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Virtual Reality and its usage in Psychotherapy

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Abstract—Psychological treatment that makes use of an advanced technology like virtual reality is an option that only a very small amount of people know about all over the world. The medical as well as the technological area of expertise normally require a person to be very educated in those areas to cover their related basics. Hence, this paper gives an introduction into the most important characteristics of virtual reality, treatment methods commonly used in psychotherapy and how these two components are combined perhaps leading to even more therapy type options to treat mental disorders in the future.

I. INTRODUCTION

In today’s society, there is a tremendous variety of factors influencing a human beings psyche every day. Pressure to achieve, personal problems, expectations, self-doubts, poor time management or considerable other kinds of stress - all of these factors accompany numerous people in their daily life cycle. If these ailments are not taken care of, their situation will become even worse resulting in burnout, personality disorders or even depressions. Eventually, psychological treatment or medication like antidepressants are the only ways to handle the situation.

Even though several mental diseases are caused by people themselves as a result of not changing their stressful and depressive life, there are other ailments that do not necessarily need any external influences. That is because these ailments are gene, brain or experience related. Examples are schizophrenia and autism as they are considered to be caused by genetic disorders and different brain structures. On the other hand, *posttraumatic stress disorder* (PTSD) and phobias mostly emerge out of traumatic experiences like sexual violence, a car accident, natural catastrophe, extreme heights or animal bites [1], [2]. People suffering from any of these illnesses have their livability seriously lowered as PTSD can cause an angry behavior towards loved ones, sleep disorder, flashbacks or a desire to hurt themselves [3]. Phobias are able to cause many additional diseases depending on the phobia diagnosed. The treatment duration of PTSD and phobias can not specifically be determined as the intensity differs for every person. As for schizophrenia and autism, a cure for these diseases has not yet been discovered [4], [5]. This raises the question if there are any other tools or methods that could potentially help to effectively treat or even cure mental illnesses. Modern technology that is not yet in actual practice makes a new approach on this matter.

Technology progresses every year leading to better hardware and more efficient devices. One technology benefiting strongly due to the progress is *Virtual Reality* (VR). It is a modern technology that has gained excessive popularity over the last few years, especially because of video games. *What exactly is virtual reality and how can it be used to help people with their mental issues? What is the most effective way to use it and can even more effective therapies be created?* This paper will concentrate on answering these questions at the example of particular phobias and PTSD. The following section gives an introduction into the basic concepts of VR and how they are supposed to work. In the third section, traditional and more advanced therapy methods will be compared. Finally, everything that has been analyzed will be evaluated in the conclusion.

II. CHARACTERISTICS OF VIRTUAL REALITY

The concept of VR is not new. In fact, the first person who defined it as a hardware created artificial environment that addresses as many senses as possible allowing a person to fully interact with it was Ivan E. Sutherland in 1965 with his publication *The Ultimate Display* [6]. Sutherland described VR like this:

”The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked.”

Although many definitions concerning VR have been constructed up until now, little about its essential meanings has changed. This section will take a closer look at the most important concepts of VR and explain how they are supposed to manipulate our senses.

A. Immersion

An ordinary PC system in 2016 delivers all information one needs through a simple monitor. Sometimes the system needs a considerable amount of time to process user inputs, running programs, animations etc. and in other cases, desired actions are instantly executed. Devices like computer mice, keyboards or controllers are used to interact with the system. Eventually hardware’s capacity determines how fast these processes can be executed. However, as regular PC systems

are bound to the actual reality, the way they work is not applicable to immersive VR systems.

To make more precise statements about immersive VR systems, the meaning of immersion has to be defined: To achieve immersion, it is necessary to create an autonomic and interactive *Virtual Environment* (VE) in which all of a person's senses are stimulated up until to a point, where it becomes impossible to distinguish between reality and the artificial world [7]. Taking this definition into account, it can clearly be said that a regular PC system's behavior is unable to create such an experience. Consequently, there have to be other criteria to do so. There are indeed 10 perceptual senses that could, if stimulated, potentially create a perfect immersion [8]:

Table I
PERCEPTIONS STIMULATED TO MAXIMIZE IMMERSION

<i>Perception</i>	<i>Ability</i>
Visual perception	Seeing
Auditory perception	Hearing
Olfactory perception	Smelling
Gustatory perception	Tasting
Haptic perception	Feeling
Tactile perception	Touching
Vestibular perception	Sense of balance
Proprioception	Body sensation
Thermoreception	Temperature sensation
Nociception	Sense of pain

Though it is important to notice that immersion does not refer to how a person experiences the created VE psychologically but to what is realizable technologically. The more stimulations and real world visualizations a system delivers, the more immersive it is [7]. Equally, immersion is lowered if the VE's appearance does not match its behavior, a person is unable to interact with the system as desired or the system visualizes unrealistic graphics. Since immersion is one of the most important characteristics of VR, it is recommended to either read the beginning of [7] or [8] to get more detailed information on it.

B. Presence

As immersion describes the scale of computer systems to which they are able to realize an illusion of the real world, there is another term that refers to how a person experiences the immersion psychologically - presence [9]. Researcher frequently describe presence as a sense of "being there" representing one of the main objectives when building VR systems. Though, as for immersion, a definition gives a clearer imagination of presence.

"Presence is defined as the subjective experience of being in one place or environment, even when one is physically situated in another [10]."

First of all, this definition supports the statement about presence being the psychological aspect of a person's VR experience, the feeling of "being there" which was mentioned

at the beginning. Furthermore, even though one is fully aware that the VE created is merely a hardware created illusion, the VE replaces reality completely. As a result, it is possible to observe behaviors and reactions towards occurring events that would normally be observable in the real world. Remaining impressions after the experience represent a part of presence as well, even though this definition does not particularly state that. A person ideally recalls these experiences as scenarios that were actually experienced rather than images [9]. Mel Slater and Sylvia Wilbur, who have done an extensive amount of research on this topic also like to describe these experiences as "places that were visited". There is one more point that needs to be stated. Presence is not a particular state but a feeling that is created by three different aspects working together:

1) *Place Illusion*: The place illusion (PI) refers to how much a person thinks to be at the place that is created in the VE. The "being there" that has already been mentioned multiple times also refers to this aspect. PI can and is highly likely to break if real world perceptions interfere with the VE. [11]

2) *Plausibility Illusion*: The plausibility illusion (Psi) concerns events happening in a VE which are not initiated by the person inside of it. Psi specifically means that it is possible to observe the person perceiving these events in a way equally to perceiving them in the real world. To get a better idea of Psi, [11] gives an actual scenario describing a person's feelings and reactions in greater detail. [8]

3) *Involvement*: The involvement describes a condition that is normally achieved if events, stimulations and activities in the VE grab all of a person's attention. The more attracted a person feels, the more involvement is created. [10]

C. Augmented Reality

Finally, a few words on *Augmented Reality* (AR) which is another important term related to VR. As explained earlier, VR aims to create a highly interactive and autonomic VE that stimulates as many of a person's senses as possible. In contrast to that, AR does not focus on creating an entirely hardware driven environment but blending virtual objects and the real world. Nevertheless, the environment still requires to be interactive and run in real time as an enormous amount of realism would be lost otherwise. Virtual elements also aim to be as realistic as possible. Creating an augmented reality is likely to be difficult as shown in [8] because of the mathematical complexity behind object projection.

There are several definitions concerning AR. Yet, because of its extent, a concrete definition and more details will not be given in this section. A section later on will take up on AR's basic meaning and show its usage though. The references at the end of this section once again provide even more elaborated information. [12], [13]

D. Visualization

In addition, there are ways to visualize presence as well as immersion. David Zeltzer visualizes the interaction between these two components by using a simple cube.

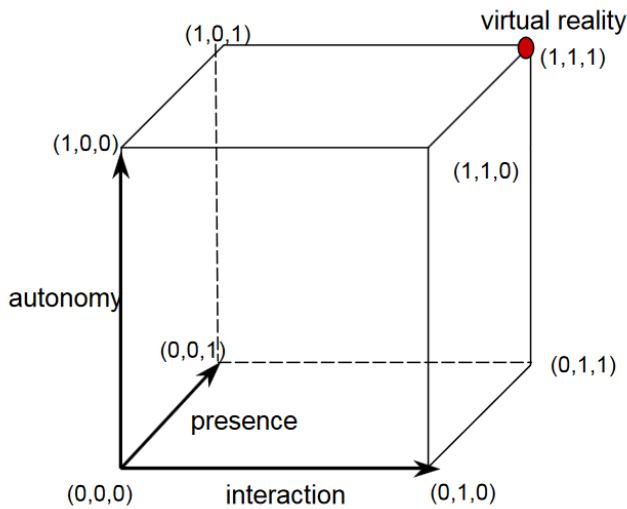


Figure 1. Zeltzer's Autonomy, presence, and interaction Cube [14], [15]

