Bachelor's Thesis:

Virtual Reality: a useful medium to reduce stress in a general public?

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Abstract

Stress is a response that affects many people's lives by being closely linked to physiological and psychological health problems. Various types of treatment are available, however only a small portion of persons are willing to actively seek those. In the last decade, a technology called Virtual Reality (VR) has gained massive popularity, not only by health practitioners but also by the general public. VR is a technology that simulates an artificial 3D environment that allows users to interact with and within it. It has shown to be a promising approach for new alternative ways for several treatments, including stress therapy. The aim of this paper is to explore if the exposure to a VR environment decreases stress in a sample of 80 subjects. The effectiveness of the VR environment was examined by measuring the level of stress and arousal among the participants, which was assessed by using a translated short-version of the Stress Arousal Checklist, developed by Mackay and colleagues (Mackay, Cox, Burrows, Lazerini 1978). The immersive VR-based environment included a tropical beach setting, soothing audio and a meditation exercise. To prove the effectiveness of VR in reducing stress, data was compared to a control group that followed the meditation without VR. Results showed a significant reduction on stress, meanwhile positive emotions (e.g. feeling "contented") increased. With regard to arousal, participants felt considerably more tired and less energetic after the treatment. However, groups did not differ on their scores on all subscales and no interaction between time and condition could be found. These preliminary findings show that an one-session VR stress-therapy has no beneficial advantage over an audio-only meditation exercise. For further studies it is suggested to construct multiple sessions of VR stress therapy to compare the results.

Introduction

In the last decades, stress has become one of the most studied subjects not only in medical literature, but also in the popular press. Stress can have its onset in a variety of circumstances and is experienced by almost every individual at a certain point in life. Research indicates that (chronic) stress can be a major factor in affecting people's lives and is closely linked to psychological and physiological health problems such as an increased chance of depression (Tyssen, Vaglum, Gronvold, & Ekeberg, 2001), concentration problems (Askenasy & Lewin, 1996), hypertension (Boedeker & Klindworth, 2007) and even in the onset of coronary heart disease (Chandola et al., 2008). With the pace of modern technology, a new possibility has arrived to help individuals to cope with stress. This research explores the use of Virtual Reality (VR) as a medium to reduce subjective perceived stress. The term "Virtual Reality" refers to a computer-generated environment in which the user experience an immersive simulation of the real or imagined world. Through the usage of a head mounted display (HMD) it is possible to alter several perceptual streams in order to create a personal experience in interaction with computer-simulated environments. In clinical psychology, VR is increasingly applied and has already shown its efficacy in the treatment of patients with PTSD (Difede et al., 2014) or in the treatment of specific phobias such as acrophobia (Rothbaum et al., 1995a) or spider phobia (Carlin, Hofman, & Weghorst, 1997). Although much research has been done on its efficacy in either treating patients in acute pain (Hoffman, Patterson, & Seibel, 2008) or certain mental disorders (Rothbaum, Hodges, Watson, Kessler, & Opdyke, 1996), little has been known about its potential to induce positive emotions in people. In this paper, we address the question whether the exposure to a Virtual Reality environment can significantly reduce stress in people.

Stress

Stress is a concept that was initially introduced in the 1930s by Hans Selye, who defined it as "an organisms non-specific response to any pressure or demand" (Selye, 1978). The increasing interest in stress, both by scientists and also the popular press, show that it is not only a theoretical problem but also one, that directly approaches real and critical aspects of people's life. Work stress or the often referred to occupational stress can be seen as one example, that gained a lot of attention and has been a topic for many investigations and extensive research (Edwards, & Burnard, 2003). One of the main causes of work related stress is when people are presented with work demands and pressure that do not fit with their knowledge and ability to cope (World Health Organization, 2016). Important mediating factors that contribute to occupational stress are a low perception of control and little support from co-workers. The prevalence rate of work stress is high. A survey from the Northwestern National Life suggests that 40% of the workers in the US regard their job as very or extremely stressful and even one employee in every fourth sees their job as the major stressor in their life (U.S. Department of Health and Human Services, 1999). A different survey from the European Agency for Safety and

Health at Work (2009) shows that "stress is the second most common threat posed by the working environment. Only musculoskeletal problems are seen as more likely to damage worker's health".

