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

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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-patient 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 scenario-based investigation 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 treat 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 treat 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 a time [1]. This paper explores if it is possible and what specifications are required, to extent current VRET systems so that a single therapist can monitor and assist multiple patients in parallel. These patients all have their own personal virtual reality exposure session at different 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. Supporting multiple patients requires that communication methods between the therapist and patient needs 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 is 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 [2]. Bouman et al [3] 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 exposing the patient to 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

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inside a VR-helmet or Head-Mounted Display (HMD). VR gives the user the feeling of actually being inside this virtual environment, often referred to as presence. This is a key factor 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 [4,5,6] with various phobias like acrophobia, fear of heights, claustrophobia and agoraphobia. The advantage of VRET over in vivo exposure 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 [7], is that patients are more willing to expose themselves to VR than in vivo. Delft University of Technology has been working on the VRET system since 1996 and has conducted research in collaboration with University of Amsterdam, the VALK Foundation 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 [8].

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 [9,10] 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 multi-patient VRET system. In this study, 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 [11] were 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 that had extensive experience with VRET. These interviews resulted in specification guidelines. To further refine and test these guidelines 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 function on the workload and performance of therapists and to explore whether therapists would request remote assistance when this was required. The results showed that the proposed automated assistance function can result in a significant reduction of the perceived mental effort and that all the participants requested remote assistance when this was needed.

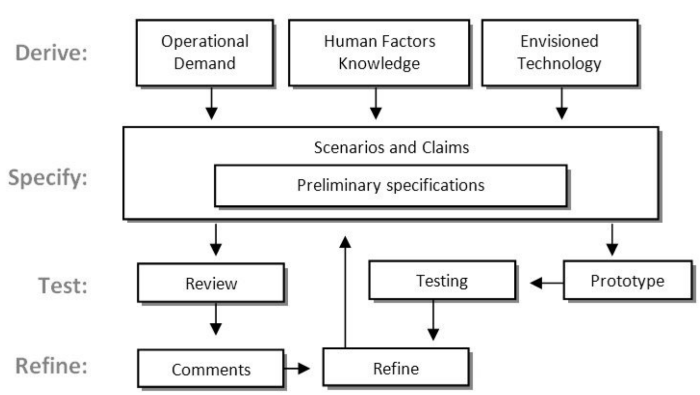

Figure 1. Overview of the phases of situated cognitive engineering extended from Neerincx and Lindenberg [8], adjusted for the design of a multi-patient VRET system.

This paper continues with an overview of the drive phase of the study. In section 2, the paper discusses the use of scenarios and interviews to form a preliminary specification. Section 3 elaborates on the lab experiment and lastly this paper presents the conclusions and some possible future research is discussed.

1.2. Current situation

The VRET system based on a description by Schuemie [12] is being used in the field since 2003 and could be considered as a starting point for this research on a multi-patient 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 oral feedback and can watch the posture and movement of the patient to monitor their state of mind. Therapists control the virtual environment (VE) of the patient by using a graphical user interface and a joystick. Furthermore, they can see the patient's view of the VE on a separate 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 monitors these movements and adjusts 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 [13] or the portion of the operator's limited capacity required to perform a particular task [12]. 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 understand the therapist's workload, the Cognitive Task Load model (CTL) as described by Neerincx [15] can be used. This model distinguishes three main load factors that have a large effect on the workload. The first load factor is the percentage time occupied, which gives the time a user is working on tasks in percentages of the total time. The second load factor is the level of information processing; this factor is determined by the cognitive task complexity. The last load factor is the amount of task-set switching. Numerous switches between different tasks will make the process much more demanding for the user. By plotting these factors in a three-dimensional space, the model distinguishes five cognitive states: (1) under-load, (2) optimal workload, (3) vigilance, (4) cognitive lock-up, and (5) overload. Cognitive lock-up can occur when users are occupied for a high percentage of their time and fail to adequately switch between task-sets. 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 [16]. When in addition the user also has to cope with a high level of information processing, overload occurs where the user is unable to manage the tasks given.

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 [17], interpreting the data and provide advice to the therapist. Endsley [18] 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 multi-patient system.

1.4. Envisioned situation

To provide an initial description and to be able to generate claims on tele-delivered multi-patient VRET, a preliminary vision of this system was created (Figure 2). It provides an overview of an envisioned therapy session 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 consultation, the therapist determines what type of treatment may suit the patient. This treatment could include virtual reality 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 at 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 with 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 therapists can 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) [19], which is the subjective anxiety level of the patient on a scale from zero to ten. A computer system could also have 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 [20], stress recognition in movement and posture, heart rate variability or galvanic skin response.

