Design and Usability Evaluation of a Multi-Modal Memory Restructuring System for the treatment of combat-related PTSD

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ABSTRACT
This paper discusses the design and usability evaluation of a system to support treatment of veterans suffering from a combat related Post-Traumatic Stress Disorder (PTSD), focusing on restructuring, reappraising and relearning of past events. The proposed application allows patients and therapist to visualize and talk about the patient's past experience by placing maps, personal pictures, stories and self created 3D virtual worlds related to past dispatches on a set timeline. The design followed a situated cognitive engineering approach; after a domain analysis a number of possible scenarios were created and reviewed by experts in the field, followed by the implementation and evaluation of several prototypes. A case study and a follow-up experiment with 18 participants, focusing on evaluating the usability of three main interface components (timeline and navigation control, content manager and the 3D world editor), indicated that the system showed no major usability issues and that the system was easy to use.

Categories and Subject Descriptors
H.5.1 [Information interfaces and presentation]: Multimedia Information System

General Terms
Design, Experimentation, Human Factors.

Keywords
PTSD, trauma-focused psychotherapy, memory, multimedia, restructuring, reappraisal, 3MR

INTRODUCTION
War is known for its high rates of potential stressors. Fire fights, terrorist attacks, losing comrades and taking care of dead bodies are only some of the events a veteran is exposed to during war or a particular dispatch. Exposures to these kinds of stressors increase the chances that these veterans develop a combat-related Post-Traumatic Stress Disorder, a severe anxiety disorder which is characterized by the re-experiencing of these traumatic events that coincides by symptoms of increased arousal and by avoidance of trauma associated stimuli. Various methods exist to treat veterans suffering from this type of disorder, each with their own advantages and disadvantages. One persisting problem among two popular treatment methods, namely 'Cognitive Behavior Therapy' (CBT) and 'Eye Movement Desensitization and Reprocessing' (EMDR), is the high drop-out rate of patients [1]. This and several other problems have lead to the exploration of new emerging treatment methods to help patients with a combat-related PTSD as well as to increase appeal relative to traditional face-to-face therapy [2]. The focus of the proposed Multi-Modal Memory Restructuring (3MR) system discussed in this paper is to support patients in the way they talk about their past experiences. The goal is to let patients restructure, relearn and reappraise past events, both directly and indirectly related to the problematic stressors. The design and evaluation of the proposed system followed the Situated Cognitive Engineering approach as described by Neerincx and Lindenberg [3]. It is an iterative approach where the requirements baseline is continuously refined as new insights are acquired through prototype evaluations and reviews with therapists. The first step of this approach was to do a thorough domain analysis. This was done in close cooperation with a psychiatrist experienced in treating veterans suffering from a combat-related PTSD, which eventually lead to the establishment of an inventory of human factor knowledge, operational demands and envisioned technology. This knowledge was used to create several scenarios and prototypes. PTSD experts were asked to review these scenarios and discuss various possibilities and limitations, while the prototypes were evaluated by experts with a background in Human-Computer Interaction (HCI). At the end, the final prototype was exposed to a follow-up experiment focusing on the usability of three main components of the system and a case study with a veteran suffering from combat-related PTSD.

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DOMAIN ANALYSIS

2.1 Acquiring Knowledge

The first step in designing the proposed system was to acquire sufficient knowledge of the current therapeutic domain. This was done in close cooperation with a military psychiatrist from the University Medical Center (UMC) Utrecht. Several meetings were planned to acquire a better understanding of current activities, theories and all involved people. Furthermore, possibilities on how technology could support or take over certain activities in the therapeutic setting were discussed in further detail.

An important patient characteristic which was found during this analysis and which would later play an important role in the design and implementation of the system was the availability of personal material. It was said that many of the patients who were treated at the medical center kept personal photos, pictures and various related documents related to the past dispatch at their homes. Although this material may not directly be related to a problematic stressor, it could still contain information necessary for the treatment or it could be used for reappraising the past dispatch as a whole.