Stress can lead to a variety of dangerous diseases and has an enormous influence on the quality of life of persons. It is not only influential in the onset of mental health problems such as anxiety and depression orders, but also in the emergence of important physiological impairments. Recent research indicates how chronic stress is linked to biological mechanisms that play a major role in the onset of coronary heart disease (Chandola et al., 2008). Furthermore, it has been correlated to other physiological impairments such as hypertension, atherosclerosis, angina pectoris, stroke and also diabetes mellitus (Boedeker & Klindworth, 2007). To analyze the mechanisms by which high stress is accomplished, the Tripartite model of affect is considered as a heuristic frame. Central component of this model, developed by Clark and Watson, is the notion of systems that detect and respond to threat, including Positive Affect (PA), Physiological Hyperarousal (PH) and Negative Affect (NA). High levels of PA refer to pleasurable engagement with the environment and feelings of delight or enthusiasm meanwhile low levels of PA relate to fatigue and lethargy (Buckby, Cotton, Cosgrave, Killackey, & Yung, 2008). PH represents anxiety-related factors such as somatic tension and arousal, represented by heart pounding or shortness of breath, which resemble typical bodily symptoms of a stress response. According to the Tripartite model of affect, different aspects of depression and anxiety overlap considerably through a shared, general factor called Negative Affect. Low levels of NA correspond to calmness and relaxation, whereas high levels reflect feelings such as anger, fear or nervousness (Buckby et al., 2008). PH, NA and PA seem to play a major role how people react to stressors in their environment and will be considered as essential components in the progress of this work.

Positive Psychology

With the development of a new approach in psychology, a variety of new possibilities arrive to help individuals to cope with stress. In 1998, Martin E. P. Seligman tried to shift nowadays psychology away from being illness-orientated and therefore paved the way for a new movement in psychology, called positive psychology. By helping individuals to thrive, this approach can be used to create meaningful experiences that lead to improvements in different areas of people's lives. Positive psychology is not limited to a specific part of the population but instead examines how ordinary people can become happier (Seligman & Csikszentmihalyi, 2000). Generally speaking, Positive psychology deals with the "positive, adaptive, creative, and emotionally fulfilling aspects of human behavior." (Compton & Hoffman, 2012). Instead of focusing on individuals who suffer under certain physiological and psychological issues, the new discipline studies the "average person", their strengths, qualities and virtues. Increasing the intensity and frequency of positive emotions will create and strengthen useful personal resources to cope with difficult moments (Fredrickson, 2001). Moreover, positive psychology on an individual level investigates subjective experiences such as well-

being, contentment, optimism and positive individual traits like the capacity for love, social skills or courage. On a group level it focuses on moving the individual towards a better citizen by putting emphasis on responsibility, altruism and tolerance (Seligman & Csikszentmihalyi, 2000). Positive psychology is not only limited to positive aspects of human functioning but instead tries to understand the entire range of human experience, including suffering, death, fulfillment and health (Linley, Joseph, Harrington, & Wood, 2007), making it a holistic approach for whole human functioning. In the last decade, positive psychology has been getting more and more attention and is adapted by many psychologists from all over the world.

Interventions in positive psychology are aimed at cultivating positive feelings, behaviors and cognitions in order to lift an individual to a more optimal state of functioning. Over the past few decades positive psychology interventions have been shown to be a promising approach to increase well-being, that is defined by the presence of positive and absence of negative emotions, resulting in a general satisfaction with life (Sin & Lyubomirksy, 2009; Centers for Disease Control and Prevention, 2016). These interventions include methods and activities that help individuals to thrive for more meaningful experiences by engaging for example in enjoyable activities (Fordyce, 1977) or using one's character strengths and virtues in new ways (Seligman, Steen, Park, & Peterson, 2005). In a study conducted by Fredrickson and colleagues (2008), an positive psychology intervention was constructed that investigates the benefits of meditation. The intervention was based on a loving-kindness meditation that increases daily experiences of positive emotions such as joy, gratitude, hope and interest. The data reported an increase in positive emotions over a span of nine weeks which enabled people to become more satisfied with their lives. The effects of the meditation were both immediate, in terms of self-generated positive emotions, and over time, in terms of increased general well-being.

