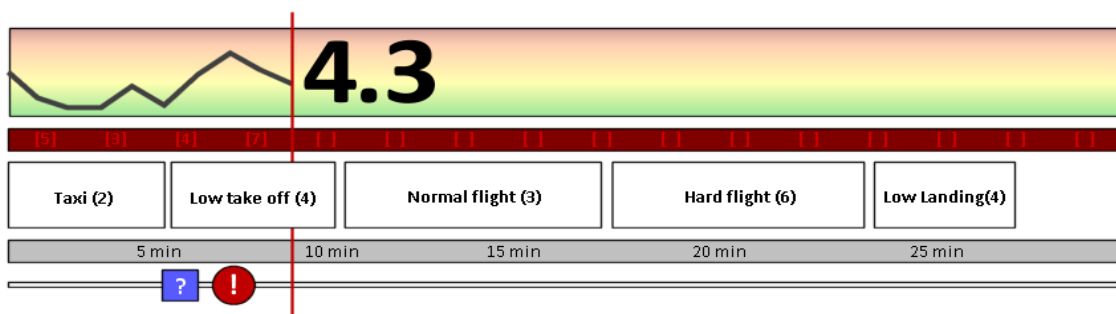

Figure 3.3: An example of a session timeline

3.7.4 VR-scenarios

Stimuli within the virtual environment are used to provide an optimal level of anxiety for the patient. To let patients experience certain situations in virtual environments VR-scenarios are used. Every VR-scenario is located in a specific virtual world, which is different depending on the type of phobia the patient is being treated for. This can for example be the interior of an airplane for people with fear of flying, a fire escape staircase to help people with fear of heights or a crowded store to provide stimuli for people with social phobias. Within this virtual world, different VR-scenarios are possible. In a store for example, different situations can be scripted, each including multiple dialogs.

Virtual world   VR-scenario   VR-scenario variation
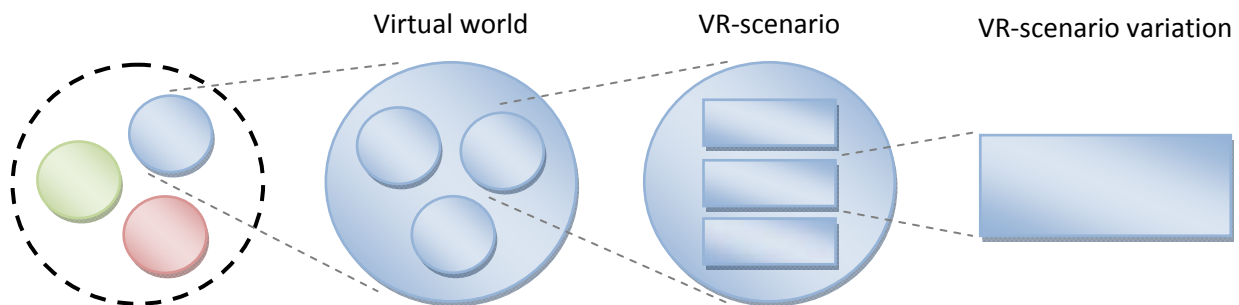
Figure 3.4: *The relation between a virtual world, a VR-scenario and a VR-scenario variation.*

The amount of anxiety that a VR-scenario provokes could be very different per individual patient. Therefore, it seems key that a therapist can predict what type of VR-scenario is fitting for the patient in each stadium of the treatment. It is useful when VR-scenarios come in different variations of expected anxiety provoking levels (Figure 3.4). For example, buying a carton of milk in the store or asking for a pack of condoms, a clear weather smooth landing or a landing with big gusts of wind. These variations should be designed to fluently fade into each other. If that is possible, the therapist or the computer can switch to a relatively easier VR-scenario, without that the patient has the chance to lower their presence in their virtual environment. Every different therapy and its coexisting virtual world could have different variables that could be adjusted to provide less or more anxiety for the patient. However, to make it easier for the user of such a system, it could be possible to design it such a way so there are always two options available; switching to an easier VR-scenario and switching to a harder VR-scenario variation.

Within VR-scenarios, extra variables can be added that can be controlled by the therapist or computer. These variables can come in an on-or-off situation, for example turbulence or no turbulence. Alternatively, they come in a scaled variety operated with a slider, like the level of crowdedness in a shop. With these variables, the therapist has the option to fine-tune the VR experience for patients and to add extra stimuli during a VRET session.

3.7.5 Therapist assistance system

In addition to the ability of the therapist to call for additional support on location, the therapist can have access to a system that provides additional support with the assistance of the patients. This therapist assistance system could consist of two phases, phase one is the setup of the assistance and phase two is the execution of this assistance. Prior to a VRET session, the therapist has the option to create or adjust a rule-set suitable for that individual patient and session. This can be based on the *working agreements* as discussed by Arciszewski et al [36]. The therapist can make simple rules with an if-statement and a then-statement, choosing between a variety of events that could occur during VRET sessions. A user-interface element could be created (Figure 3.5) to show If-rules on the left side and then-rules to the right. The user can select one if-rule and one then-rule and press the add rule button to add the rule to the rule-set. For example, if the patient's anxiety-score goes over seven, sound an alarm and automatically switch to an easier VR-scenario variety. With such a system, therapists have the option to setup the behaviour of the computer assistance, which provides them with more control.
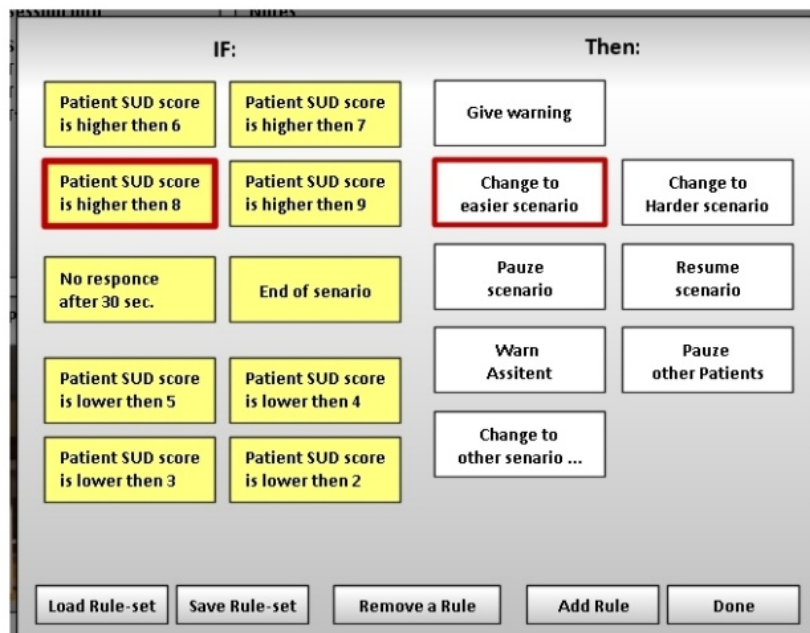
Figure 3.5: The setup screen of the proposed auto-assist.

Phase two describes what happens when a rule fires during a VRET session. The therapist is present by an information screen and an alarm will sound. The screen provide information on which rule has fired and shows the pre-programmed solution (the then-statement) to the problem. The therapist has then two options. The first option is to acknowledge the warning and tell the system he or she will deal with the situation themselves. The second option is to ignore the warning, this could occur when the therapist is too occupied with another patient. When the system notices that the therapist is ignoring the warning for a set amount of time, the system will execute the auto-assist by applying the then-condition of the rule.

4 Prototyping

After initial research and the interviews with therapists, preliminary specifications for a multiple patient VRET system were drawn up. To assess and further examine these specifications, further research was conducted. Chapter 5 will describe an experiment to explore the impact of the proposed automated assist system and the "call for remote assistance"-function on the workload of the therapist (the user of the system). For this experiment to be able to be conducted, prototype software was needed. Building a prototype had the additional benefit of providing a proof-of-concept based on the preliminary specifications. A possible third use of this prototype could be that a modified version might be used in the future for training purposes.

In this chapter, the initial prototype is presented. The next chapter will describe how this prototype was extended to support simulated patients, which was needed for the user workload experiment. The initial prototype was created to support multiple VRET sessions with different patients simultaneously. Therefore, it had to be able to support interaction with multiple patients on separate computer systems at the same time. This meant that the complete prototype should be distributed and the software should be able to run on multiple computers interacting with each other over a network.

To construct the prototype, the scripting language Python[2] (version 2.6.1) was used. The three dimensional VR visualization that was used was Vizard[3], which was based on Python. Therefore, using Python provided the option to have possible integration in the future. Because the prototype needed to support a more comprehensive user-interface, pyQT[4] (version Py2.6-gpl-4.4.4-2) a library for the user-interface modules was added to the regular set of libraries in Python. This is a specialized but flexible library for the implementations of user-interfaces on multiple operating systems.

This chapter will start with the functions and interaction needed to realize multiple patient VRET. Then the variables of a session and the outlines of the software are discussed. The last sections of this chapter will give an overview of all the objects within the prototype, the user-interface and the implementation of the therapist's automated assists.

4.1 Functions and interaction

The prototype focused on the interaction between the therapist, the system and the multiple patients. Based on the initial vision and the preliminary specifications, four main actions a therapist could take per patient, were indentified (Figure 4.1): (1) communicating with the patient, (2) changing the patient's virtual experience, (3) calling for remote assistance and (4) placing flags.

Flags are small remarks, which can be place by therapist. For example, if the patient is showing certain signs of fear or acts a particular way. These flags can have pre-programmed remarks or configured by the therapist. Pre-programmed flags have the advantage, that a therapist can quickly add a remark with one single mouse click.

Changing the patient's virtual environment can be dissimilar per type of phobia and its coexisting virtual worlds. Two general ways of changing the VE of the patient are introduced; the first is to switch to another VR-scenario and the second is to make small adjustment to the current scenario.

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[2] http://www.python.org
[3] http://www.worldviz.com
[4] http://www.riverbankcomputing.co.uk/software/pyqt

Even if all virtual worlds have different VR-scenarios, the option to switch to a less or more anxiety-provoking scenario should be some a general option always available, to provide the therapist with a consisted option to quickly assist the patient. The therapist will also receive feedback and data from the patient. Based on the preliminary specifications as presented in section 3.7, four continues streams of data were indentified. The therapist receives a video-stream of the patient, so the therapist can monitor the patient's posture and movements. In addition, a view through the eyes of the patient is shown, to better understand what the patient is experiencing in their VE. The therapist will hear the patient and he or she will see the current and the history of the combined anxiety-scores of the patient in a time line, to make better decisions on how to assist a patient.
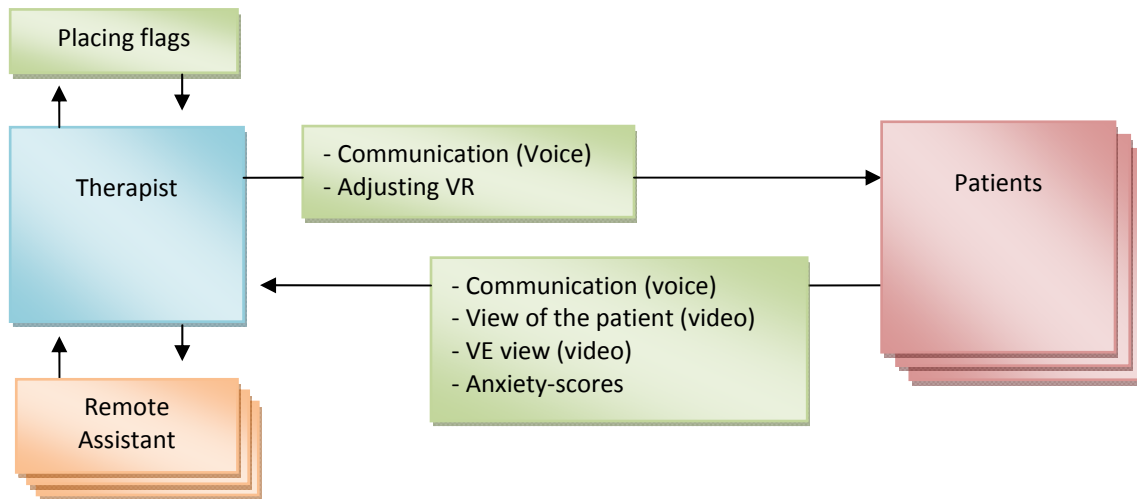
Figure 4.1: *The actions and interaction between the therapist, patients and remote assistant.*

4.2. A session object

Multiple patient VRET software should be able to manage a number of patient's sessions simultaneously. To manage a session a session object was programmed, which stores and controls all data of a therapy session. A main variable is the *status* of a session. This can be either "Paused", "Started" or "Ended". If a session is created the status is "Paused". The therapist can then make adjustments to the session, like changing the VR-scenarios, patient information, therapy type or session length. If both the therapist and the patient are ready, the session can be started. Now the session is running and all session data is stored. If the session is done, the status switches to "ended" and the data of the session can be saved or printed. An essential variable is the *session time, which* will keep track of the time passed within the session. Connected with this is the *total session length*. This can be changed at the beginning of the session by the therapist.

Within a session general therapy information is stored, things like the *patient name*, *session ID* and connected virtual world or the *type of the therapy*. This therapy type determines what variety of virtual world is loaded for the patients. It therefore dictates the available VR-scenarios and the options a therapist has to change the virtual environment. For example if a patient with fear of flight sits in a virtual airplane the therapist can choose to add turbulence, for a social phobia patient the therapist can alter the dialog the patient is having with a virtual person.

During a session, the anxiety-scores from the patient will be received. All received scores are stored in a *history anxiety-score array*, which can also be presented to the therapist trough a history graph. All notes and flags made by the therapist are also stored in an array*, the flag array*. The flags and notes have their own timestamp so the therapist can see when the flag was set or the note was made. Lastly, the session contains a *log file*, where all events of the session are logged and stored in a text file. This can be used for data gathering or storing a session.

4.3 Main server and session client applications

The prototype contained two applications. The *mainServer* application monitors all simultaneous sessions and stores their data. This application can make connections over a network to a computer with the *sessionClient* application. This application runs on a separate computer with two monitors and a speaker system. The sessionClient can create and run one patient session. When a session ends, a new session with a new patient can be created. When a therapist wants to assist three patients at the same time, three separate sessionClients are required (Figure 4.2). The mainServer and sessionClient software can be run on the same computer but then screen space can be an issue. This prototype software and instructions on how to install and use it can be found on the website of this project[5].
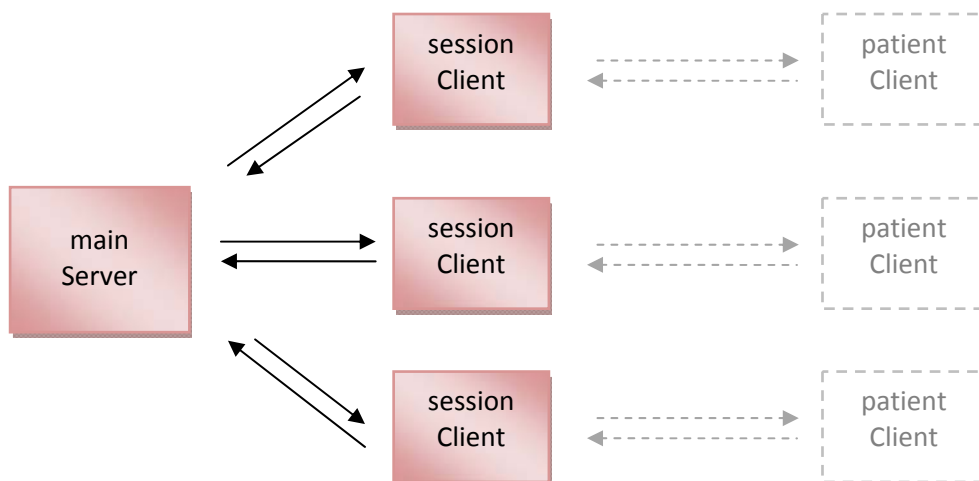
Figure 4.2: An overview of a three patient setup.

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[5] http://mmi.tudelft.nl/vret/index.php/Designing_a_Multiple_patient_VRET_system

4.4 Object diagram

Both the mainServer and the sessionClient have a *mainWindow* (Figure 4.3) Python script. These scripts initialise the application. Both windows have an internal clock to keep track of time. This clock functions as a pulse for the rest of the software, telling it when to execute certain actions. Both applications use a *MyConnection* object to setup connections. The sessionClient only needs one but the mainServer uses more to connect to multiple sessionClients. Both the mainServer and the sessionClient have their own set of widgets that state how all they look and act within the window of the application.

The mainServer has a *sessionControl* object that can store and control multiple sessions. This object was extended to run and creates patient simulations. How these simulations are created is explained in the in chapter 5. To be able to run simulations, a *SimulatorCreator* object was added. This object defines the different pre-programmed simulations. The sessionClient contains only one session, it has to end a session to start a new one. The sessionclient also has a *SoundImageControl* Object where all images and sounds of the simulated patients are stored and triggered.
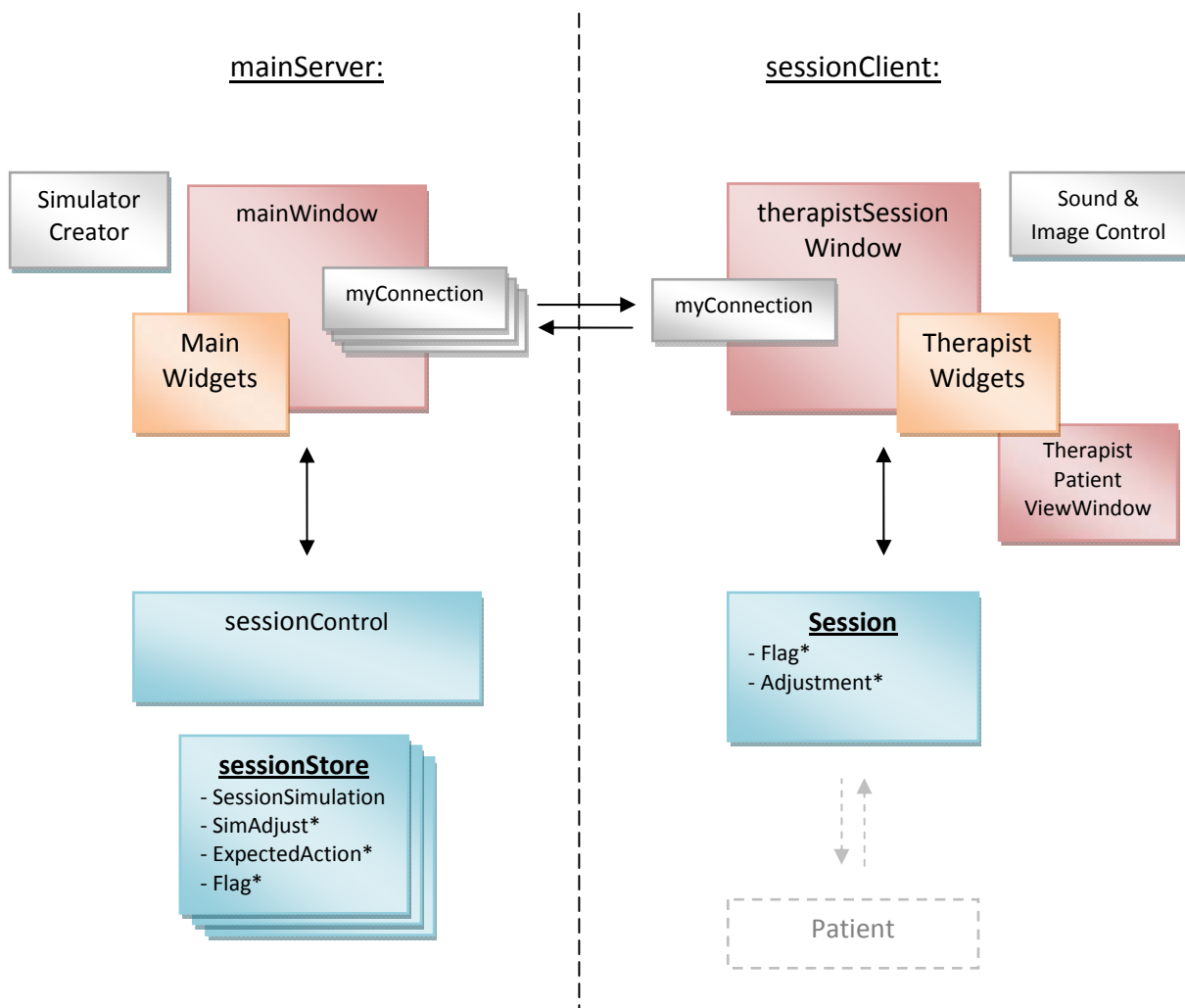
Figure 4.3: *An over view of the objects in the main server and the session client.*