2.2 Operational Demands & Human Factors

During the domain analysis, which was based on a literature study and interviews with a military psychiatrist, several operational demands were distinguished: (1) a more appealing way to support group therapy, (2) patient memory and exposure, (3) different therapist backgrounds, (4) managing therapy group sessions and (5) treatment awareness at the patient side. The first operational demand was concerned with the high drop-out rates and a possibility of using group therapy in combination with a computer application. Gathering sufficient information regarding a patient's past experience can be a difficult task as the patient might not remember exactly what happened during the dispatch or the patient does not want to be engaged in talking about these subjects as it would be too emotional for him or her. The third and fourth demands were concerned with the variety of existing therapist backgrounds and a way of managing a possible (group) session. The last operational demand was related to ways to add psycho-educational aspects to the system to make the patient more aware of both the therapy sessions and the past dispatches he or she was in. Two human factors identified as important for the design and implementation were: trust and emotion. Trust was mainly concerned with the relationship between therapist and patient, which should not be endangered by the system.

2.3 Envisioned Technology

The first idea was to solely create a 3D world editor, allowing the patients themselves to select 3D objects, such as houses, tanks and other vehicles and placing them on an empty template. To support the group process, a projector would display the computer screen on the wall. This way patients could explain to other group members what the situation looked like, what they experienced and in which order specific events occurred. During the meetings with the psychiatrist and discussions of early scenarios, the idea changed to a different type of application. This new type of application allowed the patient to place pictures, maps, text and webcam shots on a timeline to support storytelling of past experiences. The use of a 3D world editor was not scrapped as it was added as an additional storytelling feature.

SCENARIOS AND CLAIMS

A set of use scenarios [4] were created to describe and discuss possible situations in which the envisioned application was present. The gathered knowledge was later used to establish a preliminary requirements baseline. By creating these scenarios several assumptions had to be made explicit. The assumptions were linked to possible effects on the involved actors and were therefore important to analyze. A claims analysis was done to categorize the possible effects as either pro or cons.

The scenarios described three possible situations in a therapeutic setting in which the system could be used: (1) the general use of the system showing all the major features of the application, (2) the use of the 3D editor as a feature of the system and (3) modifying or extending data related to an event discussed in a previous session. To explain these scenarios better, they were transformed into three separate movie clips showing actors using a first low-fidelity prototype of the envisioned application. These movie clips were then presented to ten experts in the field, all with a background related to (combat-related) PTSD or traumatic memory.

The resulted feedback from these individual interviews was not concerned with only the application itself, but also on the way the room should be set up, about group therapy in general (and in this particular setting) and the way the patient can benefit by restructuring his or her memory using, for example, photographs and other media. The overall feedback was positive and the general idea behind the envisioned approach was supported. The acquired comments were mainly related to features which could improve the system, including additional options to facilitate memory content, such as adding maps and photos of drawings. Other suggestions, which also caused refinements to the requirements baseline, were (1) the possibilities to personalize the application for an individual patient, (2) the use of keywords to tag or summarize a specific day and (3) methods to manage and store data and session information.

Table 1. Core functions

Core Function
Provide a flexible way of storytelling
Provide a structured way of storytelling
Prevent losing track of changed and added events
Ensure trust
Ensure usage for therapists with different backgrounds
Ensuring awareness of treatment
Provide a patient personal approach
Prevent unexpected exposure to emotional material
Ensure appealing and motivating approach

The analysis of all gathered feedback resulted in a total of nine core functions, with each core function linked to one or more requirements needed for the implementation of a prototype. These core functions are listed in Table 1.

DESIGN

A projection of the timeline set on the present day is shown when the 3MR application is started. From here the patient can travel back in to a specific day of their deployment. The counting back of years and days to the specific day is done by displaying photos of historical events of that time period. This is to emphasize that the traumatic events has taken place in the past. Once arrived on the specific day, the application consists of three main components (Figure 1): (1) an overview panel, (2) a timeline which is also used as main means of navigation and (3) the content manager where the patient can add and place elements, such as pictures, maps and text.