Mindfulness Stress-Therapy

Coping with stress and stressors of the daily life is a harrowing challenge for big parts of the population. Although the area of stress interventions has greatly expanded during the last decades, there is a lack of evaluation research on intervention programs (Bossche & Houtman, 2003). The majority of the interventions are based on mindfulness meditation, that is, a non-evaluative moment-to-moment awareness of mental states and processes (Grossman, Niemann, Schmidt, & Walach, 2004). Mindfulness implies the immediate awareness of physical actions, perceptions and thoughts that arise during practice, without thinking about them. Originating from earliest Buddhist documents, mindfulness meditation aims at providing a more vital sense of life by putting emphasis on the perception of one's own responses to external and internal stimuli. In a study conducted by Williams and colleagues (2001), a wellness-based mindfulness intervention was brought to more than 100 adults with a three month follow-up. The purpose of the study was to determine if mindfulness meditation decreases the effect of stress, medical problems and overall daily hassles. At the end of the intervention, the experimental condition reported significantly lower effects of psychological distress

(44%) and medical symptoms (46%) and daily hassles (24%) (Williams, Kolar, Reger, & Pearson, 2001). Literature emphasizes the role of mindfulness-based meditations in reducing experienced stress and promoting general well-being (Grossman, Niemann, Schmidt, & Walach 2004). Although programs do exist to reduce stress in people, many of them are typically directed towards a specific illness or symptoms people show (eg. Ramel, Goldin, Carmona & McQuaid, 2004; Tacon, McComb, Caldera & Randolph, 2003; Praissman, 2008). Therefore, a single and relatively cost-effective program that can be applied to a majority of people, should be of great interest for both health care practitioners and non-professionals. Continuing advances in technology have led to many new possibilities to deliver meditation-based interventions. New devices have the potential to address social, emotional and physical issues in a unique way.

Positive Technology

With the enormous pace of technological progress, there have been new approaches that use modern technology in order to improve the quality of personal experiences (e.g. Riva, Baños, Botella, Wiederhold, & Gaggioli, 2012). Positive technology uses technology to increase social and psychological well-being in persons while being grounded on the framework of positive psychology. The approach deals with technology and how it can manipulate and facilitate features of people's personal experience to promote psychological flourishing. In a study conducted by Luthans, Avey and Patera (2008), a web-based intervention was constructed to heightened psychological capital which was assessed by four different components, that is hope, efficacy, optimism and resilience. The intervention consisted of two online sessions, each 45 minutes, and included short video clips about each capacity and self-reflection exercises. Results show that there was a significant increase in psychological capital when compared to a control group that went through a different, relevant intervention. The authors suggest that the virtual context used for the study is a promising approach to apply positive behavior interventions and that the need for such is expected to increase (Luthans, Avey, & Patera, 2008). This research makes use of positive technology by creating a computer-mediated environment that tries to evoke feelings of comfort and relaxation and simultaneously reduces participant's level of stress.

Virtual Reality

Virtual reality is one of the technologies that has the potential to be used to induce positive emotions. The computer registers the persons movements and reactions and modifies the environment in real time which creates the illusion of being immersed into a virtual location. The user experiences the virtual reality through a head mounted display (HMD) (Sutherland, 1968). In the last decade, VR and HMD's have gained more and more popularity and found their applicability in a vast variety of areas. Through the pace of technological progress and the release of several HMD's that are easier to manipulate on basis of their auditory and visual content, HMD's are now being used in medical

settings, education, construction and design, entertainment and many areas more (Virtual Reality Technology, 2003). One important advantage for the use of VR in promoting mental health is its flexibility. A computer-mediated environment has the potential to easily adapt to client's needs through the manipulation of certain variables (Fox, Arena, & Bailenson, 2009). This leads to computer-generated environments that individually adapt to client's demands in order to create a setting where one maximizes his or her personal gain.

