Virtual Reality Therapy: Physiological and Psychological Effects

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Virtual Reality Therapy: Physiological and Psychological Effects

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Abstract

Our research examined the use of virtual reality technology as a form of therapy. Participants were randomly assigned to either a control or relaxing artistic experimental condition. The control group experienced a virtual reality simulation in a neutral environment, very similar to normal vision. The experimental group experienced artistic qualities from the program *Van Gogh's Café,* a virtual reality simulation. Then, participants from the experimental condition completed the PANAS mood inventory. Blood oxygenation and galvanic skin responses were measured in order to determine whether the participant's mood was enhanced from the experimental condition. We predicted that the physiological measures, which normally indicate stress, would be lower in the experimental condition. Results trended in the predicted direction, but overall it appeared that both conditions were engaging and relaxing.

Virtual Reality Therapy: Physiological and Psychological Effects

Many therapists currently search for innovative ways to provide treatment successfully without the prescription of medication. Common biological treatments include psychotropic drugs, electroconvulsive therapy, and psychosurgery, all of which have been debated as being impersonal and unethical. In an effort to eliminate side effects caused by medical treatments and a dependency on medication, clinicians practice therapy based on cognitive, behavioral, humanistic, and psychoanalytic perspectives. Some of the many practiced treatments include cognitive restructuring, client-centered therapy, free association, and behavioral modification (Duncan, 2010). These forms of therapy are personable, but they are not all well controlled, which often causes them to be subject to observer bias (Thorndike, 1920). Our experiment used virtual reality technology to provide an innovative type of therapy for clients that is both personable and not biased. We also measured its effectiveness using objective biological and psychological data. Past research has shown that using art in psychotherapy helps clients express themselves and has improved their quality of living (Lipe, 2012). Our experiment had two conditions: artistic relaxation (experimental) vs. a control condition similar to normal life. The relaxing condition used the virtual reality technology to make a three-dimension program based on Van Gogh's artwork. The Oculus Rift artistic program combines art with technology in order to benefit the client.

Past research suggests that virtual reality therapy has been highly effective for patients suffering from anxiety disorders. Virtual reality technology was used in the past on patients as a method of neuropsychological evaluation, during painful medical procedures as a form of distraction, in patients that have eating disorders, and in patients with specific phobias (Wiederhold, 2005). Anxiety disorders are among the most common mental disorders, prevalent

in about twenty-three million Americans (Wiederhold, 2005). Artistic virtual reality technology could be more effective than other virtual reality technology that is not personable to the client and may be able to treat not only one of the most common mental disorders, but other mental disorders as well. For example, clients with PTSD, depression, or other mood disorders could benefit from a relaxing and engaging experience. Maples-Keller, Price, Rauch, Gerardi, and Rothbaum (2017) used virtual reality to assess veterans pretreatment, mid-treatment, and post-treatment exposure therapy. Symptoms of PTSD such as arousal were reduced when they were experienced multiple times (Maples-Keller et al., 2017).

Past research on art therapy has been shown to release unconscious or repressed feelings through self-expression (Edwards, 2004). Our experiment combines virtual reality with artistic programs, which are two forms of therapy that were previously shown to correlate to success in clients in the past. We also used a very simple 3-minute long design in order to demonstrate the effectiveness of the technology, rather than a comprehensive therapy program that would involve many other interventions. Through the combination of elements from art therapy and virtual reality technology, we expected to come up with a new type of therapy with improved results where clients feel that they have freedom to explore the program at their own pace and can interact with the program personally.