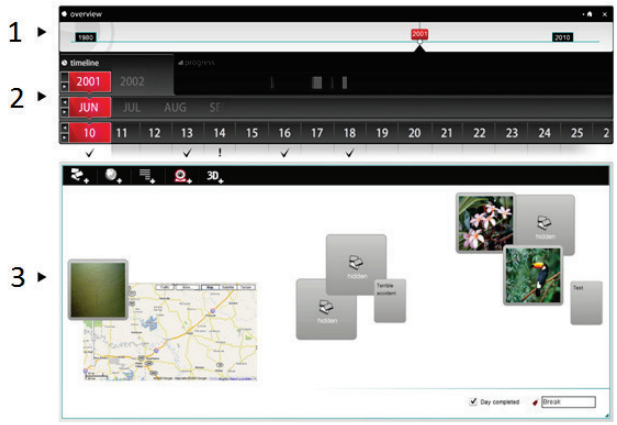

Figure 1: Three main components of the system

Patients are able to submit personal information and dates related to their dispatches. All this information is then used to create timelines corresponding to these dates. The patient can then select one of these dispatches and, together with the therapist, work on adding content to this period of time.

Figure 2: 3D world editor

Patients are able to add (1) pictures or personal photos, (2) maps, (3) text, (4) webcam shots (for drawings made during a session) and (5) 3D worlds (Figure 2). Small previews of the elements can be placed anywhere on the bottom half of the screen. This way, patients can also group certain related elements together.

The application marks days with an icon whenever the patient adds content to a day or completely filled a day. An additional progress bar is present to give both patient and therapist a general overview of which parts of the timeline have been covered and which parts still need attention.

USABILITY EVALUATION

Additional work on the 3MR system [5] indicates its ability to support people in a more detailed way of storytelling, e.g. more precise time referencing, more detailed event description, and more detailed time covering. The evaluation reported in this paper focuses therefore on another element, the usability of the system, which is considered vital for future system acceptance.

5.1 Heuristic evaluation

Several prototypes and evaluations were needed to come up with the final prototype as shown in Figure 1. After the first core functions and requirements were defined, a first high-fidelity prototype was created (Figure 3). Ten principles for user interface design [6], also known as the ten heuristics, were used to obtain feedback on this high-fidelity prototype. Six MSc students, experienced in the field of HCI, were all asked to complete, individually, a form containing several questions related to the ten heuristics. Later, a part of this group was asked to participate in a follow-up evaluation. This follow-up was a group discussion with the aim to further discuss possible usability issues present in the high-fidelity prototype.

The acquired feedback from both evaluations were mainly concerned with: (1) the state of the system, which was not clear, (2) system behavior did not follow an OS standard and (3) confusing icons and buttons.

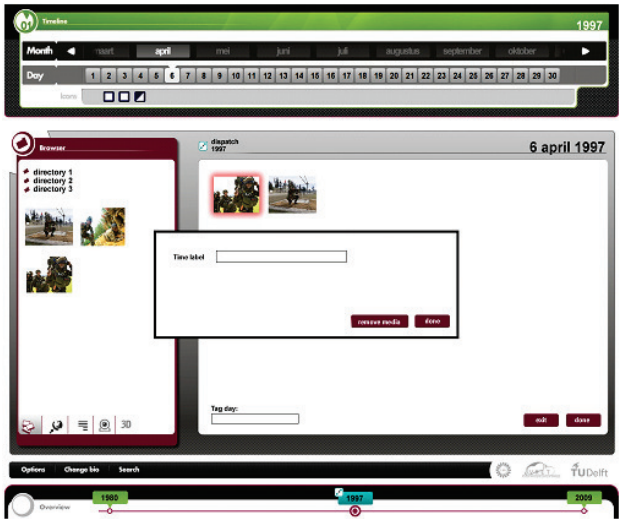

Figure 3: First high-fidelity prototype

A formative usability evaluation approach was chosen to address these issues and to continuously acquire more feedback of rapidly generated prototypes in a period of three to four weeks. During this phase various elements of each prototype were inspected by MSc students and lecturers with a background in HCI. During this time