4.5 The user-interface

The therapist user-interface of the prototype was based on the interface as described by Gunawan (Figure 2.5). The main changes where an addition of a session time line, which provided a more clear overview of the session and the simplification of the "Notes and Flag", "VR-scenario control" and the addition of a "Call for remote assistance"-button. These changes were based on the data steams explored in section 4.1. For this prototype interface, a "Patient control" section was added to replace the normal interaction with a patient for the interaction with a simulated patient. In addition to that a "Stop assisting patient"-button was added to let the user stop assisting a certain patient to be able to switch to another patient. Ongoing research is taking place on a high-quality user interface for therapists [14]. Therefore, the goal of this prototype was not to design a definitive user-interface, but to provide a flexible interface, which can easily be adjusted for internal testing. The interface is based on widgets (separate user-interface elements), which can be programmed separately. Therefore, moving, adding or removing widgets can easily be done within this prototype.
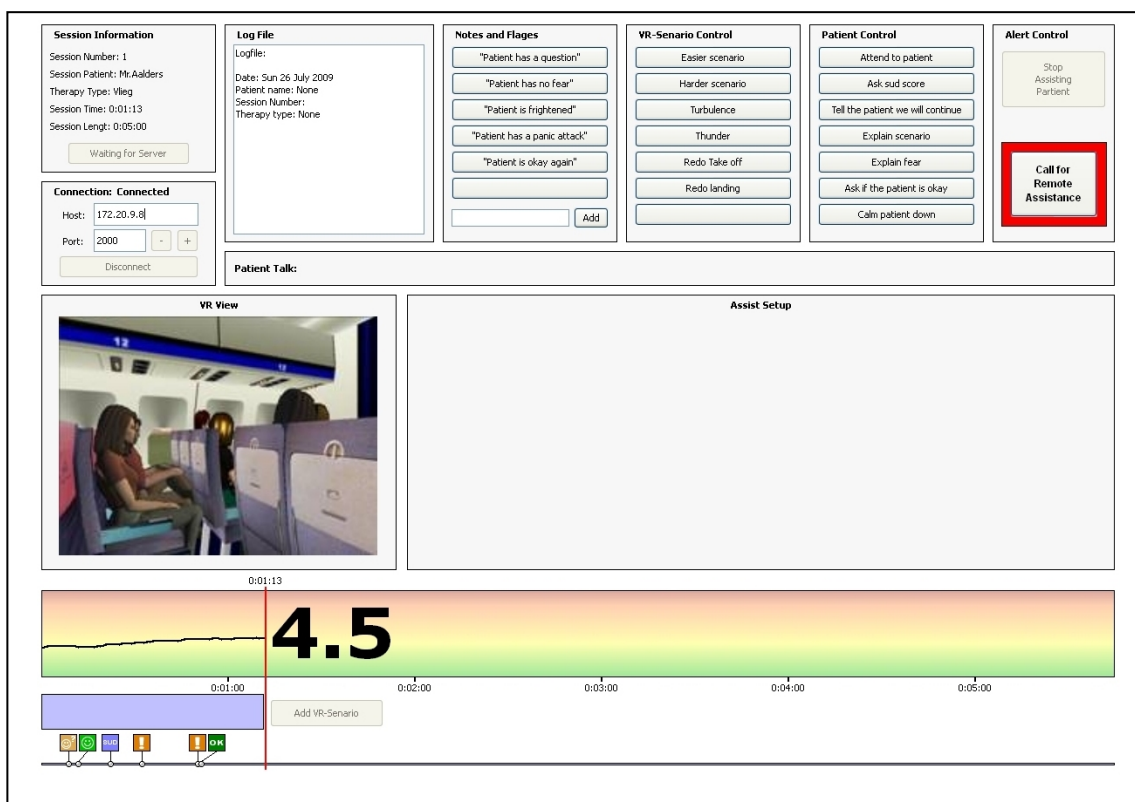
Figure 4.4: *The session client user-interface designed to be used by the therapist.*

The sessionClient user-interface

This prototype had two user-interfaces, one designed for the therapist and one for the mainServer. The sessionClient user-interface was designed to be used by a therapist (Figure 4.4). The interface was made to be full screen so a therapist cannot be distracted by anything else occurring on the desktop of the computer. The user-interface was divided in widgets each with their own separate function, to maintain a better overview and to be able to adjust the user-interface in the future.

With the "Session Information"-widget in the top left a therapist can create, input and view a session and its information. This widget changes depending if the state of the session is "Paused", "Started" or "Ended" (Figure 4.5). When a session is created the therapist has the opportunity to enter all session information. When the session started this is no longer possible. The "Connection"- widget is

used to set up a link with the main server. This connection is needed before a session can be created or a simulation can be run. The user can enter the IP-address of the computer where the mainServer application is running and set an appropriate port. A default host IP-address shown. This is the IP-address of the current computer. Therefore, if you want the mainServer and sessionClient to run on the same computer the user can use this IP-address.

There is also a "Log file" widget, which shows the content of the log. Next to that the therapists input widgets are placed; "Notes and flags", "VR-scenario control", "Patient Control" and "Alert control". There is also a widget that shows the patient's view and space for extra widgets. At the bottom of the window a timeline is visible, showing the time left for the session, the anxiety-score, the anxiety-score history, the VR-scenarios, the notes and flags.
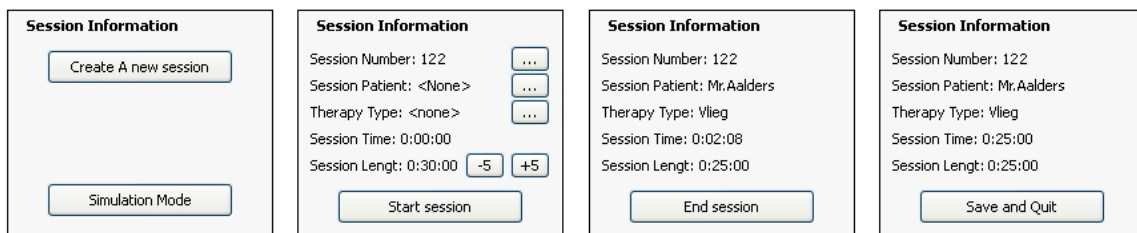
Figure 4.5: *The session information widget changes during the state of a session.*
a) No session is created.   b) The session is made.   c) The session has started.   d) The session has ended.

The mainServer user-interface

The mainServer user-interface (Figure 4.6) also has a connection widget, which is used to make a connection to multiple sessionClients. At the right side of this widget, a list of all sessions on the server is shown. These are both the running and ended sessions. If a therapist starts a new session it will appear on this list. An experimenter can select a session from the list and view the timeline and simulation score in the widgets below.
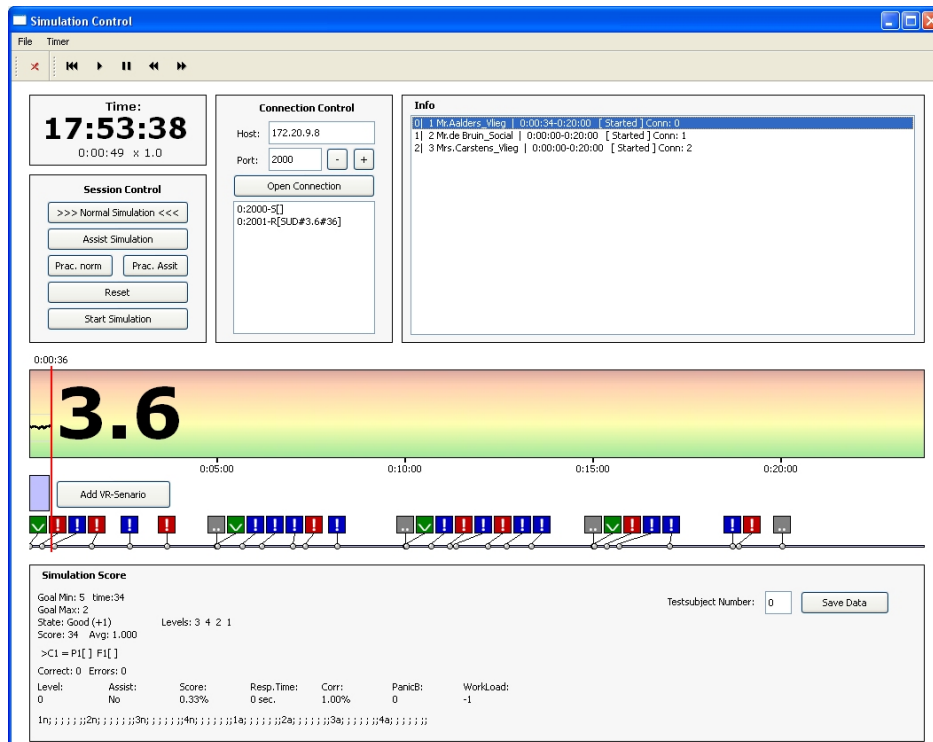
Figure 4.6: *The mainServer user-interface.*

At the top of the mainServer user-interface, time buttons are visible; with these, the simulation speed can be adjusted. The simulation can be paused or run on double speed. The mainServer application also has a "Session control"-widget, with which new simulations can be created, reset and started.

4.6 The automated-assist system

The automate assistance software (auto-assist) can monitor the patients' anxiety-score. Before each session the therapist can adjust how the auto-assist will react to certain scores for that particular patient, as described in section 3.7.5. This prototype however did not have an implementation of the setting up of an auto-assist. The experiment described in chapter 5 did not require the participants to configure the auto-assist, because they all needed to use it with the same settings. The auto-assist part of this prototype was pre-programmed.
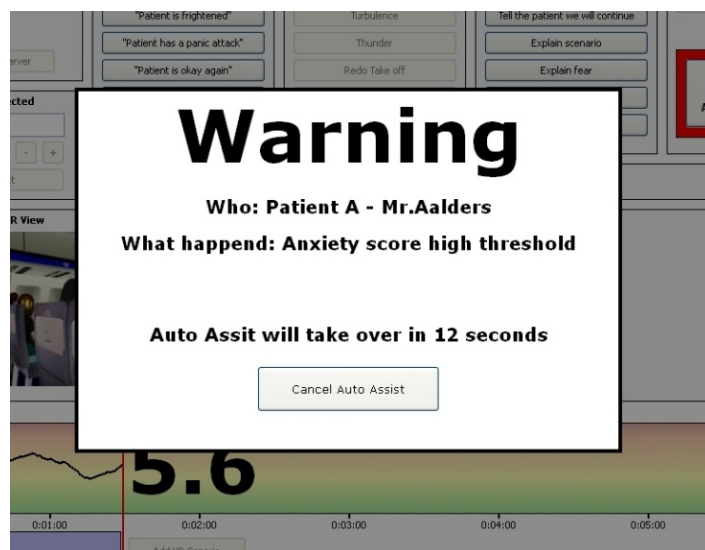
Figure 4.7: *The warning window of the sessionClient.*

The auto-assist reacts by monitoring pre-programmed upper thresholds of all patients. These thresholds are the upper bounds, in which the anxiety levels of the patients are considers not to high. If the anxiety-score of a patient goes over these upper thresholds, the system would produce an alarm and will show an alarm-window in the sessionClient's user-interface of this particular patient (Figure 4.7). A timer will start to countdown. The therapist has the option to cancel the timer on the alarm and let the auto-assist not take any actions until the system again recognises that the anxiety score crosses the threshold. If the timer has reached zero, the auto-assist will take over by giving the patient an easier scenario. If the patient's anxiety-scores stay above the threshold, the auto-assist will keep switching to an easier scenario until the most neutral VR-scenario available is reached.

5 Experiment

During initial research and the interviews with therapists, it became apparent that the workload of the therapist might play an imported role in the success of multiple patient VRET. Some therapist felt they could not adequately assist multiple patients at the same time because the workload could become so high that cognitive lock-up would occur. Three methods to lower the workload of the therapist were suggested: (1) The use of pre-programmed VR-scenarios (2) the addition of a software based automated assistance system and (3) the ability for the therapist to call for assistance on location.

To explore the impact of the auto-assist on the workload of the therapist additional research was needed. This chapter describes how an experiment was conducted to explore the effect of the suggested automated assist on the workload of participants in a multiple patient VRET situation. The hypothesis was that by adding an auto-assist, the workload of the participant would go down.

To lower the workload of the therapists an additional option was available. As described in the preliminary specifications, the therapist has the possibility to call for assistance on location. Thereby signalling an assistant in the immediate vicinity of the patient, who will then physically go up to the patient and provide local assistance. For this option to have affect, it would be necessary that a therapist assisting multiple patients feels covetable using this option. Boehne [23] describes that people are reluctant to give up certain tasks and are stuck with their choice to perform a specific task. Because of this phenomenon, it was decided to additionally explore if participants would use this "Call for local assistance"-option, thereby delegating their task and responsibility to someone else, in overload situations.

The most valid method to test the effect of the suggested auto-assist would be to use a situation with real therapist assisting real patients. Using real patients would imply that people with phobias would be placed in an experimental situation, where they had the chance to receive faulty treatments at this stage of research. This was not a desirable situation. Using real patients would also mean that every therapy session would be different thereby introducing many unknown variables to the experiment. To overcome these problems, it was decided to use computer-simulated patients that provided the same type of experience as assisting real patients with VRET.

For the most valid result of the experiment actual VRET therapists should be used as participants. Because there were a very limited amount of these therapist available and it would be hard for them to find the time to do the experiment, the choice was made to use people with the same technological skill-set as the therapists. To compensate for the fact that these people did not have the therapeutic knowledge of a therapist they were presented with protocols on how patients should be treated during VRET sessions.

Section 5.1 will go deeper in the methodology and the setup of the experiment, it discusses the participants, material, procedure and the measurements of the experiment. This section also explains how simulations with different levels of task load were created. In section 5.2 the results of the experiments are presented, both the observations and the quantitative measurements that were made during the experiment. These results show that the proposed automated assistance had a significant effect on the metal effort of the participants and that all participants did use the "Call for local assistance"-option. In section 5.3 these results are discussed, this chapter will close with further improvements to the proposed automated assistance.

5.1 Method

To test the effect of the auto-assist on the workload of participants and to explore if participants would use the "Call for local assistance"-option, the participants needed to experience the same type of environment as a therapist assisting multiple patient with VRET simultaneously. The proposes auto-assist would only take action if the task load of the therapist would be too great. This meant that in the experiment the participants needed to be exposed to different levels of talk load. There was also the need of a situation where participants needed to push the "Call for local assistance"-button, so four distinct levels of tasks load simulations were created each lasting exactly five minutes. The lowest was created to explore the effect of auto-assist on a "Low" task load situation. The second labelled "Medium" was created to simulate an average amount of task load. The third, labelled "High", simulated a high task load level. A fourth task load level was added, a manual impossible task load level, which was labelled "Impossible". In this simulation, the simulated patients needed so much attention that the user did not have sufficient time to assist all patients, thereby coursing an overload [20] situation. It was expected that users of the system in that situation would uses the "Call for local assistance"-option.

In the experiment, participants had to assist three simulated patients in the four different task load level situations. The number of simulated patients was kept the same during the experiment, because it would add more complexity to the experiment if the number of patients was an additional variable. To create different levels of task load with the same amount of simulated patients, the amount of assistance the simulated patients required was increased. Participants received pre-determent protocols on how to assist these simulated patients, this was done to ensure each participant knew how to assist the simulated patients correctly. The participants did not talk to the patients, but used buttons to simulate a conversation with the patients. Each conversation would take a fixed amount of time, during this time the system was locked, making it impossible for the participant to assist two patients at the same time.

In the proposed auto-assist system, the therapist can configure the rule-set of this system prior to a session. For this experiment it was decide to give all participants the same rule-set for the auto-assist. This was done so the participants, who were no real therapist, could not make mistakes when configuring the auto-assist. Moreover to ensure that all the actions of the auto-assist were consisted for all participants so no extra variable would be introduced to the experiment.

After a five-minute training with the software, the participants were subjected to four task load levels of simulated therapy. The participant got the same simulation blocks, however they were presented in a random order, for each experiment. This was done so that the order of the blocks would have no systematic effect on the result of the experiment. The software monitors if the patients was following the protocols correctly and thereby providing accurate treatment. To test the participants in situations with and without auto-assist, the four simulation-blocks were run twice per patient, once with auto-assist and once without. The order was counterbalanced to ensure that results were not influenced by the order of auto-assist and none auto-assist.

5.1.1 Participants

Because there were only limited amount of therapist with the skills in VRET available to act as suitable candidates, the choice was made not to use actual therapists as participant. The hardware setup of the experiment involved four computers and seven monitors so it was not practical to bring the experiment to the individual therapists (which was the case for the interviews). A great disadvantage of not using therapist for the experiment was that the data collected during this

experiment could not be directly generalized for actual therapists. Nevertheless, if results show a difference in the workload of the participants, it could be an important first step of establishing that auto-assist could also influence the workload of real therapists.

To compensate for the fact that the participants of the experiment were not therapists, participants were uses with the same type of education level as a therapist. All participants were at least following a university level of education. In total there were 27 participants of the experiment 20 males and 7 females between the ages of 21 and 30 (*M = 24, SD = 2.7*). The participants were bachelor or master students of Delft University of Technology, who volunteered to be participant in the experiment.

To achieve that not psychologically trained people could be uses for the experiment, all participants were provided with a list of protocols (Appendix E). These protocols specified how the participants had to assist the patients for all possible situations. The participants had to follow these pre-determent protocols correctly to provide proper treatment for the simulated patients. Additional, the participants did not have to talk to the simulated patients, but used buttons to simulate conversation with the patients; this meant that the participants did not need to posses the communication skills of a therapist. To ensure that participants could not talk to more than one patient at the same time, all patient-communication-actions took a set duration (Table 5.1). During this period, it was not possible to assist another patient at the same time. The participants had to wait until the action was finished before they could start a new action.

Name	Duration	Effect on Patient's anxiety	Time to take effect
Patient Communication			
Attend to patient	10 sec	0 Points	-
Ask SUD score	5 sec	0 Points	-
Tell the patient we will continue	5 sec	0 Points	-
Explain scenario	20 sec	0 Points	-
Explain fear	20 sec	0 Points	-
Calm patient down	15 sec	-2 Points	10 sec
General treatment			
Set easier scenario	10 sec	- 3 Points	30 sec
Set higher scenario	10 sec	+3 Points	30 sec
Fear of flight			
Set turbulence	10 sec	+1 Points	10 sec
Set lightning	10 sec	+1 Points	10 sec
Redo Take off	20 sec	0 Points	-
Redo landing	20 sec	0 Points	-
Social phobia			
Set new scenario	15 sec	0 Points	-
Set Dialog subject: Dogs	10 sec	0 Points	-
Set Dialog subject: Girls	10 sec	0 Points	-
Set Dialog subject: Computes	10 sec	0 Points	-
Set Dialog subject: Rodents	10 sec	0 Points	-

Table 5.1: *Overview of the possible actions to assist a simulated patient.*

5.1.2 Material (Software)

5.1.2.1 Patient simulation

To provide the participants with working conditions a therapist would face when assisting multiple patients, multiple patients were simulated by the software. These simulated patients were pre-programmed to show certain behaviour at set times within a session. Patient information was presented on two monitors and speaker sets were used to produce the speech each of the simulated patient. One monitor showed the simulated view of the patient. This view depicted different expressions with different levels of fear of the patient. These views were photos, taken of (amateur) actors depicting VRET patients, which were taken prior to the experiment. The second monitor showed the user-interface with the anxiety-score of the patient, this score told the participant the general level of anxiety of the simulated patient. The simulated patients "talked" to the participants using pre-recorded sentences coming from the speakers. Each simulated patient looked different and had a different voice.