Virtual Reality has already found its applicability in healthcare -especially in behavioral therapy- by showing its effectiveness in the treatment of specific phobias such as acrophobia (Rothbaum et al., 1995a), agoraphobia (Coble, North, & North, 1995) or spider phobia (Carlin, Hofman, & Weghorst, 1997). Furthermore, with very positive results, VR has been utilized in the treatment of patients with PTSD (Difede et. al. 2014) and acute pain management (Wolitsky, Fivush, Zimand, Hodges & Rothbaum, 2005). VR has also shown to be effective in the induction of positive emotions. In a study, conducted by Baños and colleagues (2013), a group of 19 patients with metastatic cancer were given a virtual reality intervention to induce emotions such as joy and relaxation. Results suggest that the main perceived benefits from the four 30-minutes sessions include entertainment and the promotion of relaxation states, meanwhile a decrease in negative emotions was detected (Baños et al. 2013). Similar results are obtained in a different study executed by Villani and Riva (2012). The experiment consisted of six sessions of one hour and involved a stress management protocol with different relaxation techniques and self-monitoring activities. Participants in the VR condition navigated through specific zones of a natural park that included a relaxation exercise supported by a relaxing narrative. Their results were compared to a video condition that saw a video of a VR session but without interaction and an audio condition, where participants listened to the same relaxing narrative as the VR group. It has been shown that the VR exposure was more effective in reducing stress than the video and audio conditions. Both studies suggests that VR is a promising technique that is able to increase positive emotions on the one side and reduce stress and arousal on the other side.

With modern technology available for the general public, a new promising treatment for stress could emerge. The following research question will be examined:

Does the exposure to a Virtual Reality environment decrease stress and arousal when compared to a control group?

Methods

Design and Participants

This study is constructed by a between subjects pre-post design with the respondents being recruited by convenience sampling. The descriptive statistics of the sample involved can be seen in Table 1. The study involved 80 participants in total of which 43 were females and 37 were males with an age ranging from 19 to 78 years (M = 33.25; SD = 15.33). Most of the participants were German (97,5%) with a high educational level, represented by a higher education entrance qualification from a German secondary school (55%) or the degree of an university (15,1%). For our research we regarded a general certificate of a secondary education as an average educational level which accounts for a total number of nine people in our study (11,3%). Only one participant had a lower educational level which underlines the highly educated nature of our convenience sample. The majority of the subjects were students (51,2%) and approximately one third were employed (32,5%). Participants who had a history of psychological treatment, or who do not understand German and English were not able to take part in the study. Besides that, participants with serious hearing and visual impairments were also excluded beforehand. All participants were volunteers and did not receive any payment or any other form of credit for their collaboration.

Table 1. *Descriptive Statistics of Participants*

Classification	Criteria	Frequency	Percentage (%)
Gender	Male	37	46.30
	Female	43	53.80
Nationality	German	78	97.50
	Dutch	1	1.30
	Other	1	1.30
Education	Higher educational qualification	44	55
	Secondary school certificate	9	11.30
	Main school certificate	1	1.30
	Bachelor's degree	8	10
	Master's degree	3	3.80
	Other	15	18.80

Materials

Hardware

As a tool for the virtual reality experience, we made use of Google Cardboard. Google Cardboard provides an inexpensive virtual reality tool which is uncomplicated to use for many people. The virtual reality environment was displayed through a smartphone (HTC One) put into Google

Cardboard, so that no extra hardware (besides the phone) was necessary. Additional headphones (Bose AE2) were used to provide auditory stimuli to the participants. The participants filled in the questionnaires via a laptop with internet connection.

Software

The Virtual Reality is created by using an application called "Perfect Beach VR", published by nDreams LTD Simulation. The software is compatible with the mobile operating system Android and shows a tropical beach setting that can be manipulated on two variables, including the time of the day and a different location. For our experiment, only the tropical beach at midday was relevant. As an instrument to collect the data, we made use of Qualtrics, an online research software which allows the creation and publication of surveys.

Questionnaires

This study is part of a bigger research that involves several questionnaires. In the following, only the questionnaires that are relevant for this study will be discussed.

Demographic Variables

At the start of the survey, the participants were asked to answer several questions referring to general demographic details such as the age, gender, education and occupation.

Stress Arousal Checklist

The questionnaire that was used to evaluate the effectiveness of both therapy methods, including the guided meditation with and without VR, is based on the Stress Arousal Checklist, originally developed by Mackay and colleagues (Mackay, Cox, Burrows, & Lazerini 1978). The questionnaire originally consisted of 44 items. On basis of the highest factor loading, a selection of 14 items from the original test has been made. The SACL was translated into the German language by following the procedure of forth-back translating, guarantying that the adjectives keep the same meaning. In order to measure the factors arousal and stress, the following selection of items was made.

The factor arousal is composed by two subscales, positive and negative arousal, each measured by three items. Positive arousal is related to positive emotions such as "lively", "energetic" and "activated", meanwhile negative arousal involves the perception of negative emotional states like "sleepy", "tired" and "sluggish". These six items were selected purposively because they demonstrated the highest factor loading for the concept of arousal (McCormick, Walkey, & Taylor 1985). The same procedure was used for the factor stress which was divided up into stress on the one side and relaxation on the other.