Observer bias, also known as the halo effect, occurs when a therapist's judgment of a patient and their progress is determined by a subjective and often superficial overall impression rather than any objective assessment. Previous research indicated that individuals are subjective in nature. For example, attractive people are often judged as being more successful, more intelligent, and physically and psychologically healthier, even when this is not always the case (Wade & DiMaria, 2003). One study done by Hayn-Leichsenring (2013) evaluated the

attractiveness of faces in photographs and art portraits to determine the subjective nature of society. The order in which photographs were shown (unattractive then attractive and vice versa), along with facial expressions, age, and gender, were all factors that influenced how one viewed the portraits. If these subjective perspectives influenced how one viewed portraits, an individual's appearance may also effect a therapist's evaluation and add a complication to the process of therapy. It is even more problematic when the actual biological effects of most therapies were largely unexplored. Our study is unique because it attempts to eliminate observer bias of the therapist and is not reliant on a therapist to provide treatment to patients.

Previous research has tested physiological levels in order to determine if therapy reduced galvanic skin response, blood oxygenation, and cortisol. Galvanic skin response was used to determine levels of psychological stress in deception (Horvath, 1978). Horvath found that the higher the galvanic skin response, the more stress the individual was experiencing (1978). In general, galvanic skin response uses a galvanometer to measure electrical resistance of the skin that occurs when a subject is emotionally stressed. Other research tested blood oxygenation levels by exposing participants to stressors involved in multitasking. Roberts, Wetherell, Montgomery, and Fisk (2004) found that higher blood oxygenation levels meant that an individual was under more stress (Roberts et al., 2004). Like galvanic skin response, the pulse oximeter used in the current study was non-invasive. It used two LED lights with different wavelengths in the red and infrared spectrum; absorption of ratio between the two wavelengths correlates strongly with the ratio of oxygenated hemoglobin to deoxygenated hemoglobin. Galvanic skin response and blood oxygenation were examined in each condition of our experiment to determine if artistic virtual reality technology could reduce the biological markers of stress and enhance an individual's mood.

We hypothesized that virtual technology programs containing a relaxing and artistic environment would enhance the mood of participants and reduce biological stress markers versus a neutral setting. We projected that galvanic skin response and blood oxygenation would lower in the experimental group as participants traveled through the program at their own pace. We predicted that mood would also be enhanced. Therefore, we hypothesized that participants would report moods that indicated positive affect in accordance to the PANAS mood inventory.

Our process is unique because virtual reality programs are a fairly new invention and have not been used much in therapy. However, the biological tools (galvanic skins response and the pulse oximeter) are longstanding and well-tested objective measures that have been used in the past consistently and are utilized in our experiment to evaluate our virtual reality therapy. We are open to the later possibility of a longer program and included some psychological inventories of mood to help us understand and shape this new approach as it is headed towards future therapy.

Method

Participants

Participants included 32 students from Albright College between the ages of 20-22 in the Psychology Department that gained extra credit for their classes. The sample included approximately 72% female and 28% male subjects. The study was approved by the Albright College IRB.

Apparatus

The experimenter used two computers, one of which was hooked up to the Oculus Rift Virtual Reality programs. Iworx hardware was used to hook participants up to a pulse oximeter and galvanic skin response sensor. The pulse oximeter and galvanic skin response sensors were used to measure heart rate and skin conductance values of participants, indicating their stress levels (see Figure 1). The LabScribe software program was used to record physiological data of participants.

Procedure

Each participant was randomly assigned to either the control or experimental group, making this a between-subject design. Informed consent was given out first, and then participants were asked to complete either a neutral virtual reality task (control group) or a relaxed settings virtual reality task (experimental group). The participant's pointer and ring fingers were wiped quickly with a damp cloth. Electrodes used to measure skin conductance were velcroed onto the participant's fingers. Then, a pulse oximeter was placed on the participant's thumb to measure blood oxygenation. Participants each spent three minutes in their assigned virtual reality condition. Physiological data from this experiment was put into statistical software to compare the galvanic skin responses and pulse readings of the experimental and control groups during the first and last minute of the program. Afterward, only participants in the experimental condition were given the PANAS mood inventory. The Positive and Negative Affect Scale contained two subscales. Ten items contained words indicating positive affect and ten items contained words associated with negative affect. Participants rated their own affect through a 5-point Likert scale system with 1 being "slightly or not at all" and 5 being "extremely." The subscales was analyzed by adding the participant's ratings of the words associated with positive affect and participant's ratings of the words associated with negative

affect separately. The PANAS was only given out in the experimental condition.