Two types of patient behaviour could be triggered, the first were the anxiety-score of the patient went up or down within a set time frame. When these events occurred the participant was expected to react accordingly by taking actions (Table 5.1), following the pre-determine protocol (Appendix E). The second type of patient behaviour was an action from the patient directly; the patient would talk to the therapist via the pre-recorded samples. The patient would for example have a simple question or would ask for a change in their treatment. The participant was expected to react in each situation following the protocols.

5.1.2.2 The Protocols

Within the simulation the participants had to correctly apply the pre-determent protocols to the simulated patients (Appendix E). These protocols were based on actual VRET therapies [8] and were discussed with a therapist with extended experience with VRET. The participants could study these protocols as long as they needed before the experiment began.

There were nine different protocols, each protocol consists of multiple actions needed to complete it; some protocol only required two actions while other needed up to four actions. Some actions involved "talking" to the patients, which took a set amount of time (Table 5.1). Each of the protocols thereby had their own minimal time to accomplish; this was the least amount of time needed to correctly assist that patient. While assisting a patient it was impossible for the participant to assist a second patient. Some protocols had a minimal time of five seconds other 35. In addition, some protocols were more complex to complete then others, because these protocols required additional patient information to be correctly completed. This meant that participants had to remember this information or look this up in a paper document.

There were three groups of protocols; the first had to be executed when a patient showed an anxiety-score below or above the patient's anxiety thresholds. The second set of protocols were general events triggered by the simulated patients, for example, if a patient had a question the participant had to "attend the patient" and set a specific flag for record keeping. The last group of protocols dealt with particular phobias. In the current setup, there were two patients with fear of flight and one patient with a social phobia. The participants had to make sure that they would use the proper protocols for the proper patients and execute them as good as possible.

5.1.2.3 Creating five simulation blocks

Five simulation-blocks each lasting five minutes were created: (1) a practice simulation, (2) a simulation with a "Low" task load, (3) a simulation with a "Medium" task load, (4) a simulation with a "High" task load and (5) a simulation with "imposable" task load. The practice simulation was constructed to let participant get familiar with the software. This simulation consisted of the assistance of the three patients whereby first patient A asked for assistance then patients B and lastly patient C. In this practice simulation, the participants had enough time to react, to ensure they could familiarise themselves with the controls and the protocols. To ensure that the participants got familiar with the protocols at least one protocol of each type was included in this practice simulation.

To measure the effects of the proposed auto-assist on different levels of tasks load situations, four simulation-blocks with increasing levels of task load were made. To create these tasks load levels, the three load factors from the *Current Task Load model* as described by Neerincx [20] in section 2.3.1, were used (Figure 5.2). The first load factor is the *percentage time occupied*. This factor is coupled with the amount tasks the user needed to execute in the set amount of time to correctly assist the three simulated patients. The tasks or protocols have different accomplishment times; more and longer protocols divided between the patients increase the percentage time the user is occupied during the simulation. Up to a point where tasks take too much time therefore it could happen that the user can handle the situation, but on every task, they can get a little behind, losing control in the end (vigilance). In addition, the talks load can be so high that it is impossible for the user to handle these tasks correctly, causing overload. The "Low" task load simulation had a percentage time occupied of around 40 percent. The "Medium", "High" and "Imposable" task load simulation had a respectively 70, 90 and 120 percent of time occupied.
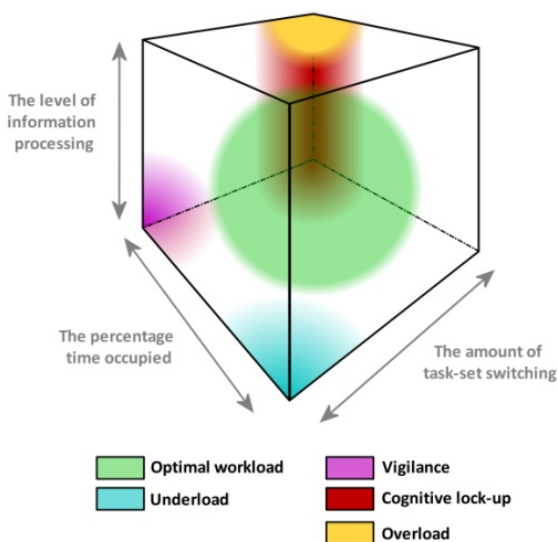
Figure 5.2: The three factors of the task load model. Neerincx distinguished several critical regions [18].
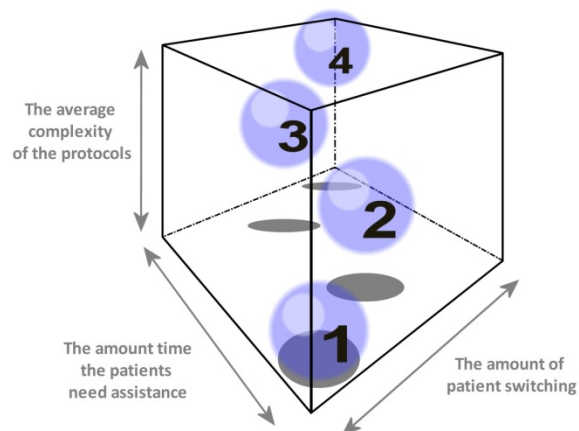
Figure 5.3: A general indication on the difference between of the four task load levels, based on the three factors of the CTL model. (1) "Low", (2)"Medium", (3) "High" and (4) "Impossible"

The second load factor of the CTL model is the level of *information processing*; this is linked with complexity of the protocols the user had to execute. More complex protocols meant that amount of information processing required by the user would increase. Some protocols were designed deliberately to require additional information processing, like looking up patient info in the patient files or memorising patient anxiety threshold levels. In simulations with higher task load levels, these protocols occurred more frequently. The last load factor is the *amount of task-set switching*. The user

always has control over which patient he or she wants to assist, however simulation- blocks with higher task load levels were created in such way that the user had to switch more often between patients, thereby increasing the amount of task-set switching.

A simulation-block was designed to have a "Low" task load, this meant that the user was expected to have more than enough time to correctly assist the three simulated patients, and the type of tasks the user had to execute to provide assistance were not complex. In addition, not much switching between patients was required. The second and third simulation-blocks were called "Medium" and "High"; these were made to test the effect of the auto-assist on increasingly higher task load level situations. More and longer task needed to be executed to assist the patients. Additional, the task were more complex and more switching between the patients was required (Figure 5.3).

The fourth simulation-block labelled "Impossible" was created in such fashion, that when the user had to assist the simulated patients without auto-assist, it was impossible to correctly provide assistance to all patients. This was the case, because the tasks the user had to execute took up more time than that was available. In addition, and the tasks were complex and a lot of switching between patients was required (overload). The only way to correctly assist the simulated patients without auto-assists, was by using the "Call for assistance"-function. Because the auto-assist is able to assist multiple patients simultaneously, it would be possible to provide assistance to all the patients in this simulation-block, but if a mistake in the treatment was made, the user could also use the "call for assistance"-function to provide additional support for the simulated patients.

5.1.3 Material (Hardware)

For the setup of the experiment, were the participants would monitor and assist three simulated patients, four computers on a local network were required. Three computers with each two monitors and a speaker set for running the three simulated patient's sessions and one computer to act as a central server. The person conducting the experiment used the server to start and reset the simulations and to collect all data. The setup was located in a closed experimentation room with no outside disturbance (Figure 5.4). The experimenter was located in the same room as the participants. He sat behind the participants so they did not feel distracted.

Figure 5.4: The hardware setup of the experiment.

The six computer monitors were placed on an L-shaped desk in three pairs of two (Figure 5.5), the left showing the user-interface and the right showing the cameral image of the simulated patient. The speakers were placed in such fashion that the sound came from the same direction as the monitors. The prototype software as described in chapter 4 was used, running three sessionClients and one mainServer. Extra functionality was added to the software, to simulate the patients and measure the participants' performance during the experiment.
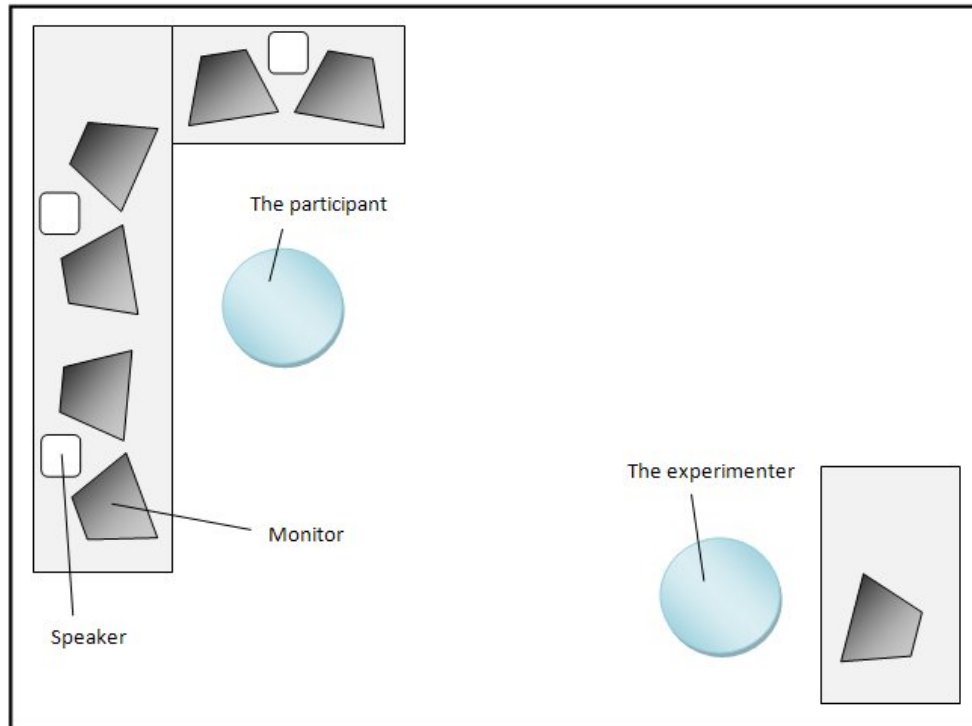
Figure 5.5: Hardware Layout.

5.1.4 Procedure

The complete experiment was divided in four phases (Figure 5.6), taking in total about an hour. In phase I of the experiment, the participant was welcomed by the experimenter and was asked to take a seat in the appropriate chair. The participant received three documents. The first consisted of general instructions on the experiment (Appendix F). The second was the list of protocols for assisting patients with VRET (Appendix E). The last were the patient documents (Appendix G) which provided additional information on the three "patients" the participant had to treat in the simulation. The participants were given time to read the documents and ask questions about the experiment.

Initial to the experiment, the participants were assigned to one of two groups; group A or group B. The first participant was assigned to group A, the next to group B, the third to group A again and so further. When a participant was assigned to group A, he or she would start phase II of the experiment with the auto-assist turned off. The participants of group B would start phase II with the auto-assist turned on. In phase I of the experiment, the participants of group B received explanations on the auto-assist, so the participants were informed on how it would function. This information was also provided to the participant in group A in phase III of the experiment, when these participants had the auto-assist enabled.

When participants had no further questions, they were asked to read through and sign the consent form (Appendix H). Subsequently, the participants were given the five minute practice simulation to familiarise themselves with the controls and the protocols. The participants of group B received the

practice simulation with auto-assist and the candidates of group A without. When the participants had completed the practise simulation and they had no further questions, phase II of the experiment could start.

Phase II and phase III of the experiment were similar with the only exception that in one phase the auto-assist was turned on and in the other it was turned off. The order of the five-minute simulation blocks was random so this could be dissimilar as well. The participants of group A started with the auto-assist turned off, the candidates in group B start with the auto-assist enabled. During phase II and phase III, the participant received a twenty minutes simulation divided in four blocks each with their own level of task load as described in section 5.1.2.3. During the simulation, the candidate had to assist all patients by following the protocols as accurate and quickly as possible. Every five minutes the participants were asked to rate their mental effort using a rating scale based on the *Rating Scale Mental Effort* (RSME) by Zijlstra [40]. When the twenty-minute simulation was finished, the participants were asked to fill in a questionnaire based on NASA-TLX [41], which will be described in section 5.1.5.

In phase III, the simulation was repeated, however with the auto-assist turned on or off respectively. The participants of group A got the explanation of the auto-assist so they would understand how it worked. When phase III was completed a debriefing was provided to the participant in phase IV. The participants were asked how they liked working with the prototype and if they saw room for future improvements. After the debriefing, if participants were interested, additional detailed information was provided about the purpose and setup of the experiment.
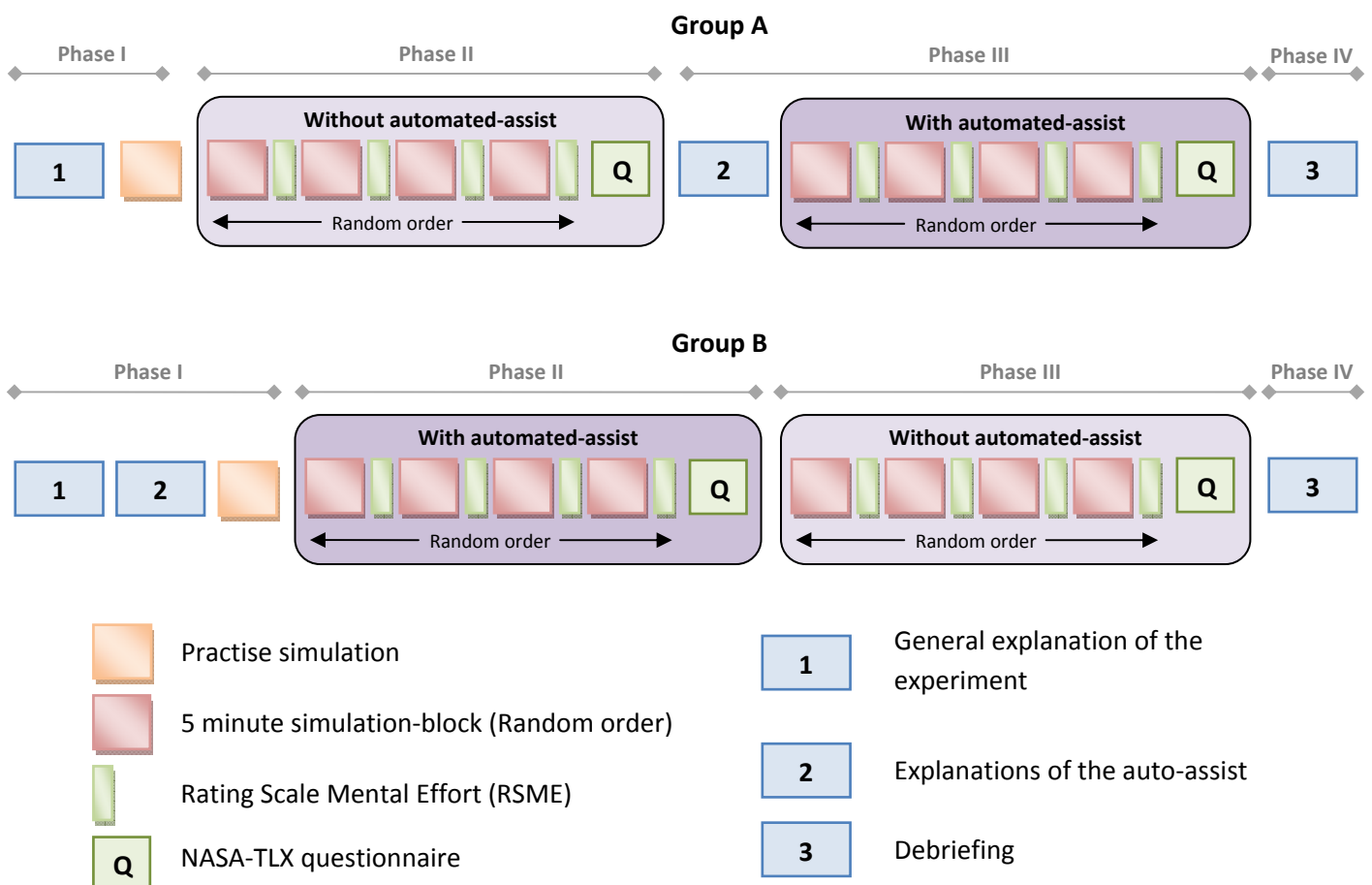

Figure 5.6: An overview of the experiment.

5.1.5 Measurements

During each experiment, the software collected four quantitative measurements. The first was the *average response time* of the participant in seconds. The software measured the time the participant needed to respond to a simulated patient. At the end of a five-minute simulation-block, the average time was calculated. The second variable was the *performance* of the treatment of the three simulated patients. The software calculates the percentage of time the anxiety-score of the patients was between the low and the high threshold.

The third software measurement was the *correctness* of the treatment*,* which is the percentage of correctly executed protocol-steps by the participant. If a participant did not follow the protocol it was regarded as a error. The system computed the percentage of correct action executed by the participant. The last variable indicated how often the participants had presses the "Call for local assistance"-button.

Apart of the data collected by the software, two subjective measurements of the participants were gathered. At the end of each five minute block the participants were presented with a screen asking them to judge there mental effort (Figure 5.7). This window was based on the *Rating Scale Mental Effort* (RSME) by Zijlstra [40]. The participant was asked to indicate how much mental effort it took to complete the task by moving the slider on the screen. The participant could see the number and could then press the "ok"-button if they were satisfied with the score. This score was saved by the computer and added to the other data collected.
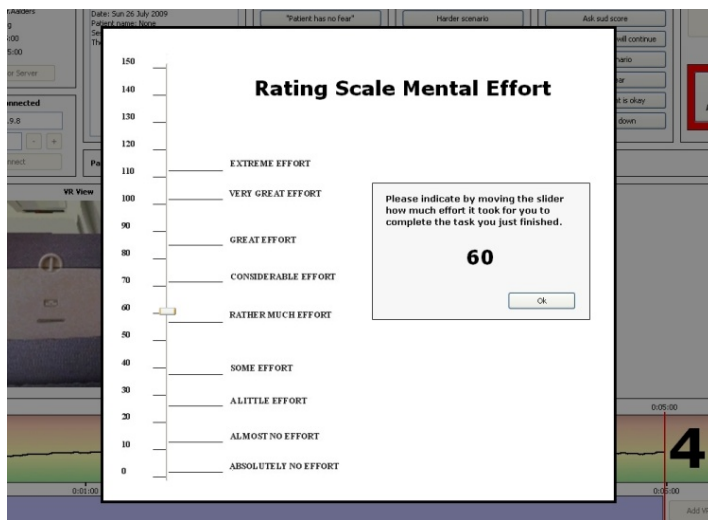
Figure 5.7: *The RSME window.*   **Figure 5.8:** *NASA-TXL.*
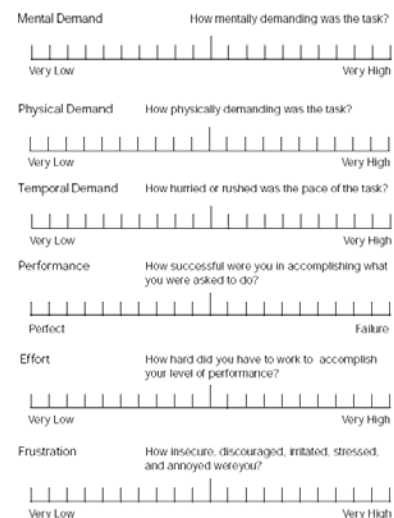
The second subjective measurement was a questionnaire the participant was requested to fill in after the completion of a twenty-minute phase of the experiment (Appendix I). This meant that the participant had to fill-in this form twice, ones after the completion of a simulation with auto-assist and once without. This questionnaire was based on the NASA-TLX [41] rating technique (Figure 5.8) which is a global and standardized workload rating system, which provides a sensitive summary of workload variations. The NASA-TLX is based on six factors: (1) mental demand, (2) physical demand, (3) temporal demand, (4) satisfaction in performance, (5) effort and, (6) frustration level. According to NASA-TLX [41] these factors are seen as most relevant to the model of the psychological structure of subjective workload.

