

Virtual Reality Exposure Therapy (VRET) effectiveness and improvement.

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ABSTRACT

The use of virtual reality in the treatment of anxiety disorders is growing. Virtual reality exposure therapy uses virtual reality environments to expose patients to realistic environments in which their fears can decrease. This technique is based on classical exposure therapy. For virtual reality exposure therapy to be effective, three aspects are of importance, and these aspects are related to each other. First of all, emotion eliciting capabilities of the virtual environment have to be strong enough, so that anxiety can be experienced. Next to that, cognitive presence experienced by people in VRET environments is an important factor. At last, the effects of VRET accomplished in virtual reality worlds will have to remain effective when a patient returns to the real physical world. Improvement of VRET may be done by moderating one of the mentioned aspects, but changing one will always result in changing the other two also.

KEYWORDS

Virtual Reality Exposure Therapy, Exposure Therapy, presence, emotions, cognition.

1. INTRODUCTION

The concept of Virtual Reality Exposure Therapy (VRET) is developed over the past decade. With the use of virtual reality, the number of new methods for psychological disorder treatment has increased. Virtual Reality Exposure Therapy uses virtual reality environments to expose patients to realistic situations in which their fears can decrease. By placing subjects in safe but frightening situations, anxiety disorders can be decreased or even erased. In this paper, a number of important aspects of virtual environments for effective exposure therapy are discussed. Presence, cognition, effects and the capability of eliciting emotions are some of these main aspects where this paper will be aiming at.

The main goal of this research paper is to find out what possible connections exist between the virtual reality side of VRET and the psychological side of VRET and where possible improvements can be made. To do this, exposure therapy and VRET will be explained in detail, so that these concepts are clear. After that, some explanation about important VRET effectiveness aspects will be given and it will be made clear what the influence of these aspects on VRET and on each other is. Finally, some options for VRET improvement are given.

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2nd Twente Student Conference on IT, Enschede 21 January, 2005
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In this paper, the terms patient and subject are used together, they both point at a person receiving treatment.

2. EXPOSURE THERAPY

Exposure therapy is a term used in psychology and psychiatry, for a form of behavioral therapy that helps subjects which target is the overcoming of various anxiety disorders, panic disorders and post traumatic stress disorders. Exposure therapy is conducted by exposing the subject to one or more specific stimuli that are causing abnormal reactions for the subject in normal life [OVEa00]. An example of this is exposing a patient suffering from fear of spiders to one or more spiders. In this case the spider becomes the stimulus that is causing anxiety/panic reactions.

The main target of exposure therapy is to attenuate an anxiety by placing a subject in a situation in which anxiety producing stimuli are present in such a level that a subject can slowly get used to it. By gradually increasing the level or intensity of anxiety producing stimuli, it is possible for the anxiety to decline [KOO]. Exposure therapy exists in different forms, all aiming at the same goal.

2.1 Forms

There are a number of different methods that all use the basic aspects of exposure therapy. These methods all are based on the same common feature of "confrontation with frightening, yet realistically safe, stimuli that continues until the anxiety is reduced" [ROT01, p482]. The stimuli can be generated in a number of different ways. Flooding, imaginal, in vivo, directed and prolonged exposure therapy all are terms used for different approaches to exposure therapy.

- **Flooding Exposure Therapy**
Flooding therapy is based on confronting the subject with a high intensity of the anxiety producing stimuli at once [KUA95]. This means that for example that a subject suffering from fear of heights gets situated on a very high building or on a very high bridge. This is done instead of gradually increasing the height, for example by beginning with a stairs, then the balcony of a first floor apartment and higher step by step.
- **Imaginal Exposure Therapy**
This form of therapy is based on the generation of stimuli in the imagination of subjects. This is very difficult form of exposure therapy which requires concentration, serious cooperation and motivation of the subject. In a trusted environment, the subject is encouraged by a therapist to imagine situations in which it has anxiety of panic reactions. This can be a realistic situation that the subject has experienced before. It can also be a purely imaginal situation generated by the subject with or without help from the therapist.
- **In Vivo Exposure Therapy**
Therapy in vivo places subjects in realistic situations, that can experienced during everyday life [KOO]. In Vivo therapy is one of the most widely used forms of exposure

therapy, because in most cases it can be performed relatively easily. Simple examples of in vivo therapy are: a situation in which a subject is confronted with one or more spiders to overcome arachnophobia or a situation in which a subject is placed in a small room to overcome claustrophobia.