During the relaxation task, participants had the opportunity to partake in a virtual "Van Gogh's Cafe." This was a three-dimensional program that either the participant or the experimenter could control though the keypad of the computer. Participants walked through a café setting with multiple rooms. The keypad and mouse were used to move through the café, which contained Van Gogh inspired rooms that were designed using his post-impressionistic style. Each room had some element of the unique artwork Van Gogh created. For instance, if a participant decided to walk over to a window, the individual would see Van Gogh's "Starry Night" outside. The participant could approach the piano and see his "Sunflower" piece sitting on top of it, or to the right they may see his own self-portrait displayed. The artistic aspects of this program are unique because participants could explore rooms that may spark their imagination or inspire their own personal expression. A particular room may provide an outlet for someone who feels they need to get away from stressors in their daily life, traumatic experiences from the past, or negative feelings. The participant had control over which rooms they visited through the keypad and mouse, which is unique because most current programs automatically take individuals through a program without their control. Participants were able to choose the rooms that inspired them the most and provided them with the most positive feelings. These rooms may also provide future clients with the motivation to pursue their own form of expression (Lipe, 2012).

The experimental condition was compared to a control condition in which participants sat with the same Oculus Rift headset on, but instead of a three-dimensional rendering of a virtual environment, they saw through a camera mounted at the front of the headset. The camera shows the real world which is very similar to how it would be seen by two normal eyes, with the

exception being that reality was viewed through a stereoscopic camera. The environment was still three-dimensional and identical to the Van Gogh condition in every way except that it lacked the artistic relaxation effect. We compared biological and psychological data from the two conditions to see whether artistic relaxation in a three-dimensional environment significantly showed a decrease in cortisol levels and heart rate.

Both conditions created a three-dimensional reality by projecting a slightly different visual image into each eye. The camera had two lenses, spaced apart about the same distance as human eyes. In normal vision, the brain takes the images from both retinas (binocular) and combines them in the lateral geniculate nucleus and occipital cortex in order to create a three-dimensional image (Lindstrom & Wrobel, 1990). The Oculus Rift technology used the same concept, except the images were created digitally and directly projected onto each eye instead of being naturally offset by the position of an individual's two eyes in the real world. As a result, a virtual world that looked and was three-dimensional in every subjective sense was created. The headset also tracked the head position of the wearer so that the individual could move their head around and see the environment from any angle they chose.

We took the average and max-min values for the first minute and last minute of a three-minute experience. This was done to gauge the initial reaction and the overall effect of the program, as well as the overall change in participants' physiology over time. Blood oxygenation was measured in percentage of oxygenated hemoglobin to non-oxygenated hemoglobin. Galvanic skin response was measured in micro-Siemens, after taking baseline readings for 30 seconds and adjusting it so that the participants' average value was set to 0 (so that all readings represent a change from baseline).

Results

We recorded physiological data for the first and last minute of the three-minute experience. For blood oxygenation (SPO_2) and galvanic skin response (GSR), we took the average values of the third minute minus the average values of the first minute, as a way to measure stress or relaxation (or stimulated engagement) over time. SPO_2 was measured in percentage, while GSR was in micro-Siemens. SPO_2 End Minus Beginning (i.e., the value for the third minute minus the value for the first) results were not significant, $t(30) = 1.66$, $p = .11$, but participants were slightly more engaged in the artistic condition than the control. GSR End Minus Beginning was also not significant, $t(30) = 1.51$, $p = .14$, but participants showed a trend where they were more stimulated in the artistic condition and more relaxed at the end of the program. Figure 2 shows these results.