5.2 Results

5.2.1 Observations during the experiment

At the start of the experiment the observation was made that about two third of participants were initially overwhelmed by the protocols presented to them. However, they soon realised there were not so complex and most of them only needed about two minutes to study the protocols. Almost all participants started to understand how to use the protocols during the practise simulation. After the five-minute practice simulation, all patients felt ready to start the actual experiment.

The observation was made that about half of the participants were annoyed by the fact that the anxiety thresholds of the patients were different. Some asked if they could use post-it notes to write down the threshold and stick them to the monitor with the appropriate patient. This was not allowed. Participants made the remark that in a final product the anxiety-scores of the patients could scale, so each patient would have the same anxiety-score threshold. Participants kept on using the information documents to look up the thresholds and protocols. Most participants quickly found a structure within the protocols making them easier for them to remember. At the end of the experiment the majority of participant knew the protocols by heart, making it much easier for them to act quickly during the simulations.

During the experiment, the observation was made that the participants had no problem using multiple monitors and mice. The participants did not show problems with distinguishing between the three patients. They recognised the voices of the patients and used the fact that they could hear the voices from the direction of the monitors of appropriate the patient. During the experiment there was no observation made of a participant making a mode-error, no participant was observed assisting a wrong patient by accident.

The observation was made that all participants remembered to use the "Call for local assistance"-button. Some stated in the debriefing that they were a bit hesitant to use it the first time, but once the participant used the button and it became clear to them what would happen, they tended to use it more often. Most participants used the button if it became apparent to them that they did not have the time to help a patient or when extremely high anxiety-scores were presented.

When the auto-assist was explained to the participants, some of them asked if it was better to use the auto-assist or do it themselves. The reply was that they had to make that choice for themselves. During the debriefing some participants made the remark that it was clear to them when the auto-assist started to assisted the patients. However it was not always clear what the auto-assist was doing, when it was ready and when it was deactivated again. Some participants saw the time they had to wait before the auto-assist would react, as a negate factor. Some participants suggested a "Start auto-assist immediate"-button next to the "Cancel"-button to remove this waiting time.

5.2.2 Quantitative measurements

The quantitative data collected during the experiment consisted of two sets. One set contained the data collected for each of the eight five-minute simulation-bocks. Four blocks with the four differed task load levels with auto-assist and four blocks without. The other set of data consisted of the information acquired with the NASA-TLX questionnaires that were filled in twice per participant once with auto-assist and once without (Chapter 5.1.4).

The data collected during each of the simulation-bocks, consisted of five variables: (1) Perceived mental effort, (2) average response time, (3) therapy performance, (4) protocol correctness and (5) the number of calls for remote assistance. To explore if the results were normally distributed *Kolmogorov-Smirnov test of normality* was used. One variable clearly showed not to be normally distribution; this was the number of calls for remote assistance. This was expected because at task load level "low" and "medium" almost none of the participant used this option, thereby showing no clear normal distribution. Because of this, the number of calls for remote assistance was analysed separately with non-parametric tests. The four normally distributed values were analysed together, using *multivariate analysis with repeated measurements*. The results of the NASA-TLX questionnaires were also tested for normality, which showed significant deviation from a normal distribution. Therefore a *one-way MANOVA* was used to analyse this quantitative data set.

5.2.2.1 Multivariate analysis with repeated measurements

The quantitative data measured during each of the eight simulation-blocks, contained four normal distributed variables: perceived mental effort, average response time, therapy performance and protocol correctness. *Multivariate analysis with repeated measurements* was used to look at the results of the data. Auto–assist (AA) and task load level (TLL) were *independent variables* (Figure 5.9). Multivariate analysis was used because the data was acquired by independent observations and all measurements were on an interval or ratio scale.
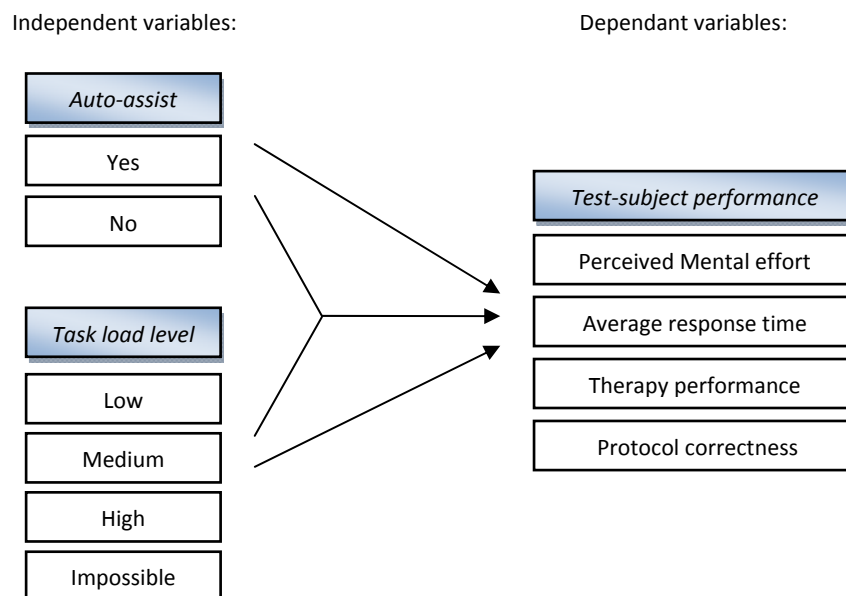
Figure 5.9: Conceptual model of components.

Initial to the use of repeated measurements, the data was checked on sphericity, which meant it had to be homogeneity of variance and the variances of the differences between levels had to be similar to one another. *Mauchly's test of sphericity* indicated that not all data was. Only protocol correctness

(*p.* = 0.110) under LLT and perceived mental effort (*p.* = 0.879) under AA*LLT proved to have no significant deviation from sphericity. The other variables showed significance level of the Mauchly's test < 0.05 so sphericity cannot be assumed. Therefore, for the remaining variables the results with the Greenhouse-Geisser correction were taken.

Main effect of the task load levels

Multivariate analysis with repeated measurements showed the main effect of the task load level to be significant (*p.* < 0.001). To visualise the difference between the variable per task load level, Error Bars were created (Figures 5.10). These gave an initial overview of the distribution for all the four task load levels. The analysis revealed that all variables showed significant difference (Table 5.11) per task load level. This meant that the levels of task load had achieved to do what they were designed for; deliver dissimilar experiences to the participants. The Perceived mental effort and average response time increased and the therapy performance and protocol correctness decreased when task load increased.

Figure 5.10: *Error Bars: 95% Cl.* Perceived mental effort, Average response time, Therapy performance and Protocol correctness

	Mean per task load level				Hyp.	Error.		
Measure	"Low"	"Medium"	"High"	"Impossible"	*df*	*df*	*F*	*p*
Joint measure	-	-	-	-	228.00	12.00	13.28	0.000
Perceived mental effort*	32.7	39.4	55.2	63.4	1.59	41.42	60.10	0.000
Average response time*	11 sec	12 sec	14 sec	20 sec	2.07	54.03	63.77	0.000
Therapy performance*	98%	90%	71%	59%	2.11	54.90	474.93	0.000
Protocol correctness	93%	88%	80%	71%	3.00	78.00	47.55	0.000

*) Greenhouse-Geisser is taken because none passed the spherical assumption test

Table 5.11: *The multivariate analysis main effect of the task load levels.*

Main effect of the automated assistance

The main goal of the experiment was to determine if the auto-assist had any impact on the workload of the participants. Multivariate analysis with repeated measurements showed the main effect of the auto-assist to be significant ($p. < 0.001$). When split out per variable, the results showed that not all variables showed significantly differences while comparing auto-assist with no auto-assist (Table 5.12). The only significant variable was the perceived mental effort of the participants ($F(1, 26) = 15.12$, $p. < .001$). The participants rated their mental effort on average 9.5 points lower with the auto-assist enabled.

Measure	Mean regarding AA		Hyp. df	Error. df	F	p
	No-AA	AA				
Joint measure	-	-	5	22	12.77	0.000
Perceived mental effort*	52.4	42.9	1	26	15.12	0.001
Average response time*	15 sec	14 sec	1	26	1.31	0.263
Therapy performance*	79 %	80 %	1	26	0.45	0.508
Protocol correctness *	82 %	84 %	1	26	1.97	0.172

*) Greenhouse-Geisser is taken because none passed the spherical assumption test.

Table 5.12: The multivariate analysis main effect of the auto-assist.

Interaction effect of the task load levels * automated-assist

The next step was to explore the two-way interaction effect of the auto-assist and the task load level. The multivariate analysis with repeated measurements showed this to be significant ($p. < 0.001$). When the individual variables were further explored, they showed (Table 5.13) that only protocol correctness had a significance different effect on the presence of auto-assist per task load level ($F(2.3,61.8) = 3.416$, $p. < 0.032$). An estimated marginal means graph (Figure 5.14) showed that at "Low" and "Medium" task load levels the auto-assist had almost no effect, however at "High" and "Impossible" task load levels the auto-assist has an positive effect. This states that the effect of the auto-assist on the amount of errors the participants made was significantly higher when the task load increased. This result could be explained by the fact that at high task load levels more protocols needed to be executed. This meant that the participants had more opportunities to make errors. The auto-assist was programmed to make no errors, therefore if the auto-assist was enabled relative more errors were avoided in session with higher task load levels.

Measure	Hyp. df	Error. df	F	p
Joint measure	15.0	228.0	5.135	0.000
Perceived mental effort	3.0	78.0	0.902	0.444
Average response time*	2.2	56.5	0.928	0.408
Therapy performance*	2.0	53.2	0.406	0.673
Protocol correctness *	2.3	61.8	3.416	0.032

*) Greenhouse-Geisser is taken because none passed the spherical test.

Table 5.13: The multivariate analysis two-way interaction effect of the TLL*AA.
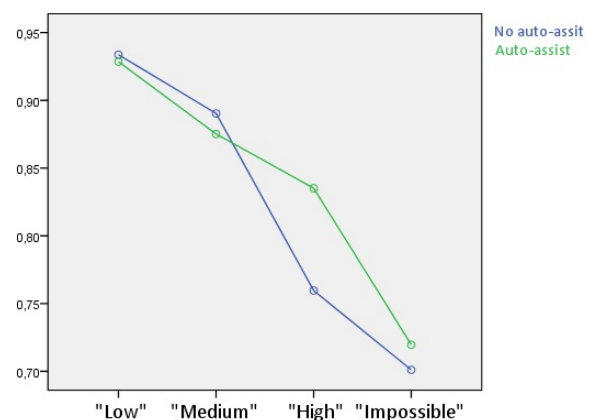
Figure 5.14: Estimated marginal means of protocol correctness.

To further visualize the impact of the auto-assist on protocol correctness the per task load level, a *clustered error bars* graph of the protocol correctness was created (Figure 5.15). This graph provides more detail in the visualisation of the effect of the auto-assist per separate task load level. In addition, a clustered error bars graph was created for the perceived mental effort per task load level (Table 5.16), because this variable showed a significant effect in regard of the auto-assist. The graph clearly showed that the auto-assist had the same relative significant effect of the perceived mental effort on all four task load levels.
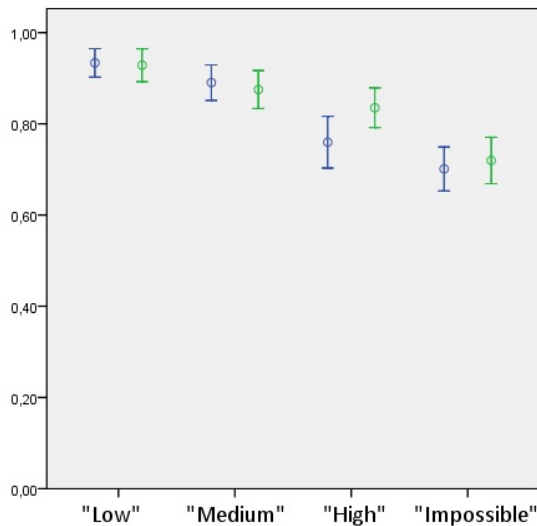
Figure 5.15: Clustered error bars (95%) of protocol correctness
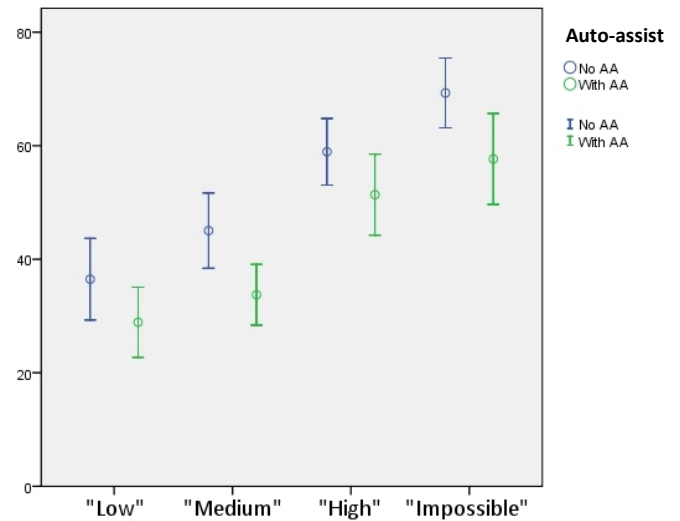
Figure 5.16: Clustered error bars (95%) of perceived mental effort.

5.2.2.2 Call for remote assistance

The second goal of the experiment was to explore if participants would use the "Call for local assistance"-option (Table 5.17), thereby delegating their task and responsibility to someone else in overload situations. The results showed that all participants used the "Call for local assistance"-option at least once. At the "High" task load level, without auto-assist, 81% of the participants used the option and at the "Impossible" task load level the results were 100%. With the auto-assist enabled, it seemed possible to assist all (simulated) patients. However, a majority of the participants still used the call for assistance option ("High" 26%, "Impossible" 70%). This could be explained by the fact that participants were able to try to assist the patients manually, they could choose this option when the auto-assist gave an initial warning. When this manual assistance failed because of time constrains, they could still used the "Call for local assistance"-option. This could indicate that even with auto-assist, additional support on location for the patients might be needed; however, the amount of local support seems less.

Measure	No-AA Median	AA Median	N	χ^2	df	Exact Sig.
"Low"	0	0	27	-	1	1.000
"Medium"	0	0	27	4.00	1	0.125
"High"	2	0	27	12.80	1	0.000
"Impossible"	2	1	27	22.00	1	0.000

Table 5.17: Friedman's ANOVA of the amount calls for local assistance within the four task load levels.

A *Box-plot* of the amount of calls for local assistance (Figure 5.18) visualises the difference of the effect of auto-assist per task level. This graph showed that the higher the task load the bigger effect the auto-assist has on the amount of calls for local assistance. *Kolmogorov-Smirnov* and *Shapiro-Wilk* tests of normality showed that the number of times the participant called for remote assistance deviated from a normal distribution. This meant a non-parametric test had to be used for analysis. A Friedman's ANOVA was made (Table 5.17), which showed that the amount the participants call for remote assistance had both significant difference for the "High" ($\chi^2(1, N = 27) = 12.80, p < .000$) and "Impossible" ($\chi^2(1, N = 27) = 22.00, p < .000$) task load level. On average the number of times local assistance was needed on a task load level "High" and "Impossible" were 73% and respectively 70%

Figure 5.18: Box-plot of the amount of calls for remote assistance.

less with auto-assist enabled. This could mean that adding auto-assist could result in less calls, and thereby less workload, for the assistant on location.

5.2.2.3 NASA-TLX questionnaires

The second set of the quantitative data was obtained by questionnaires basted on the NASA-TLX. All 27 participants had to fill in this questionnaire twice, once after the simulation without auto-assist and once after the simulation with the auto-assist enabled. The presence of the auto-assist was the only independent variable. The data consisted of the six factors of the NASA-TLX, these were the dependent variables. These factors were: mental demand, physical demand, temporal demand, satisfaction in performance, effort and frustration level (Figure 5.19).
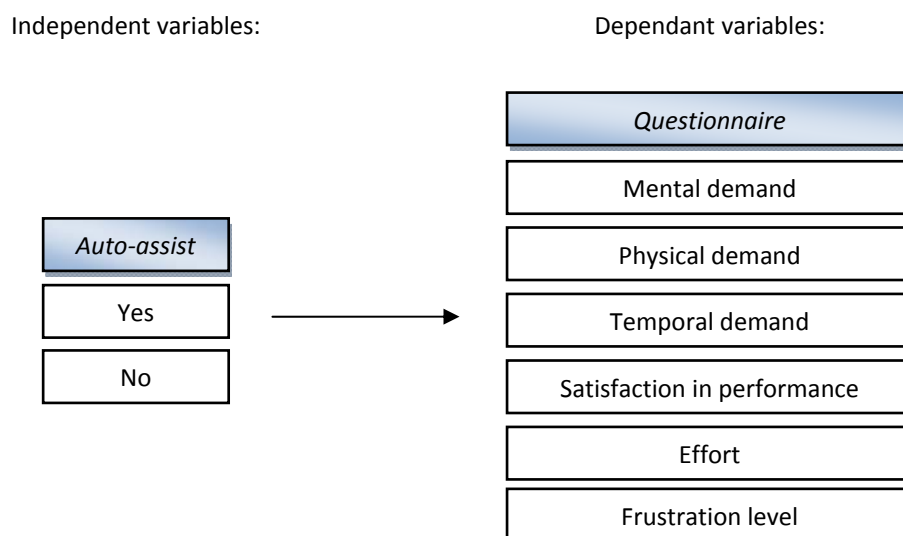
Figure 5.19: Overview of the data collected by the questionnaire.

The joint measure of the MANOVA (Table 5.20) showed a significant difference between the auto-assist enabled or disabled. When explored separately, one of the six independent variables showed a significant difference. The participants significantly rated their *mental demand* lower after a session with auto-assist enabled ($F(1,47) = 5.929$, *p*. < 0.019). The other variables did not show a significant difference.

Measure	Mean		Hyp. df	Error. df	F	p
	No-AA	AA				
Joint measure	-	-	1	47	15.731	0.000
Mental demand	10.9	8.9	1	47	5.929	0.019
Physical demand	4.6	4.6	1	47	1.320	0.256
Temporal demand	11.1	9.7	1	47	0.023	0.881
Satisfaction	9.3	8.9	1	47	0.052	0.821
Effort	10.2	9.2	1	47	0.740	0.394
Frustration level	8.7	7.7	1	47	0.020	0.887

Table 5.20: *Statistical analysis between the six factors of NASA-TLX*

5.3 Discussion

It is important to note that for this lab experiment students where used, not real therapists. It could be possible that students approach the experiment different then a real therapist would and perhaps are more at ease with using computers and software. In the lab experiment, there was no real therapist patient interaction. The participant knew that were assisting simulated patients, assisting real patients could influence the behaviour of the user of the system.

The results of the experiment showed that the participants significantly rated their perceived mental effort lower when the automated-assist was active. The NASA-TLX questionnaire confirmed this, by showing that mental demand was perceived significantly lower in the questionnaires as well. It is possible to state that for this group of participants, the proposed automated assistance had a significant impact on the workload. Because the group of participants did not consisted of actual therapist assisting actual patients, we cannot conclude that in real multiple patient VRET situations this auto-assist will have the exact same effect. However, the results give an indication that the auto-assist could help therapists deal with the higher task load multiple patient VRET could bring.

All participants used the remote of "Call for assistance"-option in the scenario with overload (The "Impossible" simulation), when the auto-assist was disabled. None of the participants forgot, or did not use this option. By using the call for remote assistance option, the participants showed that they had no problems with delegating responsibility to another person. In this situation, it should also be considered that the participants were no real therapist assisting real patients, but the result shows that this might be a viable option for the therapist to handle extreme high talks load situations.

With the auto-assist enabled, it seemed possible to assist all (simulated) patients. However, a majority of participants still used the "Call for remote assistance"-option. This could be explained by the fact that the participants still had the choice to assist the patients manually. When this failed, the "Call for remote assistance"-option could still be used to prove additional assistance. Therefore, it seems that even with auto-assist the "Call for remote assistance"-option should be part of the system. The amount of calls to a local assistant in high task load levels did dramatically decrease (71% less) with the auto-assist enabled. This could indicate that adding auto-assist could result in not only lowering the task load of the therapist but also lowering the task load of the assistant on location.