- **Directed Exposure Therapy**
The demonstration of confident non-anxious interaction between a therapist and for the subject frightening stimuli is called directed exposure therapy [WEL03]. The subject watches the therapist or even participates in the demonstration.
- **Prolonged Exposure Therapy**
In prolonged exposure therapy, subjects are confronted with anxiety evoking stimuli for an extended period of time. The essence of prolonged exposure lies in the fact that it expands exposure to a greater period of time instead of to multiple sessions [FOA86]. One feature of prolonged exposure is that it can be the basic method with which one of the foregoing forms is conducted. Rabavilas, Boulougouris and Stefanis (in: [FOA86]) give an example of prolonged in vivo exposure therapy. In this experiment, one session of 80 minutes exposure to a real life situation (prolonged in vivo) gave better outcome than 8 sessions of 10 minutes exposure (normal in vivo).

It seems obvious that these forms are not independent. It is for example possible to combine in vivo and flooding therapy at once. This can be done because the difference in these forms is based on different aspects, i.e. intensity of stimuli, type of stimuli and period of exposure to stimuli.

2.2 Effects

The overall resulting effect of all these different forms of exposure therapy is that the anxiety diminishes, and the subjects' escape behavior which kept the anxiety active declines [ROT01]. This escape behavior was causing the subject to withdraw itself from situations in which frightening stimuli could be present. An example of escape behavior can be showed very easily: A person suffering of fear of spiders will leave a room in which he/she has spotted a spider as soon as possible, or will kill the spider as soon as possible. By using escape behavior, the subject prevents natural diminishing of the anxiety.

The effects are generated through a process of habituation, which is a psychological effect, defined by Gleitman as "a decline in the tendency to respond to stimuli that have become familiar." [GLE99, pC12]. Foa and Kozak [FOA86] simply see habituation as *response decline*. Thompson and Spencer (1966, in: FOA86) describe it as: "given that a particular stimulus elicits a response, repeated applications of the stimulus result in decreased response (habituation)". For example, when a person jumps into a river, at first the water can be very cold. After a while the water doesn't seem to be as cold as when he/she jumped in. The person has habituated to the cold stimuli, because they are not new anymore.

When a subject doesn't respond with anxiety to former anxiety producing stimuli anymore, it will not experience the stimuli as a frightening situation. When this happens, extinction may occur. Extinction can be seen as the unlearning of a response to certain stimuli [GLE99]. So when frightening situations are no longer followed by a response of anxiety, occurrence of such responses will decline.

Habituation and extinction are two effects that are related but are not the same. Habituation can be seen as a short-term sensory effect and extinction refers to the unlearning of a response.

2.3 Applications

Exposure therapy is a form of therapy of which the effect has been clearly identified in the past and which is supported by research (i.e. [FOA86], [ROT01]). It is used to overcome a great number of anxiety disorders, post traumatic stress disorders and panic disorders. Foa and Kozak [FOA86] describes a number of successful cases of different forms of exposure therapy. In one case, 75% of a group of agoraphobics show long-term improvement. In another case, 75% of a group of obsessive-compulsives show improvement with the use of exposure. Jaycox, Foa and Morral [JAY98] describe successful application of exposure therapy with female victims of rape and persons with chronic post traumatic stress disorders.

2.4 Practical problems

From the foregoing information it seems clear that exposure therapy is largely based on the effective allocation of the correct anxiety producing stimuli. These stimuli have to be present in the right quantity and with the best intensity for the situation. It is possible to add more stimuli over time, to increase their intensity over time, or to extend the period of exposure over time. These variations all contribute to habituation to these stimuli and the extinction of the response to frightening stimuli.