meetings with the psychiatrist took place to discuss the progress and eventual changes made to the requirements baseline. In addition to these reviews, a small interview took place with a patient suffering from combat-related PTSD. The reviews and small interview resulted in two core functions (Table 1): providing a personal approach and preventing unexpected exposure. The core function concerned with unexpected exposure was defined after a comment was given that there was no way to categorize material or to hide very emotional images with the system. Eventually the evaluation reached a point where no usability issues were reported anymore. This last prototype, also referred to as the 'final prototype' was now suitable to be exposed to a follow-up experiment and a case study with a veteran suffering from combat-related PTSD.

5.2 User study and case study

The evaluations of the previous evaluations lead to several refinements regarding both the usability and the functionality of the system. With the final prototype finished, both an experiment and a case study were conducted to acquire more insights on the usability of the system. The aim of the case study was to acquire insights into how a patient would use and interact with the system.

5.2.1 Participants

The sample comprised 18 participants (12 males, 6 females), none suffering from a combat-related PTSD. The age varied between 21 and 59 (M =36.2, SD=15.1). The participants never worked with the final prototype before and none were given instructions beforehand.

5.2.2 Measures and materials

Participants filled out a component-based usability questionnaire [7] consisting of a series of statements which were concerned with the usability of three user interface components of the system (timeline navigation, content manager and the 3D editor). A total of 6 statements were used for every component. Participants were asked to rate the likelihood of these statements on a 7-point scale. Next to the rating, the questionnaire also had room for additional comments. After the participant completed the ratings of one component, he or she was asked to write additional feedback down in the appropriate boxes on the form before continuing with the next component.

Before filling out the usability questionnaire, participants had to complete several tasks. Therefore a task list was created which covered every feature the prototype had to offer.

5.2.3 Procedure

Using the provided task list each participant selected one specific deployment, navigated through the timeline to pick a date and eventually added, modified and deleted content elements. For the editor the participants had to create a virtual world similar to a screenshot given on the task list. Every participant received the exact same task list. No additional instructions or help files were given prior to the user study. When the participant completed all the given tasks, he or she was asked to fill in the evaluation questionnaire.

5.2.4 Results

The questionnaire elements for all three components obtained acceptable levels of reliability with Cronbach's alpha. All values were above the threshold of 0.7 [8] (Table 2), indicating an acceptable level of reliability.

Table 2. Cronbach's alpha values

Component	Alpha
Timeline navigation	0.81
Content manager	0.70
3D world editor	0.73

The ratings of all three user interface components, acquired from the filled-in component-based usability questionnaires, were compared with the norm value of 5.29 [6]. Ratings above this norm value suggest that the usability of the component is more similar to the usability of the easy to use components in the norm set. Likewise, ratings with a value below 5.29 suggest that the usability of the component is more similar to the usability of the difficult to use components in this norm set.

To see if the acquired ratings deviated from the norm value, a one-sample t-test was done using the 5.29 as test value (Table 3). The analysis of the ratings showed that participants rated the timeline navigation (M = 6.37, SD = 0.43), content manager (M = 6.08, SD = 0.45) and 3D world editor (M = 5.62, SD = 0.57) above the 5.29 norm value.