5.3.1 Adjustments to the specification

While observing the participants and interviewing them at the debriefing, it became clear that it was not always obvious to the participants, when the auto-assist was assisting the patients. To make this more apparent, the user-interface of the therapist could be altered to provide more information on when the auto-assist is actively assisting a patient and what it is exactly doing. In this experiment, the participants did not setup the auto-assist before a session. This could have an impact on the perceived transparency of the auto-assist. In a situation where the therapist prior to a VRET session first configured the auto-assist, the therapist could better understand how the auto-assist is going to react to the patients. It could be possible that the auto-assist places additional flags to communicate to the therapist, which rules fired and how the auto-assist reacted.

The participants also made the remark that they did not liked the fact that the anxiety thresholds were different per patient. They felt that it took them more effort to remember the thresholds of the each separate patient. If the thresholds of the patients were the same, they could be easier to remember. It would be possible to add an element to the interface of the final product with which the therapist can manually adjust the scaling factor for each patient or which visualises the threshold on the screen.

A majority of the participants mentioned that there were situations where they wanted to activate the auto-assist immediately. However, in the proposed version they had to wait for 15 seconds before the auto-assist would automatically start. By adding a second button marked "Start auto-assist now" next to the "Cancel auto-assist"-button (Figure 5.21) the therapist would gain the option to start the auto-assist right away and thereby not have to waist 15 seconds of the patient's time.
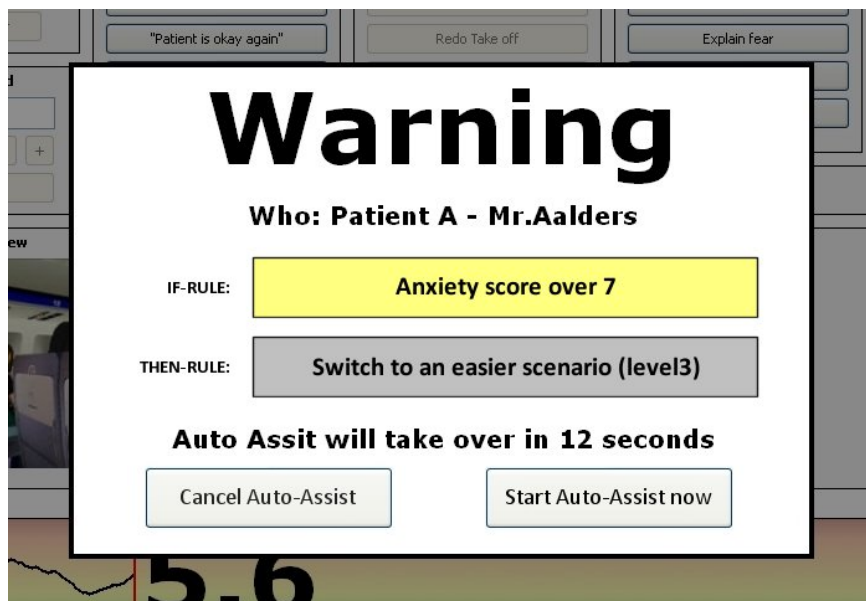

Figure 5.21: *Proposal for a new warning window.*

6 Conclusion

The goal of this thesis was to explore the possibilities and to create a preliminary specification of a multiple patient VRET system. This goal was approached in two ways, first creating scenarios and using these when interviewing experts, to come to preliminary specifications. The next approach was the construction of a prototype and an experiment to explore how people would react to simulated multiple patient VRET with and without the proposed auto-assist function.

The interviews with the experts revealed that most therapists were in favour of the remote communication setup as proposed. Some therapists were a bit hesitant to the idea of remote VRET therapy, but if it was presented as homework assignment, most of them liked the concept. All therapists reacted positive to the concept that a computer system could help them with asking the patients for a SUD score. They felt this would help them not to forget to ask for the SUD scores. In addition they liked the use of physiological measurement to obtain additional data from the patient. The therapists felt that more data from the patient could support a better analysis of the patient.

The therapists welcomed pre-programmed VR-scenarios; they felt this would give them more time to treat the patient instead of managing the virtual environment of the patient. The therapists welcomed the fact that different difficulties levels of VR-scenarios would be available, making it possible to switch between more or less anxiety-provoking scenarios. In addition, they liked the idea that they could setup an automated-assist system for themselves, making them feel more in control of the system.

During and after the interviews with the experts a preliminary specification of the multiple patient VRET setup was made. This specification describes that the communication between the therapist and the patient will be handled by speech and a video feeds. The therapist can see the patient on one monitor, a second monitor shows the controls of the VRET system and gives an overview of the results of the physical measurements. The therapist can present the patient with pre-programmed VR-scenarios, which they can adjust to fit the patients specific phobia. To help the therapist monitor and assist multiple patients at the same time, two systems are proposed. One is an automated assistance that monitors the physical measurements of the patient and reacts to them, the therapist can configure this system per patients, using simple if- and then- statements. The second system is the option for the therapist to call for assistance at the location of the patient, who will physically go up to the patient and help them.

A prototype based on the preliminary specifications was constructed to explore the effects of the proposed auto-assist systems and the "Call for remote assistance"-option on the workload of the therapist. Because this was an initial exploration, it seemed unsuitable to use both real therapist and patients in this stage of the study. Participants with the same type of education level as therapists and simulated patients were used. The experiment demonstrated that the proposed automated assistance had a significant effect on the perceived mental effort of the users of such a system. The participants indicated to experience lower mental demands when the auto-assist was enabled. In addition, the participants used the "Call for remote assistance"-function when this was required, without the auto-assist. With the auto-assist enabled, the result showed that a large amount of participants still used the "Call for remote assistance"-function, however it was used significantly less. This means that there is reason to believe that the combination of auto-assist and the "Call for remote assistance"-faction will have a significant positive on the affect when dealing with multiple patient VRET situations for real therapists as well.

6.1 General limitations of the study

When conducting this study there were some limitations. All interviewed therapists had experience with VRET, it could be possible that therapists who are new to VRET could have had different comments to the proposed system. In addition, the interviewed therapists had experience with fear of flight, fear of heights and claustrophobia. None of the interviewees had experience with social phobia or posttraumatic stress disorder, which could also be treated within a multiple patient VRET setup. For the lab experiment students were used, not real therapists. It could be possible that students approach the experiment different then a real therapist would and perhaps are more at ease with using computers and software. In the lab experiment, there was no real therapist patient interaction. The participants knew that were assisting simulated patients, assisting real patients could influence the behaviour of the user of the system. In the lab experiment, the participant did not setup the auto-assist prior to the treatment. Personalizing the auto-assist could generate different results.

6.1 Future research

With the exploration of the preliminary specifications, the focus of this research lay on the therapist. A secondary study could consider the opinions of the patients experiencing VRET. What are the patients' views on the proposed multiple patient VRET and would they feel comfortable with this type of treatment? Additional research could explore at what locations patients would prefer to have their virtual reality treatment. It is possible to explore the number of control the patients desire to have on their treatment. Moreover, is it possible to design a virtual reality treatment without the need of remote assistance?

A next step of the research could be to extend the prototype with remote communication between a patient and therapist. Research could be conducted on how real therapists and real patients would experience the proposed communicate methods, during a remote VRET sessions. There could be practical experimentation to discover if the proposed communication methods are satisfactory. Extending from this, a more elaborate prototype system could be build. Providing a way to test the complete multiple patient VRET setup. An additional experiment could be setup to determent the optimal number of patient that should be monitored and assisted using multiple patient VRET. In addition, further research can be conducted on the methods of accurately obtaining anxiety-scores from patients. The more accurate a system can continuously monitor the anxiety of the patient, the more precise the information the therapist receives and the more accurately an automated-assist can perform. In addition, more extended functions of a VRET system can be explored. For example, a method for retrieving and storing session data in some type of databank. It is possible to explore the idea of an agenda, which makes it possible for the therapist to plan various VRET sessions. In addition, research might be needed on how the system must react if a connection is lost during a remote session.

The interviewed therapists saw great benefit if certain patients could have VRET session at their own home. This can especially help people with agoraphobia and social phobia. To make this possible, patients would need to receive all necessary hardware at their home. In addition, a way to establish an adequate connection with the therapist is needed. In addition, could this system be used in war situations where it could be used to treat people with posttraumatic stress disorder on location? VRET is designed to treat people with phobias, but this multiple people VR setup could also be used for much more purposes, also with people not suffering from phobias. It can be used for training purposes, for example speaking in public or communication training. This would have a much wider audience and could have a great commercial appeal. In addition, it has the advantage that there is no patient-therapist situation, this could mean that monitoring could be much less strict.

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Appendix

Appendix A: Claims and scenarios

Scenario 1: De Opstelling

Therapeute Henrietta komt binnen in haar behandelruimte. Ze start het systeem op en bekijkt haar agenda voor vandaag. Ze ziet dat vandaag 15 mensen een therapiesessie bij haar hebben. De meeste behandelingen duren een uur met tussendoor een pauze. Henrietta bekijkt de gegevens van de eerste patiënten die dag. Alle patiënten hebben eerst een uitgebreid intakegesprek gehad bij een therapeut, die daarna een specifieke VRET sessie heeft voorgeschreven.

Henrietta heeft tussen het opstarten van de patiënten elk tien minuten de tijd. Mevrouw Aalders begint met haar tweede vliegangstsessie om negen uur, meneer de Bruin begint zijn derde sociale fobiesessie tien minuten later en meneer Carlton is nieuw en begint met zijn allereerste vliegangstsessie weer tien minuten daarna.

Henrietta maakt contact met de verschillende behandellocaties waar de patiënten de VR-sessies zullen volgen. Ze ontvangt een live videoverbinding uit de behandelkamers en krijgt de patiëntgegevens op haar monitor te zien. Op de verschillende behandellocaties zijn er assistenten aanwezig die kunnen helpen bij de VRET sessies. De assistent kan via een intercom communiceren met de therapeut en andersom. Henrietta vraagt de assistent mevrouw Aalders in de behandelkamer te laten plaatsnemen. Hierna kan de assistent mevrouw Aalders helpen met het opzetten van de HMD en het aanbrengen van de fysiologische meetapparatuur. Na een kleine minuut krijgt Henrietta een seintje van de assistent dat mevrouw Aalders klaar is om te beginnen met de VRET sessie.

Henrietta drukt op de communicatieknop zodat ze via een microfoon met Mevrouw Aalders kan praten. Mevrouw Aalders ziet Henrietta niet, maar kan haar wel horen door de hoofdtelefoon van de HMD. Henrietta vraagt aan mevrouw Aalders hoe het met haar gaat en vraagt hoe ze de vorige sessie heeft ervaren. Henrietta bekijkt alle gegevens van de vorige sessie en stelt een nieuwe VR-scenario voor mevrouw Aalders in. Ze praat nog even met mevrouw Aalders over het aankomende scenario, en vraagt mevrouw Aalders of deze klaar is om de sessie te beginnen. Mevrouw Aalders knikt, Henrietta ziet dit op haar monitor en start het VR-scenario.

Als mevrouw Aalders met haar VR-sessie begonnen is, kan Henrietta zich alvast voorbereiden op de sessie van meneer de Bruin die over enkele minuten begint. Ze houdt wel met een half oog via de monitoren mevrouw Aalders in de gaten.

Claims:

- Na een intake gesprek kunnen patiënten door worden verwezen naar een andere therapeut voor een VRET sessie.

- De patiënt heeft genoeg aan 10 minuten persoonlijke aandacht van de therapeut bij het begin van een VRET sessie.

- Een assistent is voldoende om de patiënt te helpen op locatie.

- Voor een goede therapie is het niet nodig dat de therapeut en patiënt in dezelfde fysieke locatie aanwezig zijn.

- De therapeut kan de patiënt voldoende helpen met alleen verbale communicatie.

Scenario 2: Patiënt informatie

Therapeute Henrietta behandelt drie patiënten op afstand met behulp VRET. Mevrouw Aalders heeft haar tweede vliegangstsessie, meneer de Bruin heeft zijn derde sociale fobiesessie sessie en meneer Carlton heeft zijn allereerste vliegangstsessie.

Henrietta heeft per patiënt twee monitoren ter beschikking, één geeft een live video van de patiënt in de behandelruimte weer. De ander toont de patiënt achtergrondinformatie en sessie informatie. Henrietta kijkt op de verschillende monitoren naar haar patiënten, ze kan aan de lichaamshoudingen zien dat ze alle drie geconcentreerd bezig zijn met hun VR-sessie, ook hoort ze via speakers alle patiënten. Als ze wil kan ze het geluid voor elke patiënt afzonderlijk harder of zachter zetten.

Terwijl de patiënten hun VR-sessie doorlopen krijgen ze om de 2 minuten een computerstem te horen die hen vraagt om hun SUD score te noemen. Het system herkent dan automatisch deze score. Ook is voor de aanvang van de VR-sessie bij de patiënten, door assistent op locatie, fysiologische meetapparatuur aangebracht. Dit zijn onder andere een hartslagmeter en huidweerstandmeter. Het system meet bovendien continu de stressniveaus in de stemmen van de patiënten. Al deze data wordt per patiënt via de patiëntmonitoren aangeboden aan de therapeut. De therapeut kan zowel de data per sensor zien, maar ook een volledig gecombineerd stresscijfer.

Tien minuten in de sessie kijkt Henrietta wat mevrouw Aalders ziet in haar HMD en begrijpt dat ze door het vliegtuigraampje naar buiten kijkt. Henrietta bekijkt de stressdata van mevrouw Aalders en ziet dat die al vijf minuten zeer laag is. Bovendien geeft ze zichzelf, één minuut geleden, een SUD score van twee en twee minuten daarvoor van drie. Henrietta maakt contact met Mevrouw Aalders en vraagt waarom ze zichzelf zulke lage SUD scores geeft. Mevrouw Aalders antwoordt dat ze aan dit scenario begint te wennen en het niet meer zo eng vindt. Henrietta zegt dat ze haar een enger scenario zal geven, waar het vliegtuig iets ruwer door de lucht beweegt. Mevrouw Aalders protesteert een beetje, maar Henrietta zegt dat het beter is. Henrietta selecteert op één van haar monitoren de beschikbare scenario's voor vliegangst en kiest een enger scenario uit voor mevrouw Aalders. Het systeem schakelt vloeiend over naar dit nieuwe scenario.

Claims:

- De therapeut wil altijd alle stemmen van de patiënten kunnen horen.

- De therapeut wil altijd alle patiënten via een monitor kunnen zien.

- De therapeut vind het prettig om met meerdere monitoren tegelijkertijd te werken.

- De therapeut heeft naast de aparte monitoren per patiënt ook behoeft aan een monitor met een overzicht van alle patiënten.

- De patiënt zal accepteren dat een computer systeem om bepaalde interval om SUD score vraagt.

- Fysiologische meeting hebben zeer veel waarde in deze opstelling.

Scenario 3: VR-senarios en therapeut assisteer systeem

De eerste patiënt, mevrouw Aalders, is klaar met haar sessie. Henrietta vraagt hoe het ging en noteert sommige gegevens in het systeem. De rest van de sessiegegevens wordt automatisch opgeslagen en toegevoegd aan mevrouw Aalders' bestanden. Henrietta blijft ondertussen de andere patiënten op de monitoren met een schuin oog in de gaten houden.

Over tien minuten begint de sessie met meneer Dendermonde. Ze laadt al zijn gegevens en bekijkt wat hij gedaan heeft in de vorige sessie. Meneer Dendermonde heeft last van vliegangst en dit is zijn tweede VRET sessie. Vorige keer heeft meneer Dendermonde eerst kort getaxied over het vliegveld en daarna een ideale take-off gedaan. Na een korte vlucht van 5 minuten is hij geland en daarna nog één keer opgestegen. Henrietta besluit deze sessie te beginnen met een normale take-off en een iets kortere vlucht met een klein beetje turbulentie om daarna te eindigen met een nachtelijke landing. Met een aantal muisklikken rijgt ze het scenario aan elkaar.

Henrietta kan per patiënt het waarschuwingssysteem en automatisch assisteersysteem zelf instellen. Henrietta stelt het waarschuwingssysteem zo in dat ze een waarschuwing krijgt als Meneer Dendermonde zijn gecombineerde stresscijfer boven de zeven komt. Ook stelt ze het automatisch assisteersysteem zo in dat het zelfstandig terugschakelt naar rustig vliegen als zijn gecombineerde stresscijfer boven de acht komt. Het systeem zal dit doen zonder dat de patiënt de overgang merkt. Meneer Dendermonde is klaar om met zijn sessie te beginnen, Henrietta drukt op de knop om met hem te praten, vraagt hoe alles gaat en start vervolgens het VR-scenario.

Claims:

- Het is mogelijk om voorgeprogrammeerde VR-scenario te creëren die kunnen variëren van heel neutraal tot zeer eng.

- Het is van belang voor een therapeut om meerde VR-scenario's aan elkaar te kunnen linken tot één lang scenario.

- De therapeut kan met behulp van de patiëntachtergrond en informatie van vorige sessies goede VR-scenario's uitzoeken voor de patiënten.

- De therapeut wil per patiënt een automatisch waarschuwingssysteem zelf kunnen instellen.

- De therapeut wil per patiënt een automatisch assisteersysteem zelf kunnen instellen.

Scenario 4: Het waarschuwing en assisteersysteem

Therapeute Henrietta is bezig met het monitoren en assisteren van drie therapieën op afstand. Alles gaat goed, ze hoort sommige patiënten praten tegen het systeem en alle feedback van de patiëntinformatie monitoren geeft aan dat de patiënten niet te gespannen zijn. Opeens hoort ze een waarschuwingssignaal van het systeem komen. Ze kijkt op haar computerschermen en ziet een waarschuwing die haar aangeeft dat patiënt 2, meneer de Bruin, volgens de systeemmetingen een zeer hoog gecombineerd stresscijfer heeft. Ze kijkt naar de gegevens en weet dat meneer de Bruin bezig is met een vliegangst VR-scenario waarbij het vliegtuig net opstijgt.

Ze drukt op een knop zodat ze met meneer de Bruin kan communiceren en vraagt hoe het met hem gaat. Meneer de Bruin zegt dat hij het wel heel eng vindt. Op dat moment hoort Henrietta weer een waarschuwingssignaal en weet dat ook een andere patiënt misschien aandacht nodig heeft. Ze kijkt heel even snel waarom het alarm gaat. Het blijkt dat ook patiënt 1, mevrouw Aalders, een hoog gecombineerd stresscijfer heeft, vooral haar hartslag is erg hoog. Henrietta weet dat het systeem, als zij niet reageert, zal overstappen naar een rustiger scenario. Henrietta besluit om nog even met meneer de Bruin te praten en de andere patiënt door het systeem op te laten vangen.

Als ze meneer de Bruin geassisteerd heeft en heeft uitgelegd dat hij moet wennen aan de situatie, kijkt Henrietta naar de waarschuwing die het systeem een minuut eerder gegeven heeft. Mevrouw Aalders had hoge stressdata. Dit betekent dat ze het moeilijk had met het scenario. Omdat Henrietta niet reageerde, heeft het systeem automatisch het scenario van mevrouw Aalders aangepast en minder eng gemaakt. Haar vliegangstscenario is van een turbulente vlucht naar een veel rustigere vlucht overgegaan.

Claims:

- Het assisteersysteem zal als een patiënt zeer hoge angstscores geeft, automatisch moeten terugschakelen naar een minder eng scenario.

- Het assisteersysteem moet automatisch handelen als de therapeut een waarschuwing negeert.

- Als de angstscore van een patiënt zeer laag is, mag het systeem zonder input van de therapeut, het scenario van de patiënt enger maken.

Appendix B: Film scripts of scenarios

Introduction

[voice over, text and pictures]

This video will visualize a way virtual reality phobia treatments could be given in the near future.

A key element of this visualization is that the patients does not always have to go to the therapist but can have VR-treatments in a local treatment center. All communication between the patient and the therapist will be done with remote communication techniques.