We also compared the maximum minus minimum values for the first minute and for the last minute for both dependent measures. This was done to see the relative change in physiological response during the beginning (close to baseline) and the end (fully immersed in the condition). These results were also not significant, but trends were encouraging in the sense that more change was found in the artistic condition. Figure 3 shows these results.

The PANAS standardized average positive score, which was taken from large samples in baseline conditions, is 30.8. Our score was comparable at 29.7 for the artistic condition, meaning that participants were close to experiencing overall positive affect upon completing the artistic program. A t test showed no significant difference, $t(15) = .65$, $p = .53$. The PANSAS standardized average negative score is 14.5, and our data showed an average negative score of 14.8. Again both measures suggest no difference from the standardized baseline value, $t(15) = .26$, $p = .8$, implying that the therapeutic effects of virtual reality are not captured by this in-the-moment mood inventory.

Anecdotally, we found a correlation between higher ratings of the words “interested,” “inspired,” and “strong,” with the experimental group on the PANAS mood inventory. Participants that were in the artistic virtual reality experimental condition generally had a higher positive affect score than their negative score. This is potentially significant because students reporting feelings of strength and capability along with inspiration and interest, suggests that after experiencing the artistic virtual reality program, they felt positive feelings and considered themselves to be stronger. This is important in therapy because patients may not become dependent on prescription drugs or medication if there is an alternative that gives them the same positive affect that medical treatment provides.

Discussion

This current study was a preliminary attempt to merge art therapy and virtual reality. Many logistical issues had to be worked out in pilot tests, so our overall number of participants was smaller than what would have been ideal. However, we did successfully create an artistic experimental condition that could be physiologically recorded, and a very comparable control condition. Though neither the physiological or mood inventory results were significant, it is perhaps notable that putting participants into the head-mounted display did not cause any adverse reaction or stress response. This is a new experience to see a world that is not correlated with an individual’s normal reality. That could potentially have been uncomfortable or difficult for participants. It also could be the case that participants got used to the manipulation, or perhaps did not have enough time to fully appreciate it. Participants generally reported a positive experience.

We had no negative reports or comments, and all participants seemed to enjoy both conditions. This suggests that our approach warrants further research and could eventually be empirically validated and incorporated into clinical work.

We also used relatively strict physiological measures. For example, we recorded a baseline GSR value for each participant for 30 seconds prior to the experiment and then set their baseline value to 0. This meant that any changes were relative to the participant's natural baseline. We then used average values (which would be averages of the difference from baseline) and max-min values (which would be max difference from baseline minus min difference from baseline). This was methodologically appropriate but relaxation may emerge in a larger overall difference rather than small time slices that compare baselines. Anderson, Edwards, and Goodnight (2017) conducted a study in order to test the long-term effects of virtual reality therapy exposure in patients with social anxiety disorder. They conducted a 4-6 year follow-up and discovered that the majority of patients reported feeling "very much" or "much" improved after completing multiple sessions of virtual reality exposure sessions (Anderson, Edwards, & Goodnight, 2017). Similarly, it may be important in the future to measure the entire session as a whole, or perhaps even several minutes after the session, to determine whether physiological relaxation has occurred.

Finally, we might have conflated two measures that would cancel out both physiological and mood data: relaxation and excitement about a novel experience. GSR in particular registers very fast changes in participants such as surprise, which were not present in the current experiment. Our goal was to relax and comfort the participants in the experimental condition, but we were also showing them a completely new experience that is exciting and stimulating (and relaxing).

Brinkman, Mast, Sandino, Gunawan, and Emmelkamp (2010) used fourteen virtual reality therapy sessions replicating the length of a flight on patients that had a fear of flying. They found the scenarios and the multiple amounts of these sessions improved in allowing a patient to receive exposure to a similar scenario so that when they had to fly, they felt less anxiety (Brinkman et al., 2010). Readings that are more accurate or valid might emerge if participants are given a longer time or even multiple sessions of our program so that they can orient themselves with the program. Therefore, novelty does might not influence the relaxation processes.

