Influencing the Affective State and Attention Restoration in VR-Supported Psychotherapy

Dietmar Pisalski[1], Mario Hierhager[2], Christoph Stein[2], Michael Zaudig[2], Christoph Bichlmeier[1]
[1]Faculty of Informatics – Game Engineering, University of Applied Sciences Kempten, Germany
[2]vfkv – Ausbildungsinstitut München gGmbH, Germany
dietmar.pisalski@gmail.com, hierhager@ptgz.de, stein@vfkv.de, zaudig@vfkv.de, christoph.bichlmeier@hs-kempten.de

***Abstract*—Virtual Reality (VR) has been proposed as an immersive medium in psychotherapy for supporting the treatment of various phobias or behavioral disorders. In classic therapy of mental disorders as well as to reduce stress, various relaxation methods are used. This includes guided imagery, i.e. verbally describing peaceful scenes of nature to the patient. This paper presents a virtual relaxation environment for portable VR systems that has been designed on the basis of theories and research in nature and environmental psychology. The aim of the system is to induce relaxation. We further report on the evaluation of a study design to prepare the system for experiments with patients, measuring relaxation by the change of affective state as well as attention restoration.**

Keywords—Virtual Reality, Virtual Reality Therapy, Psychotherapy, Relaxation Techniques, Study Design

I. Introduction

In psychotherapy, Virtual Reality (VR) techniques are increasingly used as a treatment support for exposures in behavior therapy, i.e. the confrontation with a phobic object or situation [1]. Using VR based confrontation offers several decisive advantages. For example, therapeutic scenarios that are difficult or even impossible to be realized in reality, can be presented repeatedly and controlled, while being adapted to the progress of therapy in a safe and discrete environment. It has been shown that VR interventions are well-received and that the results are comparable to conventional methods [2-5].

Relaxation has a major role in psychotherapy, as patients in a relaxed state can often be confronted with situations that they would otherwise avoid [4]. Relaxation also helps to reduce stress and restore mental and physical strength, which is severely strained by the mental distress of patients. In psychotherapy, various relaxation techniques have developed, including progressive muscle relaxation, autogenic training, hypnosis or imagination techniques such as guided imagery.

In the latter technique, a state of relaxation is achieved by visualizing pleasant scenes, typically of nature, which are usually described verbally by the therapist [6]. However, guided imagery is linked to some difficulties. For example, the therapist can only use words to describe the scene, but it is within the patient's control to decide what he or she actually imagines. Guided imagery also requires imaginative power, which is linked to mental effort and the ability of focusing.

Considering the drawbacks of guided imagery and the increasing popularity of VR techniques in psychotherapy, the question emerges whether a state of relaxation can also be induced with a scene simulated in VR, offering a high level of immersion. In order to investigate the stated question, a nature simulation has been developed based on three theories of nature and environmental psychology. In addition, we present a study design to evaluate whether a nature scene, presented in VR, can induce a state of relaxation, measured by the change of affective state and attention restoration. The study design is supposed to investigate the following hypotheses:

1) A natural scene in VR context has a positive effect on the emotional state.

2) A natural scene in VR context increases the attention capacity.

A. Theories of Nature and Environmental Research

Nature and environmental psychology could empirically prove that nature has a relaxing effect on humans, in particular when landscapes are perceived as aesthetic [8-14]. The design of our VR scene is based on three theories of nature and environmental research.

Savanna Hypothesis: Orians states in his savanna hypothesis [15, 16] that humans have a collective ideal of an aesthetic landscape, which has been genetically inherited over millions of years. The foundation for this theory is the hominization in the African savanna, where preference was given to the environment that offered the greatest chance of survival for the predecessor of the human in East Africa. Compared to other environments, landscapes with savanna-like characteristics are preferred, such as trees with extensive crowns, distributed over clear, level grassland [17]. It has been shown that this preference is cross-cultural as well as innate, rather than based on experience [16, 18-20].

Psychoevolutionary Theory: Ulrich's psycho-evolutionary theory [9-12] describes the recovering, stress-reducing effect of nature on humans and postulates that their behavior, attitudes, cognitions, and emotions are shaped by what has proven to be adaptable during phylogeny. According to Ulrich, the first reaction of humans to their environment is precognitive, i.e. not shaped by their experiences, which prepares the organism to react appropriately to the environment (e.g. dangerous/non-dangerous, good/bad, interesting/uninteresting). When nature contains positive stimuli that humans associate with survival (e.g. water, food, shelter) and does not include any form of danger or disgust, this translates into a positive emotional and stress reducing reaction, e.g. pleasure and relaxation.