The system should be designed in such way that it reduces mode errors [21]. In which a therapist makes the error of attending a different patient than he or she thinks. A way to avoid these errors is by providing the therapist with a physically separate interaction system per patient [22]. To ensure that the workload of the therapist does not get too high to compensate for emergencies, an automated assist function could be added. This function 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 [23,24], i.e. 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.

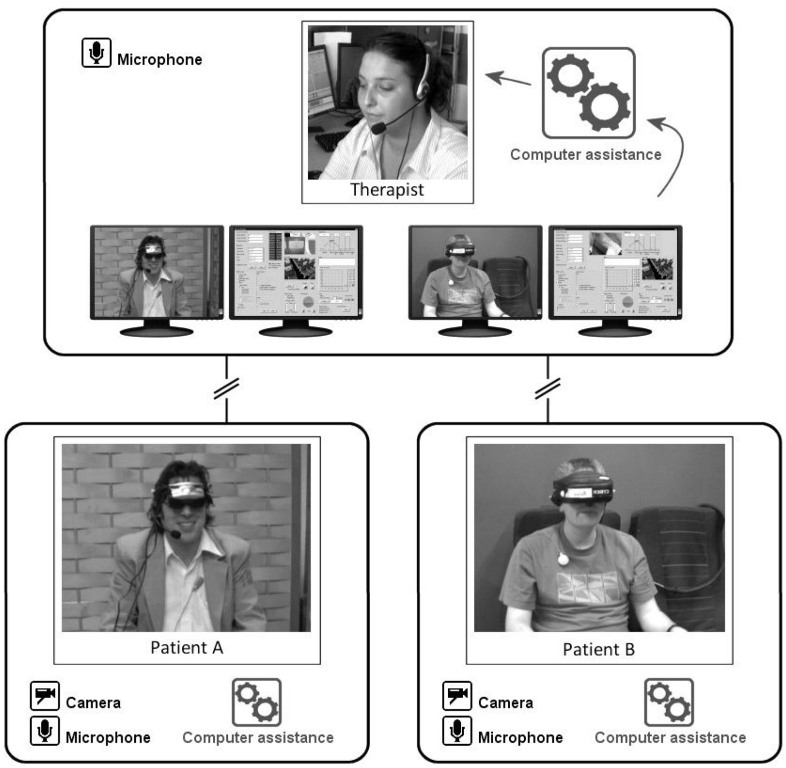

Figure 2. An overview of a multi-patient VRET setup.

2. Scenario-based investigation

Use-based scenarios were used to explore the specifications of a tele-delivered multi-patient VRET system. According to Carrol [11] 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 presented to six VRET therapists. Because the whole concept of multiple-patient VRET seemed new to most experts it was chosen to transform these

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user-based scenarios into movies, thereby better visualising and explaining the scenarios. After an expert on VRET research had reviewed the written user-scenarios, these were rewritten to a film-script. This film-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 extensive VRET experience. Semi-structured interviews [25] were used to ensure as much information per expert as possible was collected. Then, themes and specifications were derived from these interviews. The results acquired were used to draw conclusions and generate preliminary specifications.

Figure 3a. The therapist makes contact to the assistant on location

Figure 3b. The assistant on locations helps the patients

Figure 3c. The therapist monitors three patients simultaneously

2.1. Use 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.

2.1.1. Use 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-centre (Figure 3a). It states how she makes contact with her first patient that day and describes how she interacts with the assistant on location and how this assistant helps the patient put on the HMD (Figure 3b).

2.1.2. Use scenario 2: Patient and therapist communication

The second scenario describes the remote communication methods between the therapist and patient. The therapist can hear and see all patients on their own separate monitor and speaker set (Figure 3c). The patient can hear the therapist with his or her HMD. The therapist can see what the patients see in their VR environment. Before each session, the patients are connected to a heart rate 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 single 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.

2.1.3. Use scenario 3: The therapist sets pre-programmed VR-scenarios and 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 pre-programmed VR scenario, for example the combination of taking off, flying and landing into a complete fear of flight scenario. Some VR-scenarios phases differ in the amount of anxiety they can provoke giving therapists the ability to control the amount of exposure. This use scenario also explains how the therapist can manually setup the automated assist per patient.

2.1.4. Use 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 pre-programmed VR-scenario.

2.2. Claims

To test if these scenarios would be realistic, claims were made on essential elements of these scenarios. All claims were included as statements in the questionnaire, and they were used to start the discussion in the interviews. Next are some example claims for scenario 2.

- The therapist is able to assist the patient adequately by using only verbal communication.
- For emergencies, an assistant on location is enough to provide backup assistance.
- The use of physiological measurement has a large benefit in the monitoring of a patient.