Figure 1 shows Zeltzer's AIP cube representing immersion in the form of an autonomy and interaction axis and presence in the form of an identically named axis. The constructed coordinate system can serve as a scale for VE's. A VE completely equal to the real world is represented by the (1,1,1) coordinate. The according reference states the meanings of the other emphasized coordinates. [16]

III. COMPARISON BETWEEN TRADITIONAL TREATMENT AND THE PROCESS OF VIRTUAL HEALING

Numerous people suffer from some kind of mental disorder. They either chose to search for help or keep their disorder a secret, sometimes resulting the disorder to become chronic. Consequently, they will not be able to completely get rid of their condition anymore. In general, such an illness is defined like this:

"A mental illness is a condition that affects a person's thinking, feeling or mood. Such conditions may affect someone's ability to relate to others and function each day. Each person will have different experiences, even people with the same diagnosis. [17]"

The following list categorizes these disorders and mentions some of the most commonly known illnesses [18]

- Psychological disorders like eating- or personality disorder
- Anxiety disorders like phobias or PTSD
- Substance-related and addictive disorders like alcohol or drug addiction
- Neurodevelopmental disorders like communication or attention-deficit disorder

- Bipolar and related disorders like mood swings

The first part of this section will give an introduction into traditional therapy methods that are used to effectively treat mental disorders. In the second part, methods approaching to therapize people by using VR and AR technology will be shown and analyzed. As there are too many therapy methods concerning every kind of disorder, this section focuses on methods that are used to treat phobia and PTSD.

A. Treating Phobia and PTSD traditionally

The term phobias comprises dozens of illnesses. In general, a phobia is defined as "an extreme or irrational fear of or aversion to something" [19]. On the other hand, as stated in the introduction, PTSD refers to traumatic experiences that basically result in a psychological shock making a person recall the horrible event over and over. The following enumerated therapy types are used to treat these mental disorders. In this case, therapy types only show minor differences in how the disorders are treated, so the first part of every therapy type explanation points out how to treat phobias, then the differences to PTSD treatment are stated:

1) *Exposure Therapy*: In this kind of therapy, a person is directly confronted with the irrationally feared situation. This approach is supposed to show the Amygdala, which is the part of our brain being responsible for judging a situation about its degree of danger, that there is no need to be afraid. For some people, this is a really exhausting and difficult process as it normally takes several attempts until the brain gets used to the situation. [20]

This is similarly used in case of PTSD. The therapist helps a person to handle situations, environments or feelings that are normally being avoided due to a horrible experience. Approaching these situations in real world scenarios is also called "real world practice". [21]

2) *Cognitive Behavioural Therapy (CBT)*: A substantial issue with phobias is that the brain spots danger, where there is no actual danger whatsoever in the feared situation. CBT aims at changing a person's way of thinking and behaviour by learning on how to replace uncomfortable thoughts with more reasonable thoughts. This also requires the person to learn relaxation techniques helping to handle the situation. Though, the person will have to directly face the phobia eventually. PTSD clients profit from this therapy as well. [22], [23]

Treatment for PTSD clients makes the same approach. Some people blame themselves for things that were unavoidable for example. CBT gives these people a better understanding about their traumatic experience. This is supposed to make them stop accusing themselves for an event that they have not actually caused. [24]

3) *EMDR*: Eye Movement Desensitization and Reprocessing is a therapy type in which a person concentrates on recalling the phobia triggering feelings and thoughts while tracking the therapist's finger movements. This way, negative experiences caught in the brain can be released and more relaxing or enjoyable feelings are received. Sometimes auditive and tactile stimulations are used as well. Although it sounds like this is some kind of hypnosis, it is not. This kind of therapy is also quite commonly used to treat PTSD and has a success rate around 80%. [25], [26]