One problem with these variations is that they're very difficult to carry out in real life situations. Especially with in vivo and imaginal forms of exposure therapy practical problems arise. In imaginal exposure therapy for example, it's may be difficult to put a subject in its own imagination on a higher platform (to overcome fear of heights). In in vivo exposure therapy, it may for example be very costly to let a subject make repeated longer flights over time (to overcome fear of flying).

This is where virtual reality becomes an ideal technological solution.

3. VRET

With the increasing computing power, virtual reality applications are developing more and more towards realistic environments. By using a head mounted display, or other forms of VR hardware, persons can be placed inside worlds that are very similar to the real world. Such VR environments provide more control for the user and improved accessibility, privacy, convenience and reproducibility than situations that can be created in real life.

These capabilities made it very obvious that VR offered very interesting options for exposure therapy [HOD01] [AND04]. In 1992, the first reports of virtual reality exposure therapy experiments became available. Since then the research on VRET has increased, following the growing technological possibilities [KRI04]. VRET is a logical basic combination of exposure therapy and virtual reality. Subjects visit virtual environments which contain anxiety evoking stimuli for a certain period of time. With the exposure to these stimuli the effects of exposure therapy, habituation and extinction, can occur.

3.1 Requirements

To form a good alternative for for example in vivo exposure therapy, virtual environments must have certain properties. As said before, successful exposure therapy requires the correct allocation of anxiety producing stimuli. A virtual environment has to be able to elicit fear and to activate an anxiety provoking structure in the memory of the subject [KRI04]. In virtual reality situations, the allocation of stimuli is more flexible than in real life. A therapist can choose which stimuli will be present in the virtual environment, with which intensity they will be present and for which period of time. These variables may have influence on the effectiveness of VRET. Krijn et al. [KRI04]

states three aspects which are required for VRET to be effective; the degree of presence, the ability to elicit emotions and the sustainability of effects.

- Degree of presence; a person 'inside' a virtual reality world has to have the idea of being there [MEE02].
- Eliciting emotions; for effective extinction, the activation of emotions is needed. Without emotional consequences of stimuli in the virtual environment, the subject will not experience the same anxiety as in real life situations.
- Generalizing effects; cognitive changes, for example extinction, have to generalize to the world outside the virtual environment and to real situations.

It is clear that there is a difference between these three aspects. The first aspect, presence, is an important factor for the success of virtual reality [NUN01]. The latter two are factors that have to do with the effectiveness of exposure therapy itself. Secondly, these aspects are not likely to be independent. Using computer science literature and psychological literature, I will describe these three aspects and I will try to find some connections between the three aspects.

My hypothesis in this part is that the three aspects all are needed and related to each other and therefore can not lead to effective VRET on their own. I expect that this hypothesis will be grounded, partly because the relation seems trivial. Using literature I will try to prove this relationship to be true.

3.1.1 Presence

There is another important issue to virtual environments besides the correct allocation of anxiety evoking stimuli. A subject has to experience cognitive presence while visiting the virtual environment. Nunez and Blake [NUN01,p116] define cognitive presence as: "the degree to which the virtual environment dominates over the real environment as the basis for thought".

Especially the part of this definition concerning thought is important in the context of this paper. Several psychological theories point at the relationship between emotion and cognition [MAR02]. If a subject suffering traumatic memories (in the context of this paper: fearful experiences) successfully wants to recover, emotional engagement with this traumatic memory is required. It is a prerequisite for the successful processing of the event and therefore also for the successful processing of the recovery [JAY98].

Rothbaum and Hodges [ROT99] describe an example to find out what the level of presence of subjects in a virtual environment is. A pattern of exposure therapy is identified using an experiment with actual physical height situations. At first, the anxiety of the subjects increases as they are exposed to more frightening situations. Secondly, when the subjects spend some time in the situation the anxiety decreases. So if this pattern would also occur when using virtual height environments for exposure therapy, this would present some evidence of the subjects feeling presence in the virtual environment. In the study that is described, the results were that most of the subjects experienced presence, or seemed to experience presence. Besides that, a number of physical symptoms were recorded which pointed at effects of anxiety.