2.3. Results

Of the six interviewed therapists, almost all agreed on the claims that were derived from the creation of the scenarios. 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. 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, making this system setup less suitable for all types of patients and 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. The therapists mentioned that for a good exposure treatment, it is important that the patient experience 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 therapists 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, therefore a kind of “Call for remote assistance”-button should be included, which would signal an assistant at the patient side to attend the patient.

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 level of anxiety provoking VR-scenarios were available, making it possible to switch between a more anxiety provoking or less anxiety provoking VR-scenario. The therapists did warn that not all patients would perceive a specific scenario as the same level of anxiety provoking. This could 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.

2.4. 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 important role in the success of multiple-patient VRET. Some therapists 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 [26] describes a situation where the user can declare on forehand how the system should react in a case of high workload. This seemed to be applicable to multiple-patient therapy. This 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-condition 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 a less anxiety provoking VR-scenario. With such a system, therapists have the option to setup the behaviour of the computer assistance, which provides them with more control.

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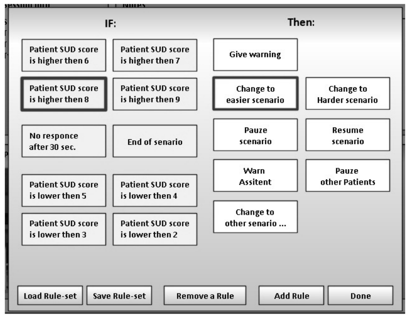

Figure 4. The setup screen of the proposed auto-assist.

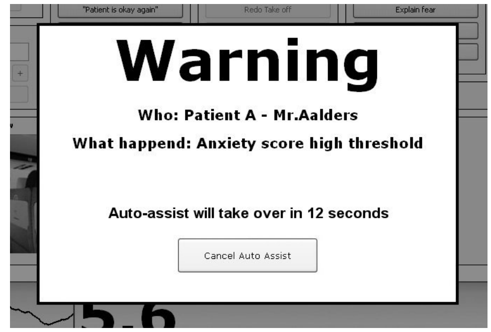

Figure 5. The warning window of the proposed auto-assist.

When during a multi-patient VRET session a rule fires, the therapist will get an alarm and an information screen is presented (Figure 5). This screen provides information on which rule has fired and shows the pre-programmed solution (the then-statement) to the problem. The therapist then has 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 not to respond to the warning, this could occur when the therapist is occupied with another patient. When the system notices that the therapist is not responding to the warning within a set amount of time, the system will execute the auto-assist by applying the then-statement of the rule.

3. Controlled lab experiment

To explore the impact of the proposed auto-assist on the workload of the therapist in a multiple-patient VRET situation and to study appropriate use of the "Call for remote assistance"-button, a controlled lab experiment was conducted. For the system to be usable, therapist should ask for remote assistant in emergency situations or if they are no longer able to attend to patients adequately because of high task load demands. In the last situation the risk of cognitive lock-up exists, in which therapists might not ask for remote assistance. As Boehne [16] describes, people in these situations can be reluctant to give up certain tasks and 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 remote assistance"-button effectively, thereby delegating their task and responsibility to someone else, in an 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. Also, using real patients would mean that every therapy session would be different thereby introducing many unknown variables into the experiment. To overcome these problems, computer-simulated patients were used with the aim of providing a similar experience as assisting real patients with VRET. These computer-simulated patients were pre-programmed to show behaviour at set times within a session. Patient information was presented on two monitors and speaker sets were used to produce the speech of 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. 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 of the three simulated patients looked different and had a different voice.

For the most valid result of the experiment, actual VRET therapists should be used as participants. Because there were only a limited number of these therapists available and with limited amount of available time, the choice was made to use people with a same level of academic education as the therapists. All participants were at least following a university level of education in a technology-oriented area. 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 for 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 observed VR-therapies [8] and were prior to the experiment discussed with a therapist experienced in using VRET. The participants did not need to talk to the simulated patients, but used buttons to simulate conversation with the patients; this meant that the participants did not need to possess 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 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 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 the simulated therapy. These four tasks load level simulations, each lasting five minutes, were created based on the three load factors from the Cognitive Task Load model as described by Neerincx [15].

One simulation-block was created to explore a low task load situation. The second level, labelled Medium, was created to simulate an average amount of task load. The third level simulated a high task load situation. The fourth simulation-block, labelled Impossible, was created to simulate a situation where users without auto-assist would never be able to correctly assist all patients because there was simply not enough time to correctly apply all required protocols. The only way to correctly assist the simulated patients without auto-assists was by using the “Call for remote assistance”-button. 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 remote assistance”-button to provide additional support for the simulated patients.