Table 3. One-Sample t-test results

One-Sample *t*-test with test value = 5.29			
Component	t	*df*	*Sig.*
Average score timeline	***10.579***	***17***	***< 0.001***
Average score content manager	***7.368***	***17***	***< 0.001***
Average score 3D world editor	***2.436***	***17***	***0.026***

The questionnaires also allowed participants to add additional comments and suggestions. One reoccurring issue was that of the 'maps' icon; the task list asked the participant to add a map, however a large amount of people thought the 'maps' icon was actually the icon to open up an internet browser. Because there were not many other options, everyone still managed to add the map, but some found this a bit confusing. A suggestion made by multiple participants was to add the ability to drag and drop objects in the 3D world editor.

5.2.5 Case study

A small case study was organized with a veteran suffering from combat-related PTSD. This patient has served in various deployments, such as Dutchbat I (Srebrenica). As the proposed system was a new concept, the aim was to acquire insights into how a patient would use and interact with the system. The case study consisted of two sessions. The first session took about an hour, while the second session took 40 minutes. Prior to the first session, the patient was asked to bring photographs of a deployment with him. The psychiatrist

also explained the idea behind the system and that a student from the University was going to attend the sessions with him. In the first session the application was explained in detail. The first couple of minutes of the first session were dedicated to explain the system and to let the patient explore the application. The second session and the remainder of the first session were used to let the patient tell more about a deployment while using the system. During the sessions notes were constantly taken by the observer. These notes consisted of code words to quickly describe a taken action of either the patient or the therapist. Also issues and suggestion were written down. Between the two sessions a small discussion took place to reflect on what happened in the previous session. In this small discussion the patient was also asked what he thought of the application and if he had suggestions. All usability related findings of the two sessions and the discussion can be found in Table 4.

Table 4. Feedback case study

The application missed a clipboard to copy/paste content.
Thumbnails could be made bigger, but they were not big enough.
Icons present in the general overview were not clickable.
No option to turn off moving back in time animation.

CONCLUSION AND DISCUSION

The main contribution put forward by this study is the identification of the definition of nine core functions for the creation of an application which allows veterans suffering from a combat-related PTSD to restructure, relearn and reappraise past experiences by giving them a tool that supports the way a story is told. Throughout the design of this application various usability evaluations took place to acquire feedback and to use this feedback to create a new and improved prototype. Eventually the 'final prototype' was created which was evaluated in a user study and a case study. The acquired ratings of the three evaluated components (timeline navigation, component manager and 3D editor) indicated that these components were easy to use. However, additional feedback and comments acquired by the conducted case study showed several suggestions that could improve the usability of the system. One of these suggestions was the ability to put content on a clipboard, or common deskspace, to first get all relevant content, discuss it and put the content on a specific day at a later time.

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Overview

- Combat-related PTSD
- How we started
- 3MR system
- Design and evaluation 3MR
- Conclusion and final remarks

1.

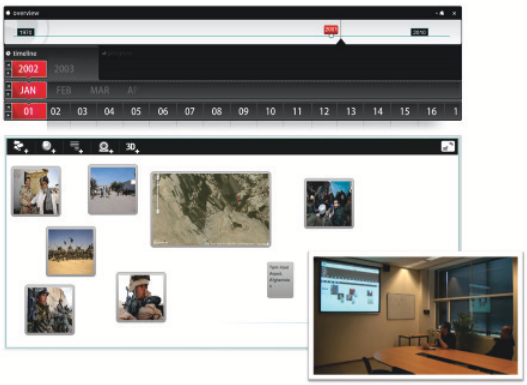
Combat-related PTSD

Current Treatment

- Individual or group session with a therapist
- Talking about past experiences
- Reconstructing events
- Multiple sessions

3.