This study shows that it is possible for subjects to feel present in virtual environments. The results also show that the frightening virtual stimuli are able to evoke anxiety reactions, which can be seen as that the subjects were emotionally engaged in the virtual environment.

3.1.2 Cognition and Emotions

In VRET, a patient is placed inside a virtual world to experience anxiety producing stimuli. Because VRET is based on classic exposure therapy it is presumable that the virtual environment has to evoke a certain level of emotional effects to be effective. In the situation where exposure therapy is aiming at healing anxiety disorders, emotional engagement in the form of fear activation is required [JAY98]. Anxiety disorders all have to do with a certain fear of something. This fear can be in such extreme forms that it prevents people from doing their daily tasks. Fear of flying, fear of heights, claustrophobia, fear of spiders, fear of speaking in public or social phobia, fear of driving and fear of open places are all examples of phobias that can handicap people.

The experience of these phobias is based on the emotion of fear, which itself is based on the cognition of frightening stimuli. According to the *James-Lange theory of emotions* [in: GLEI99], emotions are experienced by introspective interpretation of what a person or his/her body does. This means that a person notices changes in his/her own behavior. When a person experiences frightening stimuli, he/she will have a pounding heart beat, is likely to shiver and wants to abandon the situation. The observation of this behavior tells the person that he/she is subject to fear. So according to this theory, first of all frightening stimuli are experienced. Secondly, these stimuli are followed by reactions of the body and/or a change in state of mind. Finally, the observation of these reactions and/or changes tells the subject that he/she feels the emotion of fear. The second step in this process is caused by the cognition of the stimuli that are present, which can be linked to cognitive presence.

What can be concluded? Combining this information, a logical conclusion can be that VRET will only succeed if the environment can influence the subjects' cognition and thereby it's thoughts about the stimuli. If this is met, the subject can get emotionally engaged in the virtual environment.

An example of this is relatively easy to imagine. A subject suffering of agoraphobia, or fear of open spaces, can be treated using a head mounted display. With this display, the subject can be placed in a virtual environment of for example a market place. If in this situation the subjects' cognition tells the subject that the marketplace isn't real or realistically enough, the subjects thoughts will conclude that he or she is just in the therapists' room, wearing some VR equipment. In this case, the real environment is the dominant environment for the basis of thought and the anxiety producing stimuli in the virtual environment will not be effective. As a result, the conducted exposure therapy is likely to have no influence on the anxiety disorder of the subject. If the subjects' cognition would tell him/her that the virtual environment is realistic enough, the virtual environment becomes dominant for the subjects' thoughts. In that case, the frightening stimuli in the virtual environment will cause an anxiety response and the process of exposure therapy can commence.

3.1.3 Generalizability of Effects

When a subjects is treated using VRET, the target is to overcome or heal anxiety disorders. As seen before, VRET can be seen as another form of conducting exposure therapy, namely by placing subjects in virtual environments. One of the differences with normal exposure therapy is that the subject experiences the virtual world as dominant world for its thoughts. So the therapy takes place in a totally different world, only with the same stimuli and possibly comparable surroundings. In normal exposure therapy, only one world is used, in which both the anxiety is experienced and the therapy is conducted.

A problem with this may be the sustainability of the effects of the therapy. Sustainability of the therapy in this context can be seen as the independency of the therapy of the world in which it is conducted. Bartholomew [BAR01] uses sustainability to make sure that the effects of a psychological intervention program won't decrease or disappear. Overholser and Nasser [OVEb00] describe a process of relapse after applying cognitive behavioral treatment and possible solutions to overcome this problem. When relapse takes place after treatment, the patient falls back into a prior state of the disorder, meaning that the treatment has decreased effect on the patient over time. The sustainability of such a treatment will then be quantified as low.