A second important element is that the therapist gets enough support from the computer that he or she could treat multiple patients at the same time.

Introduction Virtual reality exposure therapy

[voice over]
[photo: The patient using VRET]

With Virtual reality exposure therapy the therapist can expose patients to their phobia in a save and controlled way. this has already been proven to be at least as effective as in vivo therapy.

The therapist can expose the patient to gradually more treating virtual worlds, thereby diminishing the fear of these situations.

[photo: VRET Environments]

These kind of virtual reality treatment could be used to treat people with Social phobia, claustrophobia, fear of flight and (pleinvrees) and possibly many more in the future

Patient scenario

[voice over]

[photo: The patient meeting a therapist]

When the patients feel the need that they could benefit from a phobia treatment they could contact a local therapist for a consult session.

[photo: VR treatment with therapist]

There the therapist could subscribe a VR-treatment to the patient. For the first session a patient can choose to have a VR-session together with the therapist where the therapist can give some extra support and assistance to the patient.

[photo: VR treatment with remote therapist]

For a succeeding session the patient can choose to have remote sessions, where the therapist and the patients do not need to be at same locations. The communication between the therapist and the patient can be done with video conferencing and remote physical sensors.

Locaties:

Werkruimte therapeut

Props:
6 monitoren
3 microfonen
3 keyboards/muizen

Behandel ruimte
Props:
1 HMD
1 Stoel
1 Microfonen
(lichaamssensors)

Acteurs
Therapeut, Henrietta
Assistent op locatie, Mark
Patiënt, Mevrouw Aalders
Patiënt, Meneer de Bruin
Patiënt, Meneer Carlton

Therapist Scenario 1: Remotely greeting the patient

[voice over]
This scenario will describe the situation where a therapist start the day and starts off with the first patient.

[-Shot: Werkruimte therapeut-]
<H komt binnen>
<H kijkt op het scherm naar een agenda>
[-screenshot: Agenda-]
<H maakt contact met behandellocatie>
H- Mark, is mevrouw Aalders al klaar voor haar behandeling
Stem Mark- Ja, ik zal haar in de behandel kamer binnen laten
H - Oké bedankt, ik zal ondertussen haar gegevens bekijken
<H kijkt naar haar scherm>
[-screenshot: Patiënt gegevens mevrouw Aalders -]

[-Shot: behandel kamer-]
< Mark laat mevrouw Alders de behandelruimte in>
< Mark plaatst de sensoren aan mevrouw Alders>
< Mark helpt mevrouw Alders met de HMD>
Mark in microfoon - mevrouw Alders is klaar om de therapie te beginnen

[-Shot: Werkruimte therapeut -]
H - prima
<H maakt contact met mevrouw Alders>
H - hallo mevrouw Alders hoe gaat het met u?

[-Shot: behandel kamer-]
A - Goed hoor

[-Shot: Werkruimte therapeut -]
H – zit u goed
A - Ja hoor
H - De vorige sessie ging erg goed dus we kunnen deze keer een iets moeilijker scenario doen.
A – Ehmm, prima…
H – Het is belangrijk dat als u angst voelt dat u rustig blijft, u moet wennen aan de situatie.
A - Oké ik zal het proberen

H - U krijgt een scenario waarbij u rustig zal taxiën over de landingsbaan en dan zult opstijgen, waarna het vliegtuig vier minuutjes zal vliegen.
H - ik kan u altijd horen dus als u hulp nodig heeft laat het dan weten.

[-Shot: behandel kamer-]
A – Oké

[-Shot: Werkruimte therapeut -]
H - U weet dat als het systeem om uw axatie levels vraagt dat kan aangeven met een getal tussen de 0 en 10.
A -ja net als de vorige keer
<H stelt het VR- scenario in>
[-screenshot: instellen VR- scenario -]
<H stelt het VR- waarschuwing systeem in>
[-screenshot: instellen waarschuwing systeem -]
H - Oké ik ga het scenario starten.
A – Oké

Therapist Scenario 2: Multiple Patient Monitoring

[voice over]
This scenario will describe how a therapist could monitor multiple patients.

[-Shot: Werkruimte therapeut-]
<H zit achter de computers>
<H kijkt rustig naar de 3 patiënten op de verschilde monitoren>
[-screenshot: patiënt info screen-]
 (stemmen van patiënten)

[-Shot: behandel kamer 2, meneer de Bruin, sociaal Foba-]
<B zit met zijn HMD tegen het systeem te praten>
B – (bushalte gesprek)
([VR World- bushalte])

[-Shot: Werkruimte therapeut-]
<H maakt contact met meneer de Bruin>
H – gaat het nog goed meneer
Stem B – Ja hoor.
H – Ik zie dat u langzaam aan de situatie went, heel goed. Het VR-senario is bijna klaar, zal ik u hierna een iets moeilijker scenario geven?
Stem B – dat is goed
H - in het volgende scenario is het de bedoeling dat u in een winkel een broek gaat kopen.
Stem B – Is het druk in de winkel?
H - nee u bent de enige klant
Stem B – oké
<H stelt een het nieuwe VR-senario in>
<H kijkt verder rustig verder naar de 3 patiënten op de verschilde monitoren>

Therapist Scenario 3: Two patients in need of assistance

[voice over]
This scenario will describe how a therapist could act if two patient both need attention at the same time.

[-Shot: Werkruimte therapeut-]
<H zit achter de computers>
<H kijkt rustig naar de 3 patiënten op de verschilde monitoren>
< Er klink een waarschuwingsignaal>
<H kijkt op een scherm>
[-screenshot: waarschuwing meneer de Bruin-]
<H pakt microfoon>
H - Hallo meneer de Bruin is er iets?

[-Shot: behandel kamer 2, meneer de Bruin, sociaal Foba-]
B – Dit is niet zo een prettig scenario.

[-Shot: Werkruimte therapeut-]
< een tweede signaal klinkt>
<H kijkt op haar een ander scherm>
[-screenshot: waarschuwing mevrouw Aalders-]
H – U doet het erg goed meneer de Bruin, probeer aan de situatie te wennen. Ik houd u in de gaten.
B – Oké het lukt wel.
<H pakt de microfoon voor mevrouw Aalders>
H- hoe is het met u?

[-Shot: behandel kamer 1, mevrouw Aalders, vlieg angst-]
A - kan ik niet even pauze houden

[-Shot: Werkruimte therapeut-]
H - het is het best als u het nog 2 minuutjes vol houd, lukt dat denk je
A- jawel hoor.
<H houd verder de patiënten goed in de gaten>

Appendix C: Questionnaire therapist

Als u deze film heb bekennen wat is dan uw eerst reactie?
Open vragen Interview
(mag ik het zo samenvatten?)

1) Therapie op afstand

1.1 - Welke elementen zijn essentieel voor een eventueel VRET sessie op afstand?
1.2 - Kan de therapeut kan de patiënt voldoende helpen met alleen verbale communicatie?
1.3 - Is een assistent op locatie voldoende om de patiënt te helpen?
1.4 - Of Is er nog een therapeut nodig op de locatie zelf in geval dat?

2) Patiënt therapeut communicatie

2.1 - Welke informatie heeft over de patiënt heeft de therapeut nodig voor de behandeling?
2.2 - Welke informatie heeft over de patiënt heeft de therapeut nodig tijdens de behandeling?
2.3 - Wil de therapeut altijd alle patiënten via een monitor kunnen zien?
2.4 - Is het een probleem om met twee monitoren per patiënt te werken?
2.5 - Zal de patiënt accepteren dat een computer systeem om bepaalde interval om SUD score vraagt?
2.6 - Hebben fysiologische meeting hebben waarde in deze opstelling?
2.7 - Zou het werken om meerdere angstmetingen te combineren tot één score?

3) Meerdere patiënten behandelen

3.1 - Wat vind U van de gevisualiseerde opstelling (minitoren)
3.2 - Wil de therapeut altijd alle stemmen van de patiënten kunnen horen?
3.3 - Is het een probleem om met meerdere monitoren tegelijkertijd te werken?
3.4 - Heeft de therapeut naast de aparte monitoren per patiënt ook behoeft aan een monitor met een overzicht van alle patiënten?
3.5 – Kan een therapeut zijn aandacht over meerdere patiënten verdelen?
3.6 - Heeft een patiënt heeft genoeg aan 10 minuten persoonlijke aandacht van de therapeut bij het begin van een VRET sessie?
3.7 – Hoe belangrijk is een agenda functie?

4) Patiënt scenario's

4.1 - Is mogelijk om voorgeprogrammeerde VR-scenario te creëren die kunnen variëren van heel neutraal tot zeer eng?
4.2 - Is het van belang voor een therapeut om meerde deel VR-scenario's aan elkaar te kunnen linken tot één lang scenario?
4.3 - Welke informatie is belangrijk zodat de therapeut goede VR-scenario's kan uitzoeken voor de patiënten?

5) Therapeut waarschuwing en assisteer system

5.1 - Zou volgens u een computersysteem de patiënt automatisch kunnen begeleiden?
5.2 - Hoe kan volgens u een computersysteem de patiënt automatisch kunnen begeleiden?
5.3 - Wil de therapeut per patiënt een automatisch waarschuwingssysteem zelf kunnen instellen?
5.4 - Wil de therapeut per patiënt een automatisch assisteersysteem zelf kunnen instellen?
5.5 - Moet een assisteersysteem een patiënt met zeer hoge angstscores geeft, automatisch moeten terugschakelen naar een minder eng scenario?
5.6 - Moet een assisteersysteem automatisch handelen als de therapeut een waarschuwing negeert?
5.7 - Als de angstscore van een patiënt zeer laag is, mag het systeem zonder input van de therapeut, het scenario van de patiënt enger maken?

Appendix D: Results of the interviews

<u>**Therapeut 1**</u>
Werkend bij: Stichting Valk
Ervaring VRET
Staat ver af van wat we nu doen.

Scenario 1
Als de VR therapie thuis bij de patiënt kan worden gedaan dan zou dat veel voordeel kunnen hebben,
geen reis dus geen extra externe angst
Soms goed voor de patiënten om naar locatie te komen onderdeel van therapie en meer motivatie vanuit de patiënt
Hebt eigenlijk geen therapeut nodig.. maar meer een monitor of assistent
"Ik zie het meer als een Huiswerk opdracht."
Aanraking met patiënten komt soms wel voor
Patiënten merken en weten dat de therapeut in de zelfde ruimte is
Zieken huis situatie kan… dan met zuster als begeleiding

Scenario 2
"Erg futuristisch."
"Erg ver van mijn bed."
Is geen therapeut maar meer een monitor, een assistent.
Exposeren oefening zijn goed voor de patiënten
De trappist mist dan de nuance van face to face behandeling
"De patiënt heeft aandacht nodig."
"Aandacht geven is onderdeel van de therapie."
1 van de zes voelt niet goed.
Het is geen psychotherapie
Is eigenlijk geen therapie maar oefening
Band tussen patiënt en therapeut is erg belangrijk.
Ik moet aan de patiënt uitleggen waar de angst vandaan komt.
Belangrijk dat de therapeut goed de patiënt kan aanvoelen, en de vraag is of dat zo gaat.

Scenario 3
Goed
Van te voren uitleggen dat het systeem het kan overnemen
Maar verder goed systeem.

Conclusie:
Goed voor huiswerk opdrachten
Persoonlijk contact is nodig
Meer monitor dan therapeut
Fysiologisch meten is goed
Zelf instellen is goed
Erg futuristisch
Ver van mijn bed
Goed als aanvulling op een therapie
Ik ben misschien zelf te conservatief.

<u>**Therapeut 2**</u>
Werkend bij: Stichting Valk
Ervaring VRET
Ik ben behoudend
Angst oproepen is therapie
50% patiënten VR werkt.
Patiënt moet zich goed kunnen in leven (inlevingsvermogen)

Scenario 1
In het begin negatief
Als huiswerk opdracht zou kunnen
Band met therapeut is zeer belangrijk onderdeel van de therapie
Eerste ontmoeting zeer belangrijk
De patiënt moet voelen iets te hebben aan de therapie
Taak therapeut is ook luisteren een aandacht geven.

Therapeut kan een veiligheid factor zijn voor de patiënt
-> zonder therapeut kaan waarde hebben (is moeilijker voor de patiënt die wel dingen durft samen met de therapeut)
Vret op afstand -> toch afstand maar wel veilig... Mogelijk als een soort tussen stap.
Sensors heel goed!
Sud auto is heel goed—therapeut moet het zelf in kunnen stellen
(per therapeut verschillend)

Scenario 2
Therapeut moet er altijd voor de patiënten zijn.
Je wilt als therapeut je volledige aandacht geven aan de patiënt(kan niet met meerdere)
"zal voor mij erg moeilijk zijn" – meerdere patiënten
Kunnen ze niet samen therapie hebben
VR Groepstherapie
De patiënten merken duidelijk dat ze de therapeut moeten delen.
Presence blijft zeer belangrijk

Scenario 3
"ik hoop dat het zo gaat werken"
Patiënten zijn erg kalm in de video in het echt kan het veel heftiger zijn
Afspraken maken met het systeem is duidelijk en zeer goed!

Therapeut 3
Werkend bij: Stichting Valk
Ervaring VRET

Scenario 1
Initiatief: "voor ons zie het niet zo"
Exposure is belangrijk
 Dit zou kunnen als tussen stap
Patiënt therapeut vertouwen .. zeer belangrijk
Als VRET werkt dan ook wel op afstand.
Bij Patiënten thuis zal geweldig kunnen zijn voor bepaalde patiënten

Scenario 2
Meer als huiswerk opdracht
Is niet echt een therapie
Onderdeel van therapie (tool voor de therapeuten)
Scenario's zijn ideaal
Scenario's zijn duidelijk

Scenario 3
Expo is zeer zinnig
Toch een beetje toekomst muziek
Als je de therapie goed opbouwt kan het met meerde patiënten
Graduele Exposure Zou geweldig zijn!
Ik zie het nut van meerde patiënten in
Afstand heeft meerwaarde als het ook thuis zou kunnen
Sensors is zeer goed!!
Communicatie op afstand zo is prima!
2 monitoren prima..
Als Spreek trainingen zou het geweldig zijn (spreken in het open baar)
Ook Commercieel veel waarde

Therapeut 4
Werkend bij: Stichting Valk

Scenario 1
Film komt klinisch over
Afstandelijk
Geen fysiek contact… hmmm?
Scenario's zijn er handig en multifunctioneel -> is Pree
Face to face is belangrijk
Wat doe je als de patiënten een uitgebreid verhaal wilt vertellen?

Voor sommige patiënten wel geschikt voor anderen niet
Het is een tussenstap waarbij de patiënt zich eventueel kan losmaken van de therapeut
Huiswerk is begrijpelijk
Nieuw idee: Kan zeer belangrijk zijn bij de diagnostiek van de angst van de patiënt.
Thuis VR voor sociale of pleinvrees zeer nuttig

Scenario 2
Lijkt me leuk om mee te werken / experimenteren
Moeilijk om aandacht te verdelen.. moet dan veel ervaring hebben met het systeem en patiënten
Langzaam opbouwen
Kan misschien voorkomen dat de therapeut stress van patiënt B meeneemt naar patiënt A
"Fysiologische meting super!"
Hartslag
Auto SUD is goed.. maar best als therapeut moet aangeven wanneer
Controleer baar is super goed!
Gradaties is super goed
Graduele Exposure belangrijk
Voorspelbaarheid is goed!
Controle is fantastisch

Scenario 3
De therapeut moet snel reageren. Als er geen snelle reactie naar patiënt toe is dan faalt de therapie plus alle negatieve bijeffecten
Belangrijk voor het systeem dat de therapeut kan anticiperen!!!
Zorg dat je de patiënt kan zien angstig worden en zodat je kan ingrijpen voor de grote angst.
Goede instructie op voorhand naar de patiënt toe!
Auto omhoog scenario prima!
Zelf instellen geweldig

Therapeut 5
Werkend bij: PsyQ
Ervaring VRET

Scenario 1
"komt bureaucratisch over"
Onlogisch om patiënt naar locatie b te laten reizen Waarom niet direct naar therapeut?
Thuis VR therapie "zou geweldig zijn"
E-mail word gebruikt op afstand, maar liever telefonisch contact.
Is waarschijnlijk toegankelijker voor sommige patiënten?
Er is therapie op afstand maar dan vooral voor 2 type patiënten:
1 Zeer angstige enige manier om contact te hebben
2 zeer gezonde patiënten, die niet veel hulp nodig hebben
Veel telefonisch contact
"fysiologische meting goed"
"Communicatie prima zo"
Als extra tool zeer goed
Als aanvulling op therapie zeer goed

Scenario 2
"futuristisch"
"was het maar zo rustig"
In het echt kunnen patiënten zeer zwaar in de stres schieten.. gillen, huilen
" Tja.. het zou kunnen"
"therapeut kan stapel gek worden met 3 patiënten"
Nieuw idee: Sociale therapie waar patiënten later hun gedrag terug zien. Zo kunnen ze self zien hoe ze over komen. Filmen maar ook Hun Bio feedback
Bio feedback aan de patiënten zelf presenteren zodat ze zelf beter begrijpen hoe hun lichaam reageert en hoe angstig ze werkelijk zijn.
"gecontroleerde omgevingen is goed"
Als diagnose tool erg omslachtige, kan waarschijnlijk sneller en je stelt de patiënt al bloot aan potentieel angstige situaties.

Scenario 3

"zelf instellen goed"
"een beetje een initiaal plaatje"
Systeem mag scenario moeilijker maken als lage angst score.

Feedback naar de patiënten zou ook goed kunnen zijn
Dat de patiënten zelf bepalen of ze klaar zijn voor een moeilijker scenario
Geschikt voor minder ernstige gevallen – meer gezonde mensen
"Zeer goed voor eventuele commerciële communicatie trainingen"
"zeer goed dat er onderzoek in wordt gedaan"

Therapeut 6
Therapeut gepromoveerd op VRET
Zeer veel ervaring VRET

Scenario 1
"Het verschil is niet zo groot met een normale VRET sessie"
Communicatie het zelfde als bij VRET is prima zo
Bij meeste patiënten moeten ze de therapeut wel een keer gezien hebben.
Bij sommige patiënten kan het wel met een onbekende therapeut
Je moet er wel geschikte patiënten voor hebben
Patiënt zien op scherm is voldoende
- de aanwezigheid van een therapeut (in de kamer) kan meer vertrouwen aan de patiënten geven,
Dit heeft zowel voor als nadelen.
Zonder aanwezigheid geeft ook voordelen
Voor thuis zo ook goed zijn

Scenario 2
"ik geef veel aanmoedigen aan de patiënt , heb ik daar nog genoeg tijd voor?"
"na de sessie is de evaluatie zeer belangrijk, dat groot onderdeel van de therapie, is daar tijd voor? Duurt ongeveer 2 to 5 min "
"beste resultaat voor angstmeting is voor mij als patiënt zelf hun angst aangeven SUD), zou het kunnen met een schuifje? Of knijp kracht?"
SUD is zeer persoonlijk wat voor de ene een 8 is, is voor de ander en 3
4 patiënt scenario's)
Gradueel is zeer goed, maar zal niet in elk scenario mogelijk zijn.
Angst binnen een scenario is persoonlijk wat voor de ene heel angstig is val voor de ander wel mee.

 Scenario 3

"wel leuk"
"voor patiënt apart instellen is goed, nuttig"
"Ik zou nooit naar een makkelijker scenario over schakelen!" ik zou ze proberen te kalmeren binnen het scenario."
Het is mogelijk dat patiënten bijna uit het niets in de angst schieten maar dat is zeer zeldzaam.
- Het zou goed zijn als je de controle bij de patiënt kan leggen. (bestaan onderzoeken)
Het is wel belangrijk dat de patiënt weet dat als hij naar een makkelijkere scenario overstapt hij of zij wel weer moet terug werken naar het level van het huidige scenario
Angst: het is belangrijk dat de patiënt op een angst niveau blijft (SUD 7) en daarmee leert omgaan. Dit kan tussen 3 min en 20 min duren.
Het is de taak van de therapeut om angst te zien aankomen. Veel patiënten kunnen dit zelf en kunnen prima aangeven wanneer ze angstig zullen worden.
Zo niet kan de fysiologische meting goed assisteren.
Als een therapeut 3 patiënten tegelijkertijd wil behandelen moet hij of zij erg veel ervaring hebben zowel met patiënten als het systeem.
"het is zeer goed mogelijk om een patiënt op "pauze" te zetten als de therapeut maar goed uitlegt dat een andere patiënt extra aandacht even nodig heeft. De patiënten moeten het gevoel hebben dat de therapeut ook voor hen dit zal doen!