Participant's state of stress was measured by eight items in total. The items that correlate to a high perception of stress are "tense", "uneasy", "worried" and "jittery". On the other side, relaxation was measured by positive adjectives like "calm", "contented", "relaxed" and "peaceful". All 14 items were measured using a 5-Point Likert scale (1 = strongly disagree, 5 = strongly agree). The internal consistency for the scale has been reported by literature in the range of 0.8 - 0.9 (Cox & Mackay, 1985). In our study, the reliability analysis was performed for each subscale, that is positive arousal, negative arousal, stress and relaxation. The results can be obtained in Table 2. Due to the small number of items in each subscale, the reliability values are relatively small (Tavakol & Dennick, 2011). The low internal consistency will be taking into account when the results are being interpreted.

Table 2. *Cronbach's Alpha for each Subscale*

Subscales	Internal consistency (Cronbach's Alpha)
Positive Arousal	0.63
Negative Arousal	0.49
Stress	0.65
Relaxation	0.57

Procedure

To compare the efficacy of the virtual reality environment on stress reduction, a between-subjects experiment was constructed. The data collection took place between the 01.04.2016 and the 01.05.2016**.** Before the experiment starts, the instructor has to provide Google Cardboard, a smartphone with the application "Perfect Beach VR", headphones and a laptop with a functioning internet connection. The subject was placed on a rotational office chair in a bright and quiet room. The participants were randomly assigned to either the experimental condition or the controlled condition. In order to start with the experiment, all subjects had to sign an informed consent. For a clearer description, both conditions will be discussed separately. An additional flowchart for the proposed process is presented in Figure 1.

Experimental Condition

First, a short introduction was given to the participant, which includes a brief summary over the content of the study. After that, the subject was asked to complete several questionnaires. Next to some general demographic information, the participant was evaluated on a few questionnaires, including the mood adjective checklist that assess subject's experience of stress and arousal prior to the treatment (SACL). After answering all the questionnaires, which takes approximately 20 to 30 minutes, the experimental group was asked to undergo the guided meditation by using Google

Cardboard and the application "Perfect Beach VR". After the twelve-minute long meditation, the participant completed the SACL and other questionnaires again. The experiment finished with a short debriefing about the content and intention of the study.

Control Condition

After the instructor's introduction and the signing of the informed consent, the participant was asked to fill in some questionnaires that gather information about different psychological constructs, including the participant's state of stress and arousal. Subsequently, the subject received the same guided meditation exercise as the experimental condition only without using Google Cardboard for visual stimuli. Once the treatment has been received, he or she was asked to complete the SACL and certain other questionnaires again. A short debriefing about the content and intention of the study marks the end of the subject's participation in the experiment.

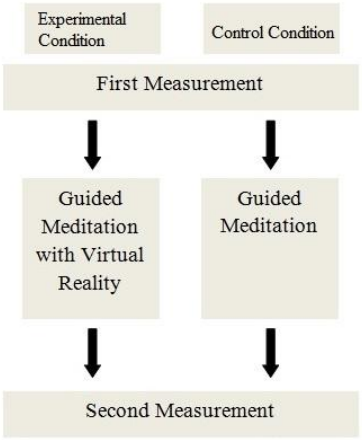

Fig. 1: The flowchart of the experiment

Analysis of data

To examine if there are any differences between the experimental and control condition on the subscales, a repeated measures MANOVA was executed. Time, defined by two levels (pre-and posttest), was selected as the within-subjects factor. The type of condition served as the independent variable in order to differentiate between the conditions. The four subscales of stress and arousal were selected as the dependent variables. An evaluation was made whether an interaction effect existed between the rate of change and the experimental condition.

Results

In this section, experiment results of 80 subjects will be presented and analyzed. Table 2 displays the mean and standard deviation of the experimental and control group before and after the intervention. Basically, it can be observed that the mean Likert scores for positive arousal was lower after the participant finished the guided meditation exercise in VR. However, similar findings could be found in the control condition as well. Both the experimental condition and the control condition reported an increase on negative arousal, including adjectives such as sleepy and tired. Furthermore, the data showed a significant change on the factor relaxation in the expected direction. In both conditions participants felt considerably more relaxed after finishing the treatment. An analysis of the Likert scores on the subscale of stress reveals that after the meditation in the virtual environment, subjects reported lower states of stress than prior to the intervention. However, a similar effect could be observed for participants who experienced the meditation only via audio.