3MR system



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3. Prevent losing track of changed and added events
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8. Prevent unexpected exposure to emotional material
9. Ensure appealing and motivating approach

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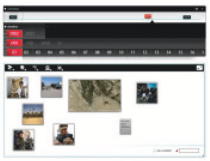

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(EMDR) Eye movement desensitization and reprocessing

Psychodynamics

(CBT) Cognitive behavioural therapy

Exposure

Art therapy

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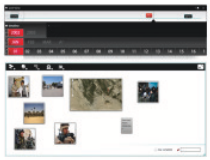
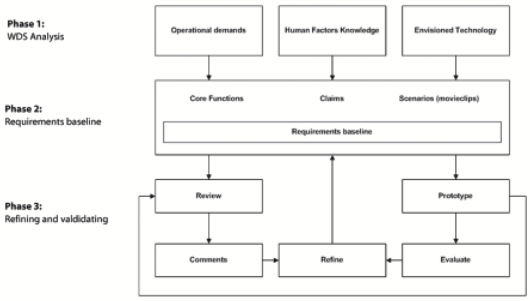


4.

Design and evaluation of 3MR

Situated Cognitive Engineering Approach



PTSD expert reviews of video scenarios

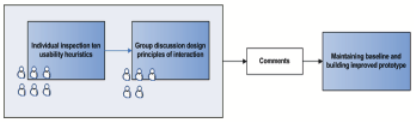
- 10 experts with background related PTSD or traumatic memory
- NATO-supported advanced research workshop, *Wounds of War: Addressing Posttraumatic Stress Disorder (PTSD) in Peacekeeping and Combat Troops*, organized by the Interactive Media Institute

Rapid prototyping and early usability evaluation

- Heuristic Usability evaluation with Six HCI MSc Students
- Continuous reviews with psychiatrist and HCI lecturers

Usability evaluation: Ten heuristics and design principles

- Individual inspection ten usability heuristics
  - 6 participants
  - Evaluation form
- Follow-up group discussion
  - 5 participants
  - Discussion design principles



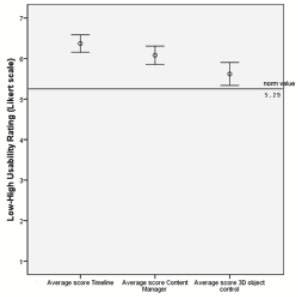
Experiment and case study with final prototype

- Experiment
  - Lab
  - 18 participants
  - Aim:
    - Acquire more feedback regarding usability
- Case study
  - Field
  - Veteran suffering from combat-related PTSD
  - Aim:
    - Acquire insights regarding use and interaction with 3MR

Experiment

- Usability evaluation
  - Evaluation of three user interface components
    - Timeline, content manager, 3D editor
  - Task list
  - Component-based usability questionnaire
    - Six statements per component
    - 7-point likert scale
    - Room for additional feedback

Experiment (2)



Method

- ***Does 3MR system brings about a more rich story-telling content?***
- 2 conditions: tell a story with or without 3MR system
- Autobiographic stories, e.g. holiday or business trip at least 3 years in the past.
- Story telling session took 6 minutes
- Order counterbalanced
- Explored 3MR system before experiment
- 18 participants (12 males, 6 females), none suffering from a combat-related PTSD
- Age varied between 21 and 59 (M=36.2, SD=15.1) years
- Asked to bring photos for both conditions
- Afterwards asked to complete questionnaire

Results - Questionnaire

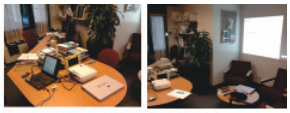
- Participants thought they put more details in the story told with the help of 3MR
- Comparing the two stories, they found more memories came back by using the application
- Participants enjoyed telling a story with 3MR more than telling a story without the application
- They thought the timeline was an essential component in a way a story was told
- All deviated significantly from middle (4) of 7-point Likert scale (H_0: score = 4, $p < .001$)

Results – Analysis story

Stories were coded, and frequencies counted of specific story elements, and analysed with Wilcoxon Signed-ranks test (p. <.05)