Appendix E: Experiment protocols

The anxiety-score is more than the personal high threshold
A high anxiety level indicates that a client is very fearful of the current situation. This is not a bad thing, but if the anxiety level is higher than the personal patients' threshold, be sure to attend to the patient and then calm the patient down.

1) Attend to patient
2) Calm patient down

The anxiety-score is more than the personal extremely high threshold
An extremely high anxiety level is bad for the client, if this happens, place a flag and try to reduce the anxiety-score by switching to an easier VR scenario.

1) Switch to an easier scenario
2) Place flag "Patient is frightened"

The anxiety-score is lower than the personal low threshold
If the anxiety level of a client is too low there is no proper therapy, it is possible that the client is getting used to the current situation and is ready to try a harder scenario.

1) Attend to patient
2) Set flag: "Patient has no fear"
3) Set a harder scenario
4) Tell the patient we will continue

The client has a question
If the client has a simple question, be sure to attend to the client and not ignore him or her.

1) Attend to patient
2) Place flag "Patient has a question"

Fear of flight
The patient wants to retry the take off
1) Attend patient
2) Set scenario: Redo Take off
3) Tell the patient the session we will be continued

The patient wants to retry landing
1) Attend patient
2) Set scenario: Redo landing
3) Tell the patient the session we will be continued

The patient is getting used to normal flight
1) Attend patient
2) Add to scenario: Turbulence or thunder (Personal)

Social phobia
The patient finds the current conversation too easy
1) Attend patient
2) Set a more anxiety provoking conversation (personal)
3) Tell the patient the session we will be continued

The patient finds the current conversation too hard
1) Attend patient
2) Set a less anxiety provoking conversation (personal)
3) Tell the patient the session we will be continued

Appendix F: Participant experiment information

As participant you play the role of a therapist who is monitoring three patients who are undergoing Virtual reality exposure.

All patients are wearing a VR helmet and are having a twenty-minute session in their appropriate VR environment. These environments are designed to induce anxiety on the patient. The anxiety levels of the patients are measured from heart rate and galvanic skin response. This is represented on the screen of the therapist by a number between 0 and 10. Where 0 is a very low anxiety-score and 10 a very high anxiety-score.

As a therapist it is your task to make sure the patients can cope with their VR environments and you should keep their anxiety-scores between their personal high and low thresholds. To accomplish this you have two types of actions. You can "talk" to the patient and you can adjust their VR environments. Both these actions take time and can only be applied to one patient at the time. It is also your task to place flags and notifications when certain events take place.

To know how to react in certain situations we present you with predesigned protocols. You need to follow these protocols for each situation. The challenge is to assist all three patients simultaneously.

Stop assisting patient button
It can occur that you are assisting a certain patient and you want to switch to another patient. You can cancel the assist on the current patient, but be careful: if you return to the cancelled patient you have to restart the action you aborted.

Call for remote assistance button
If two or more patients have a higher anxiety-score then 8 and you have the feeling you cannot properly bring back their anxiety levels within 20 seconds, you must press the "Call for remote assistance" button. The current patient will then be taken care of by a local therapist who will calm him or her down and reset the VR scenario, after which you retake control of the patient.

After every 5 minutes you will be asked to rate your mental effort on the last 5 minutes of work. This is a score between 0 and 150 ranging from absolutely no mental effort to extreme mental effort.

Appendix G: Simulated patient files

Patient Files:

Patient number: 211

Name: Mr. Aalders
Treatment: Fear of flight
Age: 26

Mr. Aalders is mostly a calm person who in general does not need a lot of attention; he needs extra practice on the takeoff of a flight. And has a high fear of turbulence.

Try to keep his anxiety-scores between 2 and 5
Give him an easier scenario if his score goes over 7

Patient 216:

Name: Mr.de Bruin
Treatment: Social Phobia
Age: 31

Mr. de Bruin is a bit of a nervous person; He does not like to talk about dogs and gets very nervous around large groups of people. He does like to talk about computers. Mr. de Bruin is pretty quiet and does not talk much

Try to keep his anxiety-scores between 3 and 7
Give him an easier scenario if his score goes over 9

Patient 219:

Name: Miss. Carstens
Treatment: Fear of flight
Age: 29

Miss. Carstens is a talkative person who does not like landings in an airplane, she can sometime have small panic attacks which are hard to predict. She also has a high fear of thunder.

Try to keep her anxiety-scores between 3 and 6.
Give her an easier scenario if his score goes over 8

Appendix H: Consent form

Toestemmings verklaring

	Ja	Nee
Ik ben naar tevredenheid over het onderzoek geïnformeerd en ik heb de schriftelijke informatie goed gelezen.	[ ]	[ ]
Ik ben in de gelegenheid gesteld om vragen over het onderzoek te stellen. Mijn vragen zijn naar tevredenheid beantwoord.	[ ]	[ ]
Hierbij geef ik aan dat de door mij gegenereerde data gebruikt mag worden voor het VRET onderzoek van TU-DELFT en ik volledig anoniem zal blijven bij elke publicatie.	[ ]	[ ]
Ik weet dat deelname geheel vrijwillig is en dat ik het experiment op ieder moment kan eindigen, zonder dat ik daarvoor een reden hoef op te geven.	[ ]	[ ]
Ik heb het recht mijn toestemming op ieder moment weer in te trekken zonder dat ik daarvoor een reden behoef op te geven.	[ ]	[ ]

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Ik stem toe met deelname aan het onderzoek.

Naam   :

Geboortedatum   :

Plaats   :

Datum   :

Handtekening   :

Appendix I: Questionnaire

Mental Demand — How mentally demanding was the task?

Very Low ‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖ Very High

Physical Demand — How physically demanding was the task?

Very Low ‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖ Very High

Temporal Demand — How hurried or rushed was the pace of the task?

Very Low ‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖ Very High

Performance — How successful were you in accomplishing what you were asked to do?

Perfect ‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖ Failure

Effort — How hard did you have to work to accomplish your level of performance?

Very Low ‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖ Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed wereyou?

Very Low ‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖ Very High

Vertel in je eigen woorden wat jouw strategie was:

_____

_____

_____

An Explorative Study into a Tele-delivered Multi Patient Virtual Reality Exposure Therapy System

Christian Paping, Willem-Paul Brinkman, Charles van der Mast

Abstract

The use of Virtual Reality (VR) technology to support the treatment of patients with phobia, such as the fear of flying, is getting considerable research attention. VR treatment may provide substantial improvement in efficient use of therapist resources and accessibility by delivering the treatment over the internet, to multiple patients simultaneously. This motivated initial exploration into the possibilities of a multiple patients Virtual Reality Exposure Treatment (VRET). With such a setup, one therapist can monitor and treat multiple patients simultaneously, each having their own personal VR treatment at their own personal location. The approach taken was (1) a scenario-based investigation with six therapists that had extensive experience in treating patients with VRET, and (2) a controlled lab experiment with 27 (students) participants to examine the effect of an automated assistance function on the therapists' workload and performance when treating three computer-simulated patients over the internet. The findings of both the interviews and lab experiment are encouraging. They imply that a tele-delivered multi patient VRET system might be possible in the future, thereby providing treatment at remote locations and making efficient use of therapist resources.

Keywords: Virtual reality exposure therapy, tele-treatment, cyberpsychology, cognitive ergonomics.

Introduction

Delft University of Technology is conducting research and developing technologies to cure patients with various phobias by using virtual reality exposure therapy (VRET). During VRET treatments, the patient is exposed to stimuli in virtual reality. A therapist monitors and provides treatment to the patient while allowing the anxiety to diminish. Various virtual worlds can be constructed to cure people with various phobias, for example the interior of an airplane for people with fear of flying and a fire escape staircase to treat people with fear of heights. With current configurations of virtual reality exposure therapy, it is possible for the therapist to treat one patient at the time. This paper explores if it possible and what specifications are required, to extent current VRET systems, with result that one therapist can monitor and assist multiple patients in parallel. These patients all run their own personal virtual reality exposure treatments at differs locations. Assisting multiple patients simultaneously may provide substantial improvement in efficient use of therapist resources and accessibility by delivering the treatment over the internet, to multiple patients simultaneously. As result of the support of multiple patients, communication methods between the therapist and patient in such a setup need to be rethought; possible tele-delivered therapy might be required. In addition, the workload of the therapist would change and extensions to the software may be needed to monitor the patients and provide additional assistance to the therapist. The question rises if it necessary and how it is possible to develop a system where the computer provides an option to take over certain tasks from the therapist.

1. Background

Phobias are described as a persistent fear of specific objects or situations. Phobias are the most common form of psychiatric disorders. Bouman et al [1] describes how these phobias can be treated by exposing patients to anxiety-producing stimuli while allowing the anxiety to attenuate. In conventional treatment, these stimuli are generated by presenting the patient actual physical situations, so called in vivo therapy. There is a second option, in vitro, where the patient imagines these stimuli. Nowadays, virtual reality offers a third option. *Virtual reality* (VR) is a technique where a computer creates a view from a three dimensional *virtual environment* (VE) and displays this on screens or inside a VR-helmet or Head-Mounted Display (HMD). VR gives the user the feeling of actually being inside this virtual environment, this is specified as *presence*. This presence can be used to induce anxiety on phobia patients much the same as in vivo therapy. VRET has already been shown to be effective with a great number of case studies and several controlled studies [2,3,4] with various phobias like acrophobia, fair

of highs, claustrophobia and agoraphobia. The advantage of VRET over in vivo therapy is that there is full control over the environment the patient is experiencing. In addition, the therapy can be performed anywhere, because there is no need for physical locations. Another advantage, pointed out by Garcia-Palacios et al [5], is that patients were more willing to expose themselves to VR then in vivo. Delft University of Technology has been working with VRET since 1996 and has conducted research in collaboration with Amsterdam University (UVA), Stichting Valk and PsyQ. With current VRET systems, it is possible for one therapist to treat one patient in the same room. Further research is being conducted on the development of VRET, to keep improving and extending its capabilities.

1.1 Research approach

Multiple patient VRET supports both human-human and human-computer interaction. In addition, there might be need for computer-controlled assistance. This defines multiple patient VRET as a *complex task environment*. *Situated cognitive engineering* [6,7] as described by Neerincx and Lindenberg can provide an extensive approach to analyse complex task environments. Situated cognitive engineering is used to analyse human-computer interaction and improve computer-supported task performance. It follows an iterative development process in which a design, gains more-and-more detail in its specifications. In this process, the specifications are being assessed repeatedly to be refined, adjusted or extended. Situated cognitive engineering consists of four phases: (1) Derive, (2) specify, (3) testing and (4) refining (Figure 1).

In this study the goal of the derive phase was to gain a better understanding of theories and technologies that could play an important role in the design of a multiple patient VRET system. In this phase, current VRET systems were explored. In addition, the operational demand, human factor knowledge and envisioned technology for tele-delivered multi patient VRET were further investigated. This knowledge was subsequently used to create a *preliminary vision* of a tele-delivered multi patient VRET system. To verify and extent this preliminary vision, *scenarios and claims* as described by Carrol [8] where used. In the specify phase, these scenarios or stories were created which make claims on the use of the system. To make the scenarios more visual and approachable, movies were produced. In these movies, actors depict how the therapist and the patients would use the proposed system. These movies were subsequently showed during interviews with therapists with experience with VRET. These interviews resulted in *preliminary specifications*. To further refine and test these specifications a *prototype* was constructed and a *lab experiment* was conducted. With this experiment, it was possible to explore the impact of the proposed automated-assist system and "call for remote assistance"-function on the workload of the participants. The results showed that the proposed automated assistance had a significant effect on the metal effort of the participants and that all participants did use the "Call for local assistance"-option.
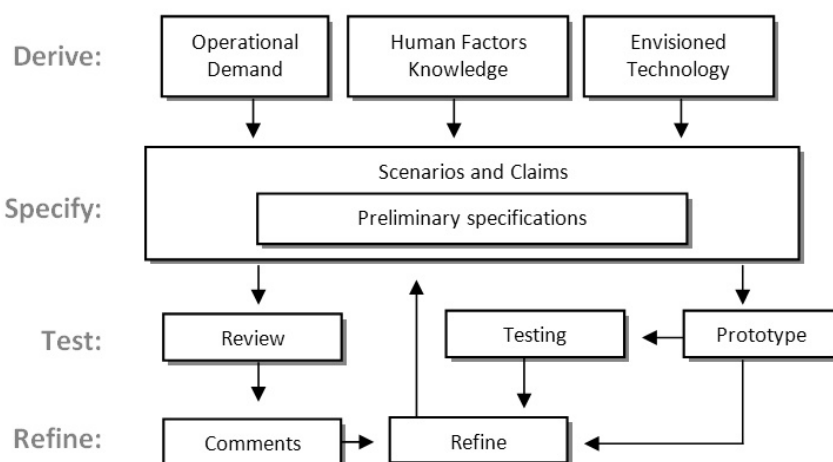

Figure 1: Overview of situated cognitive engineering for a multiply patient VRET system, extended from Neerincx and Lindenberg [7].

1.2 Current situation

A current system based on a description by Schuemie [9] is being used in the field since 2003 and could be considered as a starting point for this research on a multiple patients VRET system. In single patient VRET, communication between the therapist and the patient is very direct. The therapist is in the same room as the patient. He or she can talk directly to the patient, gets direct vocal feedback and can watch the posture and movement of the patient to monitor their state of mind. The therapist can control the *virtual environment* (VE) of the patient by using either keyboard or joystick and can see the patient's view of the VE on his or her screen. The computer system can also generate sound, which both therapist and patient can hear. The patients can see their VE in the HMD and can change their viewpoint in the VE by moving their heads. A tracker will monitor these movements and adjust the virtual view of the patient.

1.3 Human factors knowledge

Workload is a comprehensive concept with many aspects. Definitions of workload including the demand placed upon humans [10] or the portion of the operator's limited capacity required to perform a particular task [11]. The *task load* is an external workload, which is defined by the task environment. It is the number of problems that have to be processed in a given amount of time.

To achieve a better understanding of the increase of a therapist's workload, the *Current Task Load model* (CTL) as described by Neerincx [12] can be used. This model distinguishes three main load factors that have a large effect on the workload: (1) The percentage time occupied, which gives the actual time a user is working on tasks in percentages of the total time. (2) The level of information processing, this factor is determined by the speed the user can make complex decisions. (3) The amount of task-set switching which is being done. Many switches between different tasks will make the process much more demanding for the user. By plotting the factors above in three-dimensional space, the model distinguishes five cognitive states: (1) Under-load, (2) Optimal workload, (3) Vigilance, (4) Cognitive lock-up and (5) Overload.

When unexpected and time-critical problems occur, where time may be limited, it is important that a therapist can make fast and accurate decisions. A well-designed system should help the therapist by collecting and presenting relevant data [13], interpreting the data and provide advice to the therapist. Endsley [14] warns for factors that cause loss of situation awareness like; *tunnelling, memory trap, data overload, salience, complexity creep* and *out-of-the-loop*, all these factors should be considered when designing a multiple patient system.

1.4 Envisioned situation

To provide an initial description and to be able generate claims on tele-delivered multi patient VRET, a preliminary vision of this system was created. It provides an overview of the envisioned therapy structure and describes the proposed remote communication methods between the therapist and the patient. Subsequently it describes how software could assist the therapist.

When a patient begins phobia treatment, he or she has an initial consultation with a therapist. During this interview, the therapist determines what type of treatment may suit the patient. A treatment that consists of psychotherapy could be extended with virtual exposure therapy. If a therapist chooses to use VRET, he or she can decide to start with VRET at a location where the therapist and the patient are in the same room. At a certain point, the therapist can choose to sign the patient up for a remote session of VRET. The patient can have VRET at a location of their choice, for example a nearby mental health clinic, which has rooms equipped with a HMD and remote communication hardware. On these locations, an assistant has to be nearby so if anything goes wrong the therapist can warn this assistant to check up on the patient.

In this remote VRET setup, the therapist sees the patient trough a video-feed from a camera at the location of the patient. The therapist and patient can communicate via an audio-feed over a network; both the therapist and the patient will have a microphone. The therapist receives all the patient data via a network and can choose from a set of pre-programmed VR-scenarios for the patient. Because the therapists can always talk to the patient, they can always ask the patient for their level of anxiety. This can be given in a so-called SUD-Score (Subjective Units of Discomfort) [15], which is the subjective anxiety level of the patient on a scale from zero to ten. A computer system also has the ability to ask for these scores and relay them to the therapist. In addition, the possibility exists to extend these stress measurements with the use of biosensors and software. For example, stress recognition in the voice

[16], stress recognition in movement and posture [17], heart rate variability or galvanic skin response [18].

The system should be designed such way that it reduces mode errors [19]. In which a therapist makes the error of attending a different patient he or she thinks. A way to avoid these errors is by providing the therapist with separate a monitor and input-system per patient. To ensure that the workload of the therapist gets too high to compensate for emergencies, an automated assist system could be added. This system could monitor the anxiety levels of patients and warn the therapist, but also take over tasks if the therapist is too busy. This auto-assist function can be based on *adaptive automation* [20]: "the dynamic division of labour between man and machine". This is based on the conception of actively aiding the operator only when human information processing limitations emerge and assistance is required in order to overcome bottlenecks and to meet operational requirements.
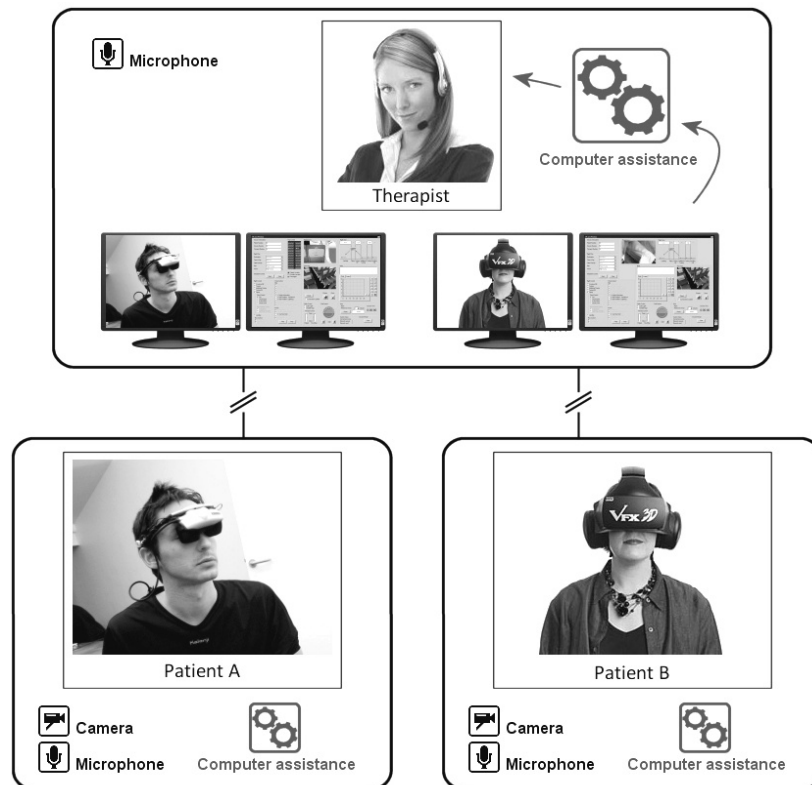

Figure 2: An overview of a multiple patient VRET setup.