As an independent t-test analysis indicates, there is a notable difference on the factor negative stress between the groups. Subjects from the experimental condition reported higher feelings of tenseness and uneasiness prior to the treatment than participants in the control condition did (*M-experimental* = 7.42, *SD* = 3.06 versus *M-control* = 6.37, *SD* = 2.14, F (2,78) = 6.88, p = 0.01). This difference will be considered in the interpretation of the results.

Table 2. *Mean (M) and Standard Deviation (SD) of the SACL for each Subscale*

Subscales	Experimental Condition		Control Condition	
	Pretest	Posttest	Pretest	Posttest
	M	*M*	*M*	*M*
	(SD)	*(SD)*	*(SD)*	*(SD)*
Positive Arousal	9.27	7.67	9.85	8.35
	(2.35)	(2.24)	(2.2)	(2.65)
Negative Arousal	7.77	8.57	7.22	8.05
	(2.89)	(2.9)	(2.55)	(2.81)
Relaxation	15.35	16.62	15.92	17
	(1.91)	(2.18)	(2.17)	(2.68)
Stress	7.42	5.9	6.37	5.8
	(3.06)	(1.87)	(2.14)	(2.36)

Positive arousal. The obtained mean scores on the factor positive arousal can be seen in Figure 3. Basically it can be observed that all participants felt less active after the treatment with a significant time effect (Wilks' Lambda = 0.71, F (2,78) = 31.12, p > .001), but there was no difference between the control and experimental condition (F (2,78) = 1.91, p = 0.17). The results of an interaction analysis showed that the type of condition and time did not have a statistical significant impact on the outcome variable (F (2,78) = 0.03, p = 0.85), indicating no interaction effect.

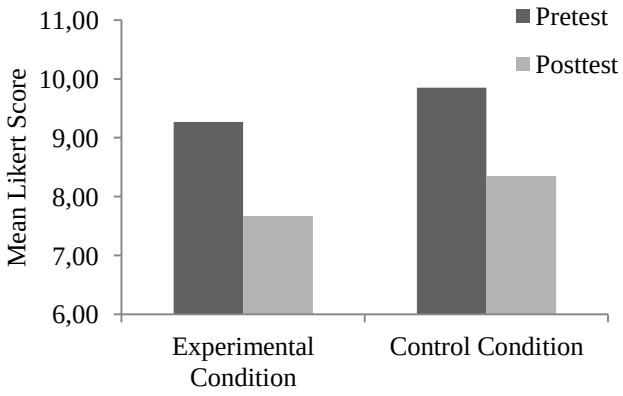

Figure 3. Mean scores on positive arousal for experimental and control condition

Negative Arousal. Analogously to the decrease of activation-based items on the posttest, participants scored substantially higher on items like tiredness, sleepiness or sluggishness with a significant time effect (Wilks' Lambda = 0.94, F (2,78) = 4.97, p = 0.029). Figure 4 shows that subjects in both conditions reported higher feelings of sleepiness, tiredness and sluggishness after the treatment, but the groups did not differ from each other (F (2,78) = 1.11, p = 0.29). The analysis for interaction shows that the combined effects of time and type of condition did not significantly impact the outcome on the dependent variable (F (2,78) = 0.001, p = 0.97). The findings of the experimental condition that received the meditation exercise in combination with VR did not differ significantly from the control group over time.