The participants all got the same simulation blocks but in a random 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 participant 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 participants, once with auto-assist and once without. The order in which they were presented was counterbalanced per participant to ensure that results were not influenced by the order of auto-assist and none auto-assist condition.

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-blocks. Four blocks with the four differed task load levels with auto-assist and four blocks without the auto-assist. The second set of data consisted of the information acquired with the questionnaires based on the NASA-TLX [27] that were filled in twice by a participant: once after the blocks with the auto-assist and once after the blocks without the auto-assist function. The data collected during each of the simulation-blocks, consisted of five measures: (1) perceived mental effort based on the Rating Scale Mental Effort (RSME) by Zijlstra [28], (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 measure clearly showed not to be normally distributed; this was the number of calls for remote assistance. For the other four measures multivariate analysis with repeated measurements was used to analyse the data. The auto–assist (2 levels) and task load level (4 levels) were used as independent variables. In cases where the Mauchly’s test showed significant ($p. > 0.05$) deviation from sphericity the Greenhouse-Geisser correction were taken.

3.2.1. Multivariate analysis with repeated measurements

Multivariate analysis with repeated measurements showed a significant main effect for the task load level (Table 6). This meant that the levels of task load had achieved to do what they were designed for - deliver dissimilar experiences to the participants. Table 6 also shows that univariate analyses found a significant main effect for the task load level in each of the individual measures.

One of the main goals of the experiment was to determine if the auto-assist had any impact on the workload and performance of the participants. The multivariate analysis with repeated measurements revealed a significant main effect for the auto-assist. When split out per measure, a significant main effect for auto-assist function was only found in the perceived mental effort reported by the participants. The participants rated their mental effort on average 9.5 points lower on the RSME scale with the auto-assist enabled.

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	Mean per task load level					Hyp.	Error.	
Measure	Low	Medium	High	Impossible	*df*	*df*	*F*	*p*
Joint measure	-	-	-	-	228.00	12.00	13.28	< 0.001
Perceived mental effort*	32.7	39.4	55.2	63.4	1.59	41.42	60.10	< 0.001
Average response time*	11 sec	12 sec	14 sec	20 sec	2.07	54.03	63.77	< 0.001
Therapy performance*	98%	90%	71%	59%	2.11	54.90	474.93	< 0.001
Protocol correctness	93%	88%	80%	71%	3.00	78.00	47.55	< 0.001

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

Table 6. The main effect of the task load level.

	Mean regarding AA		Hyp.	Error.		
Measure	No-AA	AA	*df*	*df*	*F*	*p*
Joint measure	-	-	5	22	12.77	< 0.001
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. The main effect of the auto-assist.

The next step was to explore a two-way interaction effect between the auto-assist and the task load level. The multivariate analysis with repeated measurements showed this to be significant. When the individual measures were further explored, they revealed (Table 8) a significant two-way interaction effect only in the protocol correctness measure. Figure 9 shows that at low and medium task load levels the auto-assist had almost no effect. However, at high task load levels the auto-assist has a positive effect. This states that the effect of the auto-assist on the number 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 the high task load sessions. In the impossible condition the increased use of remote assistant seems to have removed the advantage of auto-assist function.

Measure	Hyp. *df*	Error. *df*	*F*	*p*
Joint measure	15.0	228.0	5.135	< 0.001
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. The two-way interaction effect between the task load level and auto-assist.

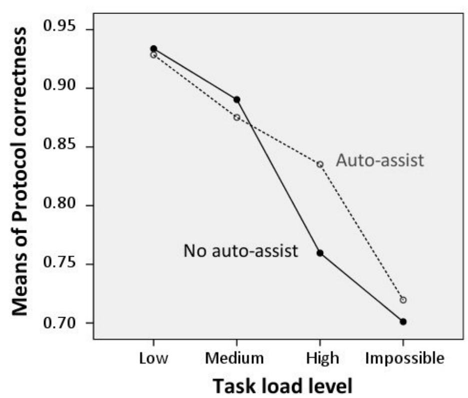

Figure 9. Means of protocol correctness for in auto-assist and auto-assist conditions.