If in a virtual world successful exposure therapy is conducted, the subject doesn't show fear reactions anymore to stimuli in the virtual world that prior to the therapy did cause fear reactions. When this subject is back in the real world after the VRET session, it may be the case that the effects of the therapy are not extendable to the real world. It is also possible that relapse takes place, resulting in weaker effects of the treatment outside the virtual world. While not being anxious in the virtual world when exposed to certain stimuli, these same stimuli occurring in the real world may still be causing anxiety reactions in the subject.

The stated information seems to make a number of things clear. First of all the effects that are acquired in the virtual reality environment should be maintained when returning to the real world. Secondly, the effects of VRET should not decline or have less influence in the real world. Since both these things have to do with the difference between the virtual world and the real world, this difference may play an important role in the success of VRET.

Looking at the cognitive presence as described earlier, the level of presence that is experienced may be related to the level of perceived difference between the virtual and real world. It may be interesting to research what the influence of the difference between the virtual and real world is on VRET effectiveness. It also may be interesting to find out if effects of therapy conducted in a virtual world change when a subject reenters the normal world. This can possibly be a way to find out if VRET can be improved by changing the perceived difference between the two worlds. It is on the other hand possible that the level of presence has important consequences for this perceived difference.

3.1.4 Conclusion

I stated in my hypothesis that I expected the foregoing three aspects to be related to each other and that using only one of these aspects for VRET improvement wouldn't be possible. Literature has shown that this hypothesis indeed is grounded. Presence has great influence on how a person experiences a virtual world, and with that also great influence on the level of emotions that can be elicited and experienced. Without presence it seems impossible for someone to experience emotions in a virtual world. The experienced emotions are the basis for the sustainability of the effects of VRET. Either way, presence is the most important factor for VRET to be effective, because it influences every other aspect.

3.2 VRET examples

To illustrate the way in which VRET is conducted and which different forms of anxiety disorders can be healed with VRET, a number of examples will be given.

- Fear of heights (acrophobia)
Rothbaum and Hodges [ROT99] describe a case study to treat people suffering from fear of heights. On all factors that were measured to assess the therapy, VRET was successful in reducing the fear of height. Measures were on

anxiety, avoidance, attitude, distress and included a behavioral avoidance test.

The experiment consisted of three different models to conduct VRET: a glass elevator on the side of a large building, an outdoor balcony with four height levels and foot bridges over a canyon.

- Fear of Flying
Because of the costs and time constraints of in vivo exposure therapy for fear of flying, VRET for fear of flying is an ideal solution [ROT99][MAL02]. A simulation of a flying aircraft can be used to place subjects in fearful situations. Advantages are that the simulation can be conducted repeatedly, with different airplanes and other properties of the environment. Four case studies are available describing the use of VRET for fear of flying, and they all reported to have positive result [KRI04]. Maltby et al. [MAL02] describe a controlled investigation to test VRET. Outcomes of this investigation were very positive on the short term, but in a 6 month follow up, differences between the control group (which received attention-placebo group treatment) and the VRET group were disappeared or attenuated. This possibly can be related to sustainability.
- Fear of public speaking (social phobia)
Persons suffering of fear of public speaking have difficulties with confronted with a public when they are the subject. To treat these kinds of patients, anxiety-provoking virtual environments have been created in which subjects give a presentation to a virtual audience. The audience can be positive, neutral or negative and was formed of virtual people, avatars. Krijn et al. [KRI04] give an overview of some research on this subject, and states that virtual audience can generate anxiety.

VRET can be conducted in several different forms. These different forms are linked to the possibilities that are offered by VR hardware. In the examples that are previously given, experimenters used Head Mounted Displays in combination with 3D environments. Some of the stated experiments provided subjects with a number of supporting entities in the real world. For example the experiment with people suffering from fear of heights that were placed on a virtual balcony had a real physical rail around them, onto which they could hold on.