In further research involving virtual reality, it may also be crucial to consider the prior events participants experienced. For example, the amount of sleep a participant got the night before or daily stressors may be greater in some participants than others. Therefore, the mood inventory as well as physiological data would be influenced. Further research may introduce the same stressor to all participants so that there is not as much variability in mood. Our physiological results may have also been impacted by the lack of water or too much water (or sweat) on an individual's skin. The use of gel instead of water may be a better measure for galvanic skin response. Another suggestion for future research would be to give the PANAS mood inventory to both conditions so that there is more data to compare, or to use a different type of inventory to measure excitement and/or relaxation rather than general mood.

Overall, our attempt suggests that virtual reality technology is a viable and potentially useful form of therapy that deserves further research and attention. Though the equipment used is somewhat expensive up front, compared to the ongoing cost of medication or traditional therapy programs it is a potentially inexpensive and non-invasive form of therapy that could be administered in a variety of settings.

Figure 1. Materials for the experiment. The top left image shows stereoscopic cameras that fed visual information to participants during the control condition, which was similar to normal vision without any artistry. The top right image shows an example of one of the rooms in the experimental condition, which was presented to participants in 3D and through which they could navigate as they wished. The bottom images show the GSR sensors on the left and the pulse oximeter on the right.

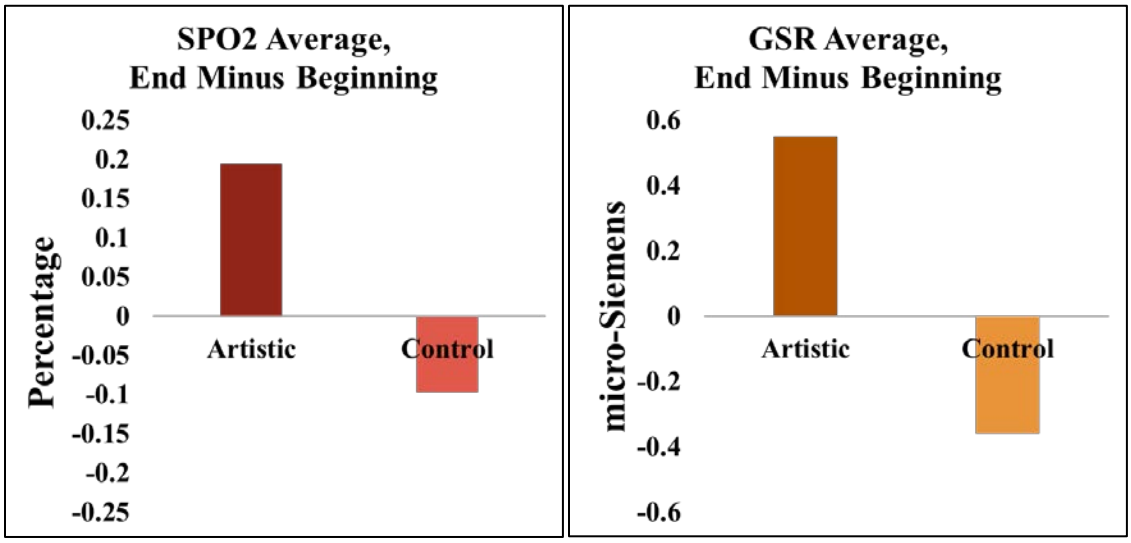

Figure 2. Comparing changes in blood oxygenation and galvanic skin response, last minute minus first minute. SPO2 is measured in percentage, while GSR is in micro-Siemens.