Attention Restoration Theory: In their Attention Restoration Theory (ART) [13, 14], Kaplan and Kaplan describe nature as having a restorative effect on the limited attention capacity and recovery from mental exhaustion. Exhausted attention capacity results in similar effects like stress, reduced performance, or a negative emotional state. The attention capacity can be regenerated by being fascinated by something, i.e. *effortless attention* is being evoked by soft fascination, while the opposing *directed attention* is not demanded and can therefore regenerate.

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B. Attributes of a Relaxing Natural Environment

In the above mentioned and further theories of natural recreation research, various characteristics are listed, which give nature its relaxing effect. These include:

Green space, Blue space: A place with vegetation of any kind, even if it is not necessarily green (e.g. wheat fields). For example, a forest, the wilderness, or even a city park or garden is considered as green space [21]. Analogous to the term green space, blue space refers to all environments that contain any form of standing or flowing water, such as the sea, rivers, ponds, moors, canals or wells, whose waters do not always appear clearly blue [21].

Aesthetics: An environment that one perceives as aesthetic induces a positive emotional reaction and invites to stay and explore, whereas one turns away from an unaesthetic environment and tries to avoid it in the future [22, 23]. However, aesthetics is not objective, but strongly depends on the experiences of the individual. Kaplan and Kaplan [13] name four characteristics that are intended to satisfy the information needs of "understanding" and "curiosity" on which the aesthetic appearance of nature depends. *Legibility* and *coherence* are essential for the orientation and understanding of the landscape, *complexity* and *mystery* arouse curiosity and the desire to gain new information.

Fascination: Fascination is the main focus of ART, although a distinction must be made between soft and hard fascination. Only the former, which is understood as a mixture of fascination and pleasure, can allow attention to be regenerated and therefore result in a relaxing effect. As an example of soft fascination, waves that are gently washed ashore can be mentioned; hard fascination is evoked, for example, when looking at a steep hillside or a cars race [13, 14]. If the surroundings would arouse too much excitement or interest, this would have a counteracting effect on relaxation [24].

Being Away: In ART, “being away” is defined as an absence that is caused by cognitively engaging with content different from the usual. In this context, “being away” does not necessarily mean physically being in a far-away natural environment; even going into one's own garden can trigger the feeling of being completely isolated and distant from the everyday world of work [13, 14].

Extent: An environment that is perceived as expansive has a relieving effect in contrast to a small, limited space. However, analogue to the factor "being away", the degree of spatial expansion does not necessarily seem to be in focus here. It is rather important how extensive and coherent the landscape is designed, so that it conveys the impression of a "small world of its own". More important than the physical expanse is probably the feeling that there is more to discover in this environment than is apparent at first glance [13, 14].

Compatibility: Environments that suit one's own needs, motives and intentions have a higher potential for recreation. People seem to easily fall into certain patterns of action and behavior that can be realized in a natural environment. These include hunting and fishing, hiking, jogging, cycling, gardening, bird watching or testing one's own survival skills [13, 14].

II. Methodology

A. VR Simulation Scene and Design Decisions

Based on this theoretical background, a VR nature simulation has been created. As mentioned before, the preference and aesthetic evaluation for savanna-like scenes is cross-cultural. The factors described above are perceived as relaxing, especially in western culture [11, 13, 20].

One requirement for the software is the ability to be used on portable and inexpensive VR setups, such as smartphones combined with Google Cardboards or standalone VR-headsets. These devices require comparatively little efforts for setup, training, and maintenance, which is appropriate for the workflows in mental health clinics and therapy practices. Limited by the target hardware, the nature simulation for the study was designed in a low poly style. As shown in [25], the graphic style (low poly vs. high poly) seems to have no relevance with respect to the relaxation effect.

The savanna scene was designed with the open source modeling software Blender and rendered with the game engine Unity on the mobile VR headset Oculus Go.

The low poly savanna scene (see Fig. 1) is very spacious *(being away, extent)* and well-arranged *(coherence)* and represents a *green and blue space*. The viewer finds himself on a slight elevation on the shore of a waterhole, surrounded by vegetation of various kinds, which gently sway in the wind. Every now and then a flock of birds flying past attracts the attention of the spectator *(fascination)*, when not watching the giraffes drinking. Giraffes were integrated into the scene for several reasons. On one hand, the so far unspectacular simulation should be given some interest to a degree that is neither boring nor exciting *(fascination)*. On the other hand, giraffes, in contrast to other animals living in the savanna, are commonly perceived as relatively harmless and unthreatening. The scene is accompanied by an audio track recorded in the savanna, in which different kinds of birds, as well as running water and a light wind breeze, can be heard.