As EMDR works the same way concerning PTSD clients, no further information need to be added. [24]

B. Treatment using VR and AR technology

First off, some information on therapies including VR in general. The usage of VR enables a client to dive into a VE. That VE immerses the client and can theoretically be customized in any way needed as long as the running software allows it. By being able to create any scenario, an individual, controllable and safe environment can be created including the following advantages [27], [28]:

- The therapist does not need to entirely rely on a client's memory and can directly monitor the situation via a computer screen
- Very complicated scenarios that would either be impossible to re-experience or cost-intensive in the real world can be simulated
- VR's individuality makes therapies including the technology applicable to almost any kind of mental disorder
- VE's can help people to recall situations that are the root cause to their mental disorder even though they do not remember the particular event at all

This subsection will focus on presenting *Virtual Reality Exposure-based Therapy* (VRET). VRET combines all of VR's characteristics and the traditional therapy type exposure therapy, that was explained in the Treating Phobia and PTSD traditionally subsection, in relation to acrophobia, the fear of heights and arachnophobia, the fear of spiders. [29], [30].

1) *Acrophobia*: At the beginning of an acrophobia therapy, there are no major differences compared to traditional methods. It is necessary for the therapist to talk to the client about the critical situations in which panic attacks would normally happen. In terms of acrophobia, these situations can include being on or inside a higher building, taking an elevator or just climbing a ladder. Whenever there is a scenario that would require the person to go into some sort of height, it will be avoided. [31]

Since VR technology can simply create a VE containing any kind of building, monument or object, neither a real high rise building nor walking on a real bridge are needed that would potentially risk a client to go crazy or suffer from a panic attack. Of course, it would not be the first step in a therapy to get a client to walk on top of a high rise building

or similar. The statement is supposed to emphasize that the risk does not need to be taken in the first place as the same experiences can simply be made in an artificially created VE. If a client happens to get a panic attack in the VE, only the *Head-Mounted-Display* (HMD) which is the device used by the client to be able to look around in the VE, needs to be removed and the situation is defused. The amount of presence created significantly contributes to the therapy's success. Realistic graphics and other stimulations like wind or vibrations are used to maximize that feeling. [32]

2) *Arachnophobia*: As well as in acrophobia treatment the therapist has to get a better idea about the client's particular problem first. In this case, it is about some kind of extreme fear related to spiders. Arachnophobia can be treated in the same way as acrophobia: A VE in which the client is able to learn how to deal with the fear would be created. Progressing in the therapy, more challenging actions including spiders might be taken by the client. Maybe even touching a spider will eventually be possible. That would of course be the best case and is completely individual for every person depending on factors like the phobia's intensity and how long it has already been a problem. Though these are not the main reasons why this kind of phobia is being explained in this section. [33]

In case of arachnophobia, there is a second option available: *Augmented Reality Exposure-based Therapy* (ARET). As the AR subsection has already explained, the purpose of that technology is to blend as realistic looking virtual elements as possible with the real world. With a view to arachnophobia, it is necessary to achieve some kind of realistic spider projection as shown in the following figure.



Figure 2. Difference between an exclusively VR created VE on the left side and the usage of AR on the right side [28]

Figure 2 shows an artificial spider on a virtual as well as a real table. By involving the real world, a person's experience is completely different as the whole situation still takes part in the actual reality. This results in a different kind of measurement in relation to AR meaning that immersion and presence can not entirely be applied in their original meanings. There will not be an explanation on how AR is measured though. Nevertheless, the therapy process of ARET ultimately resembles VRET in many stages. [28]

IV. CONCLUSION

In conclusion, VR and AR are technologies delivering everything needed to create even more opportunities to effectively treat mental disorders. It is important to keep in mind that this paper has mostly analyzed the positive facts about these technologies. There are several issues as far as their negative aspects are concerned. Jeremy Bailenson who is the funding director of Stanford University's Human Interaction Lab says: "The truth is we don't know what VR does to the brain yet, in part because the best brain studies require MRIs where the head needs to be still, and that's not happening with VR". Bailenson adds that many people "feel somewhat ill after being deprived of real-world stimuli for long periods of time". [34] Even though VR and AR might become tools to treat mental disorders all over the world in the future, an extensive amount of research on these technologies and their consequences has yet to be done.

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