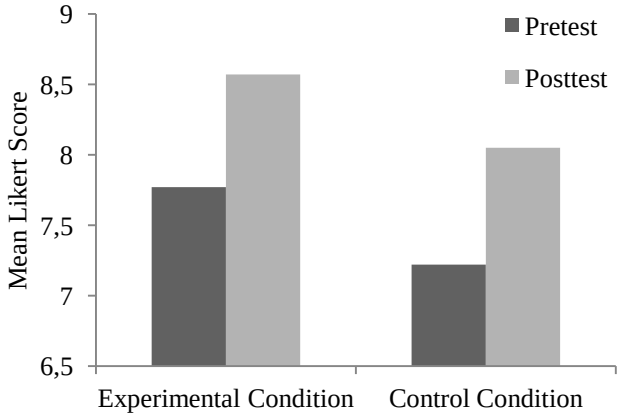

Figure 4. Scores on negative arousal for experimental and control condition

Relaxation. In terms of positive emotions like feeling contented or calm, Figure 5 illustrates that there was a significant increase in the level of relaxation over time (Wilks' Lambda = 0.813, F (2,78) = 17.92, p > .001). An increase in almost all positive emotions after the meditation has been observed, suggesting the effectiveness of both treatments in inducing a relaxed and contented emotional state. A between-subject analysis suggests that groups did not differ on their level of relaxation (F (2,78)= 1.26, p = 0.26). The interaction analysis shows however that the effect of time did not vary between the groups (F (2,78) = 0.13, p = 0.72). VR seemed to have no significant beneficial value for the induction of positive emotions.

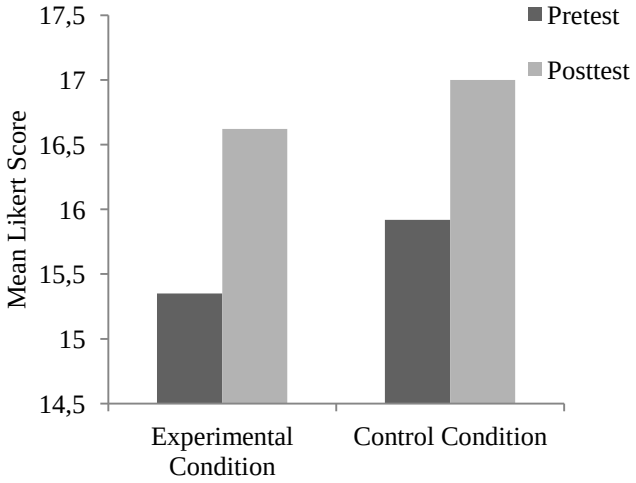

Figure 5. Scores on relaxation for experimental and control condition

Stress. Next, the items that correlate to participant's state of stress are analyzed. The result of the analysis are demonstrated in Figure 6. Basically, it can be shown that both treatments were successful in decreasing participant's state of tenseness or uneasiness and that this effect was significant over time (Wilks' Lambda = 0.84, F (2,78) = 14.77, p < 0.01). A further between-subjects analysis however shows that there was no significant difference between the groups (F (2,78) = 1.54; p = 0.21). Although both groups show slightly different decreasing levels of stress, the effect of time is not different for the two conditions (F (2,78) = 3.02, p = 0.08).

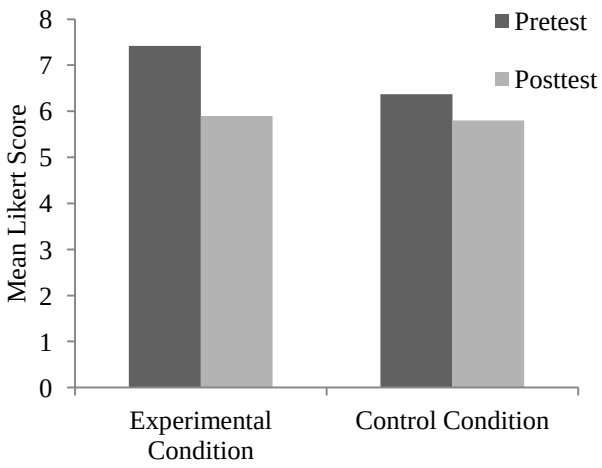

Figure 6. Scores on stress for experimental and control condition

To summarize, the research question about the effectiveness of the VR environment in reducing stress and arousal among the participants cannot be confirmed. VR does not seem to provide a significant beneficial effect to the guided meditation.

Discussion

The present study examines the effectiveness of a virtual environment in reducing stress and arousal in people from the general population by answering the following research question: "Does the exposure to a Virtual Reality environment decrease stress and arousal when compared to a control group?". With a computer-mediated environment in combination with a meditation exercise it was tried to significantly reduce stress in a general public. The analysis of the data from 80 participants indicates that VR was as successful as the control condition in reducing stress and arousal, suggesting that the artificial environment did not provide significant beneficial effects to the meditation.

The analysis for the scale of arousal showed that all participants, whether they were exposed to a VR environment or not, felt less