- **Time referencing**
  More participants mentioned a precise date with 3MR than without. (the opposite was true when participants referred to a less precise time frame)
- **Event description**
  participants were more precise with the system than without, e.g. buying a cola and watching football on TV vs going on a business trip and studying for an exam (the opposite was the case when participants referred to more general events)
- **Time period covered**
  Stories told with 3MR covered a smaller time period in months than without, e.g. days vs weeks/months
- **Location reference**
  No significant different in frequency location reference

Case study



- 2 clinical sessions, with a veteran with PTSD who has served in various deployments, such as Dutchbat I (Srebrenica)
- Veteran already received outpatient PTSD treatment
- Ask to bring photos to first session

Session 1
- Google maps was often used
- Therapist typed what veteran told

Session 2
- Veteran brought document related to the deployment
- Started with reflection on previous session
- Discussion of events in the documents without 3MR system

- Veteran very positive about 3MR system, felt that he was more in control of his own treatment

5.

Conclusion Future work

Conclusion and final remarks

Conclusion
- Study with participants (no combat related PTSD)
  - Significant difference in how a story is told between non 3MR and 3MR system (time referencing, event description, time period covered)
- Case study with one veteran with combat related PTSD
  - Positive about application

Future work
- Conducting a series of more extensive cases studies with multiple therapists
- Considering civilian version of 3MR system

Literature

Difede, J., Cukor, J., Jayasinghe, N., Hoffman, H., (2006). Developing a virtual reality treatment protocol for posttramatic stress disorder following the world trade center attack. In M.J. Roy (ed). *Novel approaches to the diagnosis and treatment of posttraumatic stress disorder* (pp. 219-234). Amsterdam, The Netherlands: IOS Press.

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Thank you for your attention!

Any questions, or suggestions?

http://mmi.tudelft.nl/vret

WORKSHOP DISCUSSION

[Mario Conci] memories are not only images, but also experiences and sensations. How can be delivered and recreated in a VR system?

> [Willem-Paul Brinkman] The virtual reality world is only one element of the 3MR system. In this system we use VR in a different manner as how VR is use at part of exposure therapy where the emphasis is often in creating an effective level of presence. In the 3MR system the VR worlds in only use as a tool for story telling. It allows the patient to talk about a traumatic event by building/re-creating a specific situation in VR. Traditionally this is done just by making sketches on paper or a flip over. Building it in VR creates the possibility to look at the situation from a 3D perspective and the ability looking at the sense from different view points. In short, VR is not used directly to exposure a patient, but to facilitate story telling.

[Maurice Mulvenna] What is the relative 'value' of the different technical components towards the overall working system?

> [Willem-Paul Brinkman] We have not study the relative importance of each of these components. This would assume that there is one therapy approach that would fit all patients and therapists. However, as from engineering point of view, we have learned that people might like to use the 3MR system differently. For example: in a group, or one-on-one, at home, or in the clinic, some people are more text oriented other visually. Our idea was to create a multi-modal system giving people several options to tell their story and structure this.

[Maurice Mulvenna] Are personal memories of trauma used?

> [Willem-Paul Brinkman] Yes, the system is completely individualized. The patients' stories are about their own experience. They bring there own photos and tell their own story including their memories of their traumatic event.

[Maurice Mulvenna] What is "situated cognitive engineering approach" (slide 20) and can it be easily used - how is it discriminated from other more traditional approaches?

> [Willem-Paul Brinkman] Situated Cognitive Engineering is a method that originates from the field of cognitive science, human-computer interaction and artificial intelligence to improve computer-supported task performance. It follows an iterative design process, including both expert review cycles and evaluation cycles to examine the design claims that have been originally formulated form analysis of operational demands, human factors involved, and advanced in technology. The approach is very flexible and helps to structure your research into the core claims on which you base your design, ie the requirement based line. The focus therefore is not on simply developing an application, but to develop a design (or prototype) that is based on claims which have been evaluated. These claims are often situation depended and therefore requires thorough prior analysis, ie a work domain analysis but also bottom up analysis for example scenario analysis to consider the specific situation in which the system and human have to operate.