B. Study Design

To evaluate the effect of our VR system, we carefully designed a user study. The experimental setup shown in Fig. 2 is almost identical for both the experimental group (EG) and the control group (CG). It differs only in the intervention in which subjects of the EG observe the VR scene, while the CG stays in a waiting area.

For the determination of the current emotional state, the Positive and Negative Affect Schedule (PANAS) is applied. It assesses the positive and negative affect (PA and NA) based

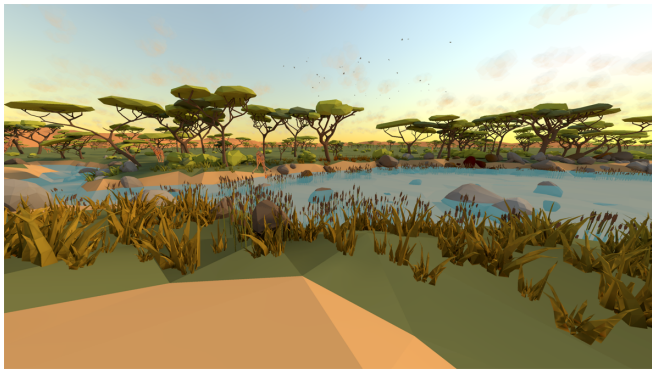

Fig. 1. The low poly savanna simulation

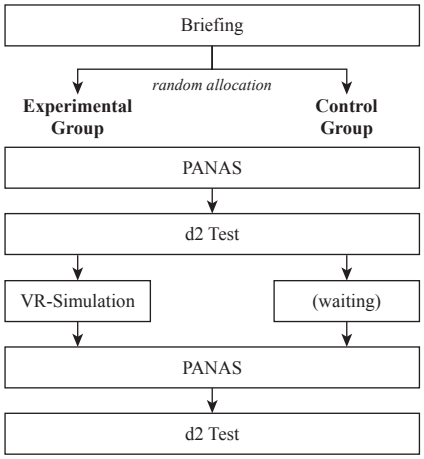

Fig. 2. Flowchart of the experiment

on the rating of 10 positive and 10 negative emotional attributes on a Likert scale ranging from 1 to 5 [26]. PA is associated with pleasant arousal, social activity and satisfaction, while NA is associated with unpleasant arousal, stress and health problems.

The d2 Test of Attention is used to evaluate concentration as a directed form of attention by measuring the accuracy in distinguishing similar visual stimuli under time pressure [27].

At the beginning, subjects are briefed about the schedule of the experiment without revealing the aim of the study. Subjects are then randomly assigned to one of the two groups and are asked to fill out the PANAS and the d2 Test.

During the subsequent intervention, subjects of EG observe the nature simulation for five minutes wearing an Oculus Go and over-ear headphones while sitting on a swivel chair, allowing a 360° view of the scene. Simultaneously, subjects are informed that the examiner leaves the room during the intervention to prevent the feeling of being observed or judged.

For the CG, a waiting room situation is simulated during this time. They have to wait alone in an acoustically isolated room for five minutes without being exposed to any external visual stimuli from nature, e.g. views out of the window.

After the respective intervention, the PANAS questionnaire is repeated as well as the d2 Test. Finally, feedback on the simulation is obtained from the test group.

C. *Testing the User Study*

The study design was tested in February 2020 over a period of three weeks in an IT laboratory at the University of Applied Sciences Kempten.

Current psychotherapeutic treatment was not a criterion to select volunteers (N=38, 17 female) taking part in the experiment. Primary goal of the experiment was the evaluation of our study design. For this reason, our expectations were low with respect to measure statistically significant effects from this sample.

The subjects were of different age groups: under 18 (1), 18-29 (24), 30-45 (8), 46-60 (5). Most of the subjects had previous experience with VR (23).

The time points before and after the intervention are referred to as t1 and t2 respectively.

D. *Statistics*

The data in Fig. 3 shows that, on average, for the EG, PA has risen marginally, a slight decrease in the NA is also observed. This indicates an improvement in the emotional state for our sample during the period of VR exposure.

In the CG, on the other hand, the shift of the boxes from t1 to t2 illustrates that the PA has dropped while the NA has decreased.