It must be stated that most of these experiments were research driven. The subjects that were used in the experiment did all suffer in some level of the specific fear that the experiment was aiming at. Krijn et al. [KRI04] describes that in actual therapy in a lot of situations multiple therapy forms are used together. In such situations, VRET is only a part of a complete program, which, among others, usually also incorporate in vivo exposure therapy. If VRET could be enough to fill in a therapy program on its own is not yet clear.

4. EFFECTIVENESS AND IMPROVEMENT

From the foregoing information about VRET aspects, it can be made clear that the success of VRET depends on different aspects. Exposure therapy itself has a number of prerequisites that must be met before it will be effective. Besides these prerequisites, VRET also has to do with the fact that an emotional environment will have to meet some criteria.

The three aspects that were mentioned, presences, emotion eliciting capabilities and generalizing effects all seem related to each other. Fear eliciting capabilities of VRET are based on the level of cognitive presence that a virtual environment can address. This level of virtual cognitive presence plays an

important role in the capabilities to cause emotional effects, which are needed for the exposure therapy to have positive effects. To make sure that the effects of therapy in VR will be present in the real world, the perceived difference between the real world and the virtual world may play an important role. Looking at the definition of cognitive presence, it is possible that this presence has influence on the difference. These are all conclusions that can be drawn using a number of assumptions, so further research on the link between these three factors will be needed to draw hard conclusions.

Possible improvement of VRET lies in the cognition of subjects in VRET. Cognition is the starting point for all emotions that are experienced during a VRET session. Improving emotions or the level of emotions experienced in virtual reality environments is therefore most important. If it is possible to let people experience more directed or more realistic stimuli, emotional effects will be greater. This can be done by representing important stimuli in such a way that cognition of these stimuli can only be done in one unified manner. With this, ambiguity can be prevented, which means that stimuli will be perceived in the way that they were meant to. For example, an elevator in a virtual environment should look and feel like a real elevator, and not as some unidentifiable object.

Another option is to present the stimuli more intense so that the impact of the stimuli increases. This can be a part of the VRET program, where gradually increasing the intensity of stimuli contributes to the extinction process. But it can also provide a basic improvement, because more intense stimuli can lead to more presence and more emotional engagement.

At last, by removing interfering objects in the virtual world, the subject will focus its attention to the correct stimuli. Objects which are not necessary in the virtual environment may only form a distraction for the subject who is in the virtual environment. Removing such objects may lead to better emotional engagement in the virtual environment, which is very important for successful exposure therapy. However, if such objects do not contribute directly to the experienced stimuli, they may indirectly be of influence. For example placing furniture etc. in a virtual room gives a subject the idea of a normal living room (higher presence), whereas placing the subject in an empty room may seem strange to the subject (potential decrease in presence). This last improvement therefore will always be a choice between less objects (resulting in more attention to important stimuli) or more presence (resulting in potentially interfering objects).

Further research will be needed to find out in which way and in which form stimuli can be presented and arranged to provide subjects with unambiguous anxiety eliciting entities in VR.

5. CONCLUSION

This paper has presented information about exposure therapy, including various forms that are known, effects of the therapy, applications and some examples. Exposure therapy is a therapy used with people suffering anxiety disorders, panic disorders and/or post traumatic stress disorders. Various sources show the positive effect of exposure therapy.

Virtual reality adds new options to exposure therapy. Using VR, exposure therapy can be conducted better and more controllable. VRET is a very useful concept for overcoming anxiety disorders. It is more and more used, often in combination with other forms of therapy. Results are promising but further research is needed, especially about VRET as stand alone therapy.

The target of this research paper was to identify possible relations between the psychological and virtual reality sides of VRET. As shown, successful and effective VRET can only be

conducted if both sides are well represented. Where presence is a virtual reality factor, the emotion eliciting capabilities and the aspect of generalizing effects are psychological factors. The three of them are related, and it is impossible to influence one aspect without influencing others.

Therefore, improvement not only may be found in the quality of VR techniques, but also in the quality of exposure therapy as conducted in VR environments. Cognition, emotion and presence are keywords.

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