3.2.2. Call for remote assistance

The results of the experiment showed that all participants used the "Call for remote assistance"-button at least once. At the high task load level, without auto-assist, 81% of the participants pushed the button at least once and at the impossible task load level 100% of the participants pushed it. With the auto-assist enabled, it was possible to assist all (simulated) patients. However, a majority of the participants still pushed the "Call for remote assistance"-button (high: 26%, impossible 70%). This could be explained by the fact that participants still had the option to try to assist the patients manually. This

Preliminary version of Paping, C., Brinkman, W.-P., and van der Mast, C., (2010). An Explorative study into tele-delivered multi-patient VR exposure therapy system, *Coping with posttraumatic stress disorder in returning troops: Wounds of War II*, ISBN 978-1-60750-570-9, pp. 203 - 219, IOS press, Amsterdam, The Netherlands, 2010.

could indicate that even with auto-assist, additional support on location for the patients might be needed; however, the number of calls for local support seemed far less.

A Box-plot (Figure 11) shows the number of times the "Call for remote assistance"-button was pressed in the five-minute simulation per task load level. A Friedman's ANOVA on the number of times the "Call for remote assistance"-button was pressed (Table 10) showed that at high ($\chi^2(1, N = 27) = 12.80$, $p < .000$) and impossible ($\chi^2(1, N = 27) = 22.00$, $p < .000$) task load level, that the number of calls was significantly lower with the auto-assist enabled. This could indicate that adding auto-assist could result in less remote calls, and thereby less workload, for the assistant on location.

Measure	N	χ^2	*df*	Exact Sig.
Low	27	-	1	1.000
Medium	27	4.00	1	0.125
High	27	12.80	1	< 0.001
Impossible	27	22.00	1	< 0.001

Table 10. Friedman's ANOVA on the number times the "Call for remote assistance"-button was pressed within the four task load levels with or without the auto-assist function.

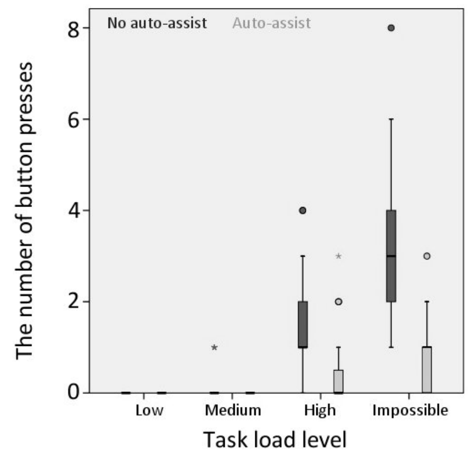

Figure 11. Box-plot of the number times the "Call for remote assistance"-button was pressed

3.2.3. NASA-TLX questionnaires

The second set of the quantitative data was obtained from the NASA-TLX questionnaire. The data consisted of the six factors of the NASA-TLX. These were taken as the dependent variables in the analysis. These factors were: (1) mental demand, (2) physical demand, (3) temporal demand, (4) satisfaction in performance (5) effort, and (6) frustration level. The joint measure of the MANOVA showed a significant ($F(1,47) = 15.731$, $p. < 0.001$) difference between the auto-assist enabled or disabled. When explored separately, only the NASA-TLX measure mental demand showed to be significantly ($F(1,47) = 5.929$, $p. < 0.019$) lower when the auto-assist was enabled. The other five measures showed no 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. As also reported by another study [29], therapists feel this would give them more time to treat the patient instead of being occupied with controlling the virtual environment of the patient. The interviews indicated that the therapists welcomed the fact that different difficulty levels of VR-scenarios would be available, making it possible to switch between a more or less anxiety provoking 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.

The controlled lab experiment was an initial exploration. It was unsuitable to use both real therapists and patients in this stage of the research. Therefore, participants with the same academic level of education as therapists were used as well as computer-simulated patients. 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 in situations without the auto-assist. With the auto-assist enabled, the result showed that a large number of participants still used the "Call for remote assistance"-button, however it was used far less. This means that there is reason to believe that the combination of auto-assist and the "Call for remote assistance"-button will have a significant effect on the workload of both the therapist and the local assistant when dealing with multi-patient VRET. Furthermore, these participants were still able to request for remote assistance when needed. If even these technology-oriented students were unable to use this functionality, cognitive lock-up would certainly be a potential risk factor for therapists in the field. However, no such indication of a cognitive lock-up was found in this experiment.

5.1 Future research

With the exploration of the preliminary specifications, the focus of this research was on the therapist. Future studies could consider the opinions of the patients experiencing VRET. What are the patients' views on the proposed multi-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 level 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 communication methods, during a remote VRET sessions. Extending from this, a more elaborate prototype system could be build, providing a way to test the complete multi-patient VRET setup. An additional experiment could be setup to determine 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 applications. It might be used for education and training where a teacher can monitor multiple students that can do exercises in VR, for example speaking in public or communication training. With these kind of functions even greater number of people could benefit from the research and development of these kind of technologies.

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