Fig. 4 shows that both groups have improved in terms of their concentration performance (CP). This increase is due to the training effect of the d2 Test [27], which was performed twice by both groups within a short period of time. However, the EG shows a greater effect than CG, which may speak for a restorative effect on attention capacity of the VR nature scene. At the end of the study, all subjects of the EG (n=19) were asked to fill out a final questionnaire about the experiment and the VR scene. 17 subjects (89.5%) found the duration of the simulation of five minutes to be appropriate for relaxation. A total of 15 subjects (78.9%) stated that they felt more relaxed after the intervention than before, the rest felt no difference. None of the subjects showed any signs of sickness caused by the seated VR experience. Despite this positive qualitative feedback, we could not measure statistically significant effects from the assessed data of the PANAS and the d2 Test, i.e. quantitative analysis (t-test for paired and unpaired samples, 2-factor RMANOVA) of our sample data did not show positive effects on affective state and attention restoration.

III. Results & Discussion

In this paper, we present our ongoing research of a system for VR supported psychotherapy to positively influence the

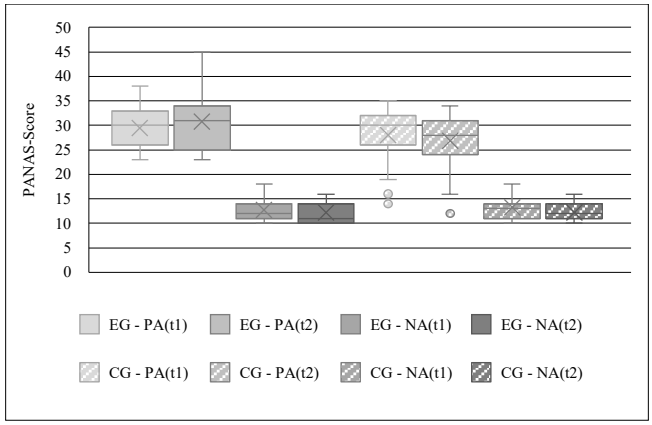

Fig. 3. PANAS-scores of both experimental and control group

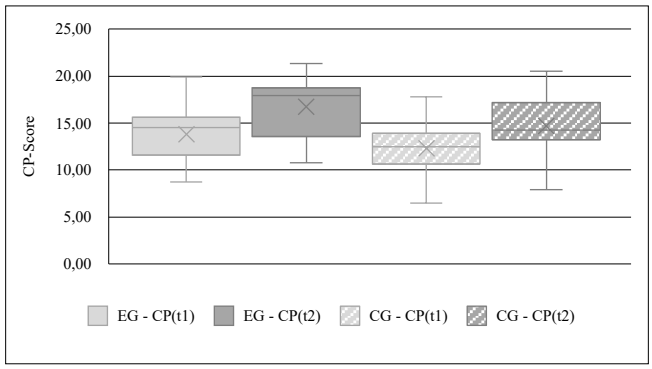

Fig. 4. d2 Test CP-scores of both experimental and control group

affective state and attention restoration of patients. The VR system is supposed to be used in a daily routine in offices of psychotherapists. For this reason, we choose a mobile VR device, which is (1) affordable to typical budgets in psychotherapy, (2) easy to use to avoid usability barriers and (3) easy to be maintained. The choice of hardware influences the design of the VR scene. Our scene follows design principles derived from psychological research findings to create a savanna scene. As our previous study [25] and various popular games have shown, alternatives to high-realistic rendering, such as the low poly style, is well accepted by users/gamers.

In addition, we present a study design to evaluate psychological effects of our scene. Before we start to expose real patients with the VR system, we carefully evaluated the system and the experimental setup with healthy subjects.

We considered artificially inducing stress to our healthy subjects to simulate a psychological state similar to the one of our target users/patients. However, we concluded that the properties of the recovering phase of a healthy patient getting artificially stressed may be very different from a patient requesting support from a psychologist. For this reason, we will focus on running the experiment with patients in the next phase of our research activities.

One conclusion of our experiment is the need of enriching data assessment with additional modalities to obtain continuous, physiological data even during the experiment. For instance, blood pressure, heart rate, skin conductivity or brain waves, serving information about the stress level, can be used to measure the time needed for a relaxing effect to commence.

VR may support relaxation for people living in isolated, narrow environments, especially if VR scenes are adapted to their personal preferences (e.g. changing the time of day, number of trees/animals etc.). The full control of the environment allows for measuring and documenting the therapeutic exercise as well as the adaption of the experience to the patient's preferences and treatment progress. More general factors, such as long waiting times to get place on a treatment program and increasing patient numbers, will open the door for fundamental changes in treatment plans.

Future work will also investigate the effects of having the option to interact and move within the VR scene. In addition, we plan to investigate the impact of combining VR and guided imagery and compare it with the conventional approach of guided imagery, in terms of cognitive differences.

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