2. Scenario-based investigation

User-based scenarios were used to explore the specifications of a tele-delivered multi patient VRET system. According to Carrol [8] scenarios should be used in a design process because they can capture the consequences and divers trade-offs in a particular design. Because scenarios are narrative, they can help users, experts and designers to imagine user situations and contexts for the new technology. By creating scenarios, automatically assumptions are made on what a system can and cannot do. These assumptions were used to create claims, which were reviewed by experts. Because the whole concept of multiple patient VRET seemed new to most experts it was chosen to transform these user-based scenarios into movies, thereby better visualising and explaining the scenarios. After an initial expert consensus on the written user-scenarios, there has been a rewrite of the user-scenarios to a script. This script was turned into three short films using (amateur) actors to further visualize multiple patient VRET (Figure 3). These films of a therapist assisting multiple patients were shown to six therapists with experience with VR therapy. *Semi-structured interviews* [21] were used to ensure as much information per expert possible was collected. Then, *Qualitative research* was used to extrapolate themes and specifications from these interviews. The results acquired were used to draw conclusions and generate preliminary specifications.

Figure 3: Stills from the user-based movies.

2.1 Scenarios

For every scenario, corresponding claims were made. These claims were created as statements that were presented to experts during interviews, to explore if they would agree or disagree. The next section will give a brief description of the four created scenarios.

Scenario 1: The start of the day for a therapist
The first scenario deals with the general setup of a remote VRET session. It describes how therapist Henrietta starts her day at a multiple patient VRET-center. It states how she makes contact with her first patient that day and describes how she interacts with the assistant on location.

Scenario 2: Patient communication
The second scenario describes the remote communicate methods between the therapist and patient. The therapist can hear and see all patients on their own separate monitor and speaker set. The patient can hear the therapist with his or her HMD. The therapist can see what the patients' view is in their VR environment. Before each session, the patients are connected to a heart rate variability measuring system and a galvanic skin response monitor, which measure the patients' physiological state. The system automatically asks a SUD score from the patients every two minutes and combines this score with the physiological data into a total anxiety-score. This score is presented continually to the therapist. This scenario also explains that a therapist can fluently switch to another VR-scenario in the same virtual environment.

Scenario 3: The therapist sets up the VR-scenarios and the setup of the assist system
This scenario elaborates on how a therapist can choose the VR-scenarios for the patient. It shows how a therapist can combine different VR scenario phases to a complete scenario, for example the combination of takeoff, flight and landing into a complete fear of flight scenario. Some VR-scenarios phases come in a variety of difficulties adding an option to the therapist to make session more anxiety or less provoking for the patient. This scenario also explains how the therapist can manually setup the automated assist per patient.

Scenario 4: Multiple patients need immediate assistance
The last scenario describes a situation where two patients need immediate attention from the therapists at the same time. It explains that the therapist will assist one patient and the automatic-assist automatically starts to calm the other patient down by switching to a les anxiety provoking VR-scenario.

2.2 Results

The interviewed therapists agreed on most of the claims that were derived from the creation of the scenarios. Some interviewees did stress on the importance of the patient-therapist relationship. Some were afraid that the distance between the therapist and the patient could become too great when using remote communication methods. Therefore making this a tool, which could be not suitable for all patients or all therapists.

The therapists affirmed with the remote communication setup shown in the video and liked the idea that a computer system could ask the patients for their SUD score. They also liked the use of physiological measurement in generating additional anxiety data on the patient.

For a good exposure treatment, it is imported that the patient has anxiety and a therapist can help the patient deal with this anxiety so the patient has the opportunity to overcome it. Some therapists feared that treating multiple patients could lead to a high workload for the therapist. In addition, some therapist felt that it could lead to situations where patients needed attention simultaneously. Most

therapists agreed that some type of therapist assistance software could help them in assisting multiple patients. They all agreed it was necessary to have some system that could provide additional help on location in emergency situations.

The therapists liked the idea of pre-programmed VR-scenarios where they could choose an appropriate scenario for the patient. They welcomed the fact that different difficulties of the scenarios were available, making it possible to switch between a harder or easier scenario. The therapists did warn that not all patients would perceive a specific scenario as the same difficulty level. This could probably be different per patient. Lastly, the interviewees liked the idea that they could setup an automated warning and assist system for themselves, making sure they are in control of the therapy.

2.3 The proposed automated assistance software

During initial research and the interviews with therapists, it became apparent that the workload of the therapist might play an imported role in the success of multiple patient VRET. Some therapist felt they could not adequately assist multiple patients at the same time because the workload could become so high that cognitive lock-up would occur. Two methods to lower the workload of the therapist were suggested: (1) the addition of a software based automated assistance system and (2) the ability for the therapist to call for assistance on location.

The proposed automated assistance software (auto-assist) can monitor the patients' anxiety-score. Prior to a VRET session, the therapist has the option to create or adjust a rule-set suitable for that individual patient and session. Arciszewski et al [22] describes a situation where the user can declare on forehand how the system should react in a case of high workload. This can be applied to multiple patient therapy, it could mean that the therapist can make *working agreements* with the system per patient by telling the system how to act in situations with a high workload. In the proposed system, the therapist can make simple rules with an if-statement and a then-statement, choosing between a variety of events that could occur during VRET sessions (Figure 4). For example, if the patient's anxiety-score goes over seven, sound an alarm and automatically switch to an easier VR-scenario variety. With such a system, therapists have the option to setup the behaviour of the computer assistance, which provides them with more control.
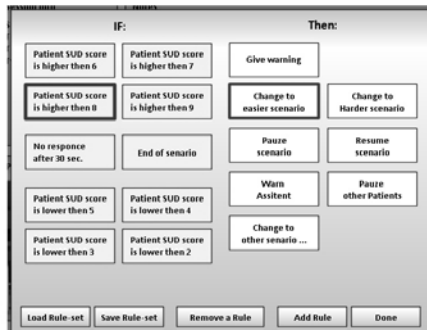

Figure 4: The setup screen of the proposed auto-assist.

Figure 5: The warning window of the proposed auto-assist.

When during a multi patient VRET session a rule fires, the therapist is present by an information screen and an alarm will sound. The screen provide information on which rule has fired and shows the pre-programmed solution (the then-statement) to the problem. The therapist has then two options. The first option is to acknowledge the warning and tell the system he or she will deal with the situation themselves. The second option is to ignore the warning, this could occur when the therapist is occupied with another patient. When the system notices that the therapist is ignoring the warning for a set amount of time, the system will execute the auto-assist by applying the then-condition of the rule.

3. Controlled lab experiment

To explore the impact of the proposed auto-assist and the "Call for local assistance"-option on the workload of the therapist in a multiple patient VRET situation, a controlled lab experiment was conducted. For the "Call for local assistance"-option option to have affect, it would be necessary that a therapist assisting multiple patients feels covetable using this option. Boehne [21] describes that people are reluctant to give up certain tasks and are stuck with their choice to perform a specific task. Because

of this phenomenon, it was decided to explore if participants would use this "Call for local assistance"-option, thereby delegating their task and responsibility to someone else, in overload situations.

Using real patients would imply that people with phobias would be placed in an experimental situation, where they had the chance to receive faulty treatments at this stage of research. This was not a desirable situation. Using real patients would mean that every therapy session would be different thereby introducing many unknown variables to the experiment. To overcome these problems, it was decided to use computer-simulated patients that provided the same type of experience as assisting real patients with VRET.

For the most valid result of the experiment, actual VRET therapists should be used as participants. Because there were a very limited amount of these therapist available and it would be hard for them to find the time to do the experiment, the choice was made to use people with the same skill-set as the therapists. All participants were at least following a university level of education. In total there were 27 participants of the experiment 20 males and 7 females between the ages of 21 and 30 ($M = 24$, $SD = 2.7$). To compensate the fact that these people did not have the knowledge of a therapist they were presented with protocols on how patients should be treated during VRET sessions. These protocols were designed based on real VR-therapy and were prior to the experiment discussed with a therapist. The participants did not needed to talk to the simulated patients, but used buttons to simulate conversation with the patients; this meant that the participants did not need to posses the communication skills of a therapist. To ensure that participants could not talk to more than one patient at the same time, all patent-communication-actions took certain duration. During this period, it was not possible to assist another patient at the same time.

3.1 Methods

Based on these preliminary specifications, a prototype was constructed that was used in the controlled lab experiment. In the experiment, participants had to assist three simulated patients in the four different task load level situations.

After a five-minute training with the software, the participants were subjected to four levels of task load (low, medium, high, and impossible to handle manually) of simulated therapy. These four tasks load level simulations, each lasting five minutes, where created based on the three load factors from the *Current Task Load model* as described by Neerincx [12].

The lowest simulation-block was created to explore the effect of auto-assist on a "Low" task load situation. The second labelled "Medium" was created to simulate an average amount of task load. The third, labelled "High", simulated a high task load level. The fourth simulation-block labelled "Impossible" was created in such fashion, that when the user had to assist the simulated patients without auto-assist, it was impossible to correctly provide assistance to all patients. The only way to correctly assist the simulated patients without auto-assists, was by using the "Call for assistance"-function. Because the auto-assist is able to assist multiple patients simultaneously, it would be possible to provide assistance to al the patients in this simulation-block, but if a mistake in the treatment was made, the user could also use the "call for assistance"-function to provide additional support for the simulated patients.

The participant all got the same simulation blocks but in a different order. This was done so that the order of the blocks would have no systematic effect on the result of the experiment. The software monitors if the patients was following the protocols correctly and thereby providing accurate treatment. To test the participants in situations with and without auto-assist, the four simulation-blocks were run twice per patient, once with auto-assist and once without. Counterbalance was used to make sure that results were not influenced by the order of auto-assist and none auto-assist.

3.2 Results

The quantitative data collected during the experiment consisted of two sets; the data collected for each of the eight five-minute simulation-bocks. Four blocks with the four differed task load levels with auto-assist and four blocks without. The seconds set of data consisted of the information acquired with the questionnaires based on the *NASA-TLX* [23] that were filled in twice per participant once with auto-assist and once without.

The data collected during each of the simulation-bocks, consisted of five variables: (1) Perceived mental effort based on the *Rating Scale Mental Effort* (RSME) by Zijlstra [24], (2) average response time, (3) therapy performance, (4) protocol correctness and (5) the number of calls for remote assistance.

To explore if the results were normally distributed *Kolmogorov-Smirnov test of normality* was used. One variable clearly showed not to be normally distribution; this was the number of calls for remote assistance. For the other four variables *multivariate analysis with repeated measurements* was used to analyse the data. The auto–assist (AA) and task load level (TLL) were *independent variables*. Multivariate analysis was used because the data was acquired by independent observations and all measurements were on an interval or ratio scale. Initial to the use of repeated measurements, the data was checked on sphericity, which meant it had to be homogeneity of variance and the variances of the differences between levels had to be similar to one another. *Mauchly's test of sphericity indicated* that not all data was. Only protocol correctness (p. = 0.110) under LLT and perceived mental effort (p. = 0.879) under AA*LLT proved to have significant sphericity. Therefore, for the remaining variables the results with the Greenhouse-Geisser correction were taken.

Multivariate analysis with repeated measurements showed the main effect of the task load level to be significant ($p. < 0.001$). The analysis revealed that all variables showed significant difference (Table 6) per task load level. This meant that the levels of task load had achieved to do what they were designed for; deliver dissimilar experiences to the participants.

Measure	Mean per task load level				Hyp. df	Error. df	F	p
	"Low"	"Medium"	"High"	"Impossible"				
Joint measure	-	-	-	-	228.00	12.00	13.28	0.000
Perceived mental effort*	32.7	39.4	55.2	63.4	1.59	41.42	60.10	0.000
Average response time*	11 sec	12 sec	14 sec	20 sec	2.07	54.03	63.77	0.000
Therapy performance*	98%	90%	71%	59%	2.11	54.90	474.93	0.000
Protocol correctness	93%	88%	80%	71%	3.00	78.00	47.55	0.000

*) Greenhouse-Geisser is taken because none passed the spherical assumption test.

Table 6: Multivariate analysis with repeated measurements between the four task load levels.

The main goal of the experiment was to determine if the auto-assist had any impact on the workload of the participants. Multivariate analysis with repeated measurements showed the main effect of the auto-assist to be significant ($p. < 0.001$). When split out per variable, the results showed that not all variables showed significantly differences while comparing auto-assist with no auto-assist (Table 7). The only significant variable was the perceived mental effort of the participants ($F(1, 26) = 15.12$, $p. < .001$). The participants rated their mental effort on average 9.5 points lower with the auto-assist enabled.

Measure	Mean regarding AA		Hyp. df	Error. df	F	p
	No-AA	AA				
Joint measure	-	-	5	22	12.77	0.000
Perceived mental effort*	52.4	42.9	1	26	15.12	0.001
Average response time*	15 sec	14 sec	1	26	1.31	0.263
Therapy performance*	79 %	80 %	1	26	0.45	0.508
Protocol correctness *	82 %	84 %	1	26	1.97	0.172

*) Greenhouse-Geisser is taken because none passed the spherical assumption test.

Table 7: Statistical analysis between auto-assist and no auto-assist

The next step was to explore the two-way interaction effect of the auto-assist and the task load level. The multivariate analysis with repeated measurements showed this to be significant ($p. < 0.001$). When the individual variables were further explored, they showed (Table 8) that only protocol correctness had a significance different effect on the presence of auto-assist per task load level ($F(2.3, 61.8) = 3.416$, $p. < 0.032$). An estimated marginal means graph (Figure 9) showed that at "Low" and "Medium" task load levels the auto-assist had almost no effect, however at "High" and "Impossible" task load levels the auto-assist has an positive effect. This states that the effect of the auto-assist on the amount of errors the participants made was significantly higher when the task load increased. This result could be explained by the fact that at high task load levels more protocols needed to be executed. This meant that the participants had more opportunities to make errors. The auto-assist was programmed to make no errors, therefore if the auto-assist was enabled relative more errors were avoided in session with higher task load levels.

Measure	Hyp. df	Error. df	F	p
Joint measure	15.0	228.0	5.135	0.000
Perceived mental effort	3.0	78.0	0.902	0.444
Average response time*	2.2	56.5	0.928	0.408
Therapy performance*	2.0	53.2	0.406	0.673
Protocol correctness *	2.3	61.8	3.416	0.032

*) Greenhouse-Geisser is taken because none passed the spherical test.

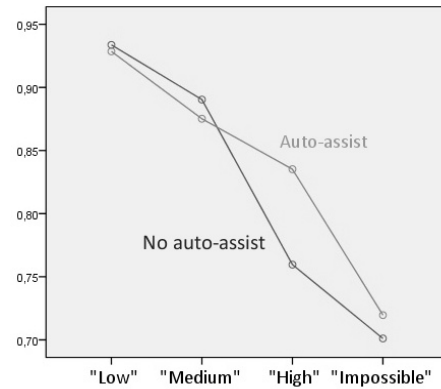**Table 8: Multivariate analysis with repeated measurements TLL*AA.**

Figure 9: Estimated marginal means of protocol correctness.

Call for remote assistance

The results of the experiment showed that all participants used the "Call for local assistance"-option at least once. At the "High" task load level, without auto-assist, 81% of the participants used the option and at the "Impossible" task load level the results were 100%. With the auto-assist enabled, it was possible to assist all (simulated) patients. However, a majority of the participants still used the call for assistance option ("Hard" 26%, "Impossible" 70%). This could be explained by the fact that participants still had the option to try to assist the patients manually. This could indicate that even with auto-assist, additional support on location for the patients might be needed; however, the amount of local support seemed far less.

A *Box-plot* of the amount of calls for local assistance (Figure 11) visualises the difference of the effect of auto-assist per task level. A Friedman's ANOVA was made (Table 10), which showed that the amount the participants call for remote assistance had both significant difference for the "Hard" ($\chi^2(1, N = 27) = 12.80$, $p < .000$) and "Impossible" ($\chi^2(1, N = 27) = 22.00$, $p < .000$) task load level. On average the number of times local assistance was needed on a task load level "Hard" and "Impossible" were 73% (1.56 compared to 0.41) and respectively 70% (2.90 compared to 0.90) less with auto-assist enabled. This could mean that adding auto-assist could result in a lot less calls, and thereby less workload, for the assistant on location.

Measure	No-AA Mean	No-AA STD	AA Mean	AA STD	N	χ^2	df	Exact Sig.
"Low"	0.00	0.000	0.00	0.000	27	-	1	1.000
"Medium"	0.20	0.362	0.00	0.000	27	4.00	1	0.125
"High"	1.56	1.188	0.41	0.797	27	12.80	1	0.000
"Impossible"	2.90	1.577	0.90	0.781	27	22.00	1	0.000

Table 10: Friedman's ANOVA of the amount calls for local assistance within the four task load levels.
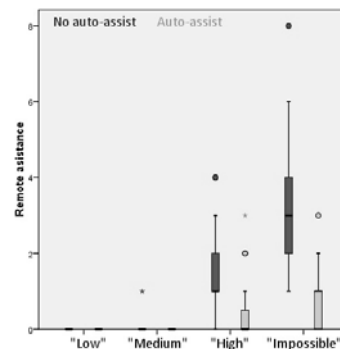
Figure 11: Box-plot of the amount of calls for remote assistance

NASA-TLX questionnaires

The second set of the quantitative data was obtained by questionnaires basted on the NASA-TLX. The data consisted of the six factors of the NASA-TLX, these were the dependent variables. These factors were: (1) mental demand, (2) physical demand, (3) temporal demand, (4) satisfaction in performance, (5) effort and frustration level. A *joint measure of the MANOVA* showed a significant difference between the auto-assist enabled or disabled. When explored separately, one of the six independent variables showed a significant difference. The participants significantly rated their *mental demand* lower after a session with auto-assist enabled ($F(1,47) = 5.929, p. < 0.019$). The other variables did not show this significant difference.

4. Discussion and conclusion

The interviews with the experts revealed that most therapists were in favour of the remote communication setup as proposed. Some therapists were a bit hesitant to the idea of remote VRET therapy, but if it was presented as homework assignment, most of them liked the concept. All therapists reacted positive to the use of physiological measurement to obtain additional data from the patient. The therapists felt that more data from the patient could support a better analysis of the patient. The therapists welcomed pre-programmed VR-scenarios; they felt this would give them more time to treat the patient instead of managing the virtual environment of the patient. The therapists welcomed the fact that different difficulties levels of VR-scenarios would be available, making it possible to switch between a harder or easier scenario. In addition, they liked the idea that they could setup an automated-assist system for themselves, making them feel more in control of the system.

Te controlled lab experiment was an initial exploration, it was unsuitable to use both real therapist and patients in this stage of the experiment. Therefore, participants with the same type of education level as therapists and simulated patients were used. The experiment demonstrated that the proposed automated assistance had a significant effect on the perceived mental effort of the users of such a system. The participants indicated to experience lower mental demands when the auto-assist was enabled. In addition, the participants used the "Call for remote assistance"-function when this was required, without the auto-assist. With the auto-assist enabled, the result showed that a large amount of participants still used the "Call for remote assistance"-function, however it was used significantly less. This means that there is reason to believe that the combination of auto-assist and the "Call for remote assistance"-function will have a significant positive on the affect when dealing with multiple patient VRET situations for real therapists as well.

4.1 Future research

With the exploration of the preliminary specifications, the focus of this research lay on the therapist. A secondary study could consider the opinions of the patients experiencing VRET. What are the patients' views on the proposed multiple patient VRET and would they feel comfortable with this type of treatment? Additional research could explore at what locations patients would prefer to have their virtual reality treatment. It is possible to explore the number of control the patients desire to have on their treatment. Moreover, is it possible to design a virtual reality treatment without the need of remote assistance?

A next step of the research could be to explore how real therapists and real patients would experience the proposed communicate methods, during a remote VRET sessions. Extending from this, a more elaborate prototype system could be build. Providing a way to test the complete multiple patient VRET setup. An additional experiment could be setup to determent the optimal number of patient that should be monitored and assisted using multiple patient VRET. In addition, further research can be conducted on the methods of accurately obtaining anxiety-scores from patients.

The interviewed therapists saw great benefit if certain patients could have VRET session at their own home. This can especially help people with agoraphobia and social phobia. To make this possible, patients would need to receive all necessary hardware at their home. VRET is designed to treat people with phobias, but this multiple people VR setup could also be used for much more purposes, also with people not suffering from phobias. It can be used for training purposes, for example speaking in public or communication training. This would have a much wider audience and could have a great commercial appeal. This also has the advantage that there is no patient-therapist situation, this could mean that monitoring would need to be less strict.

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