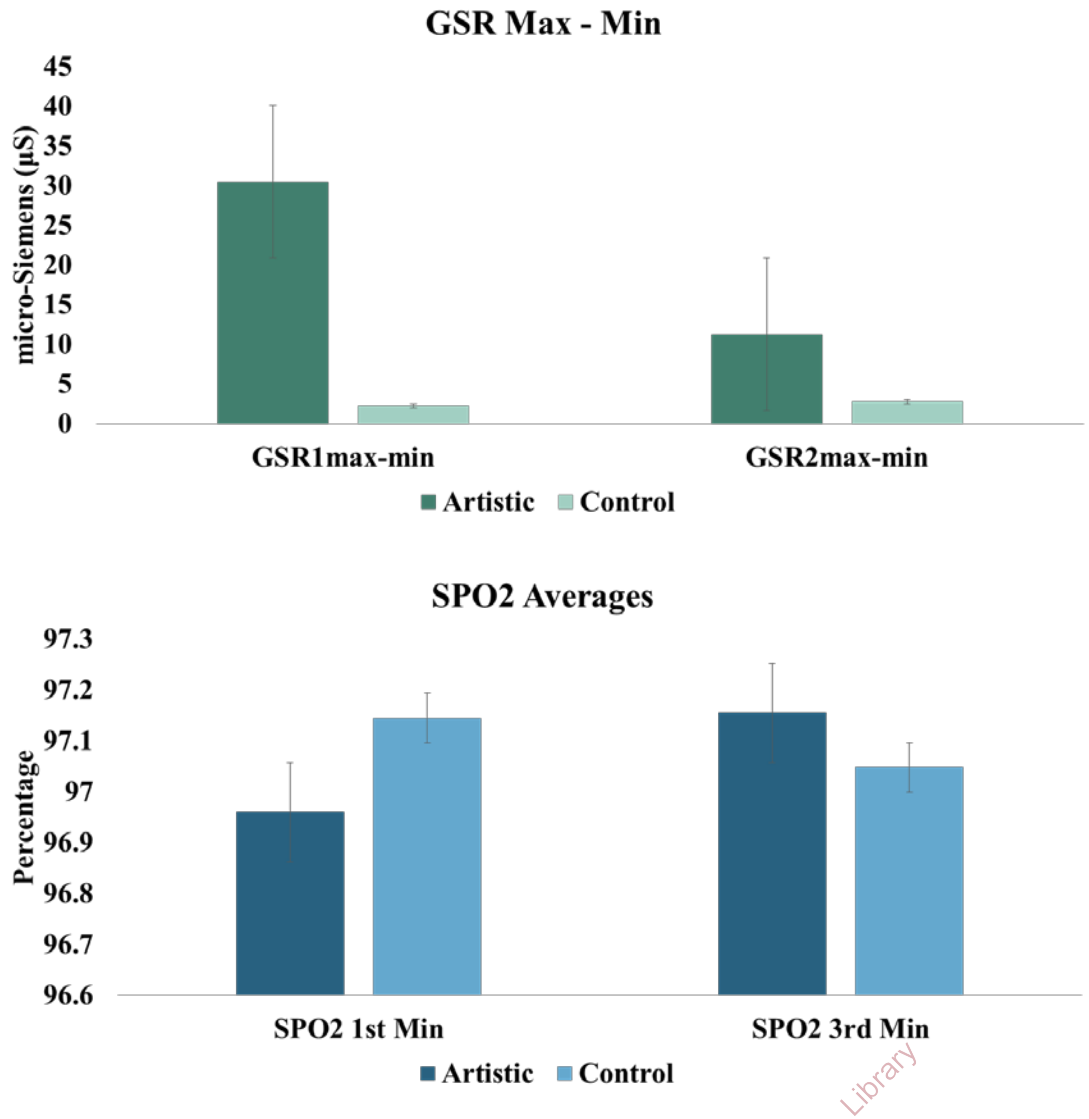

Figure 3. Comparing changes in blood oxygenation and galvanic skin response, maximum minus minimum for the first minute and for the last minute. SPO_2 is measured in percentage, while GSR is in micro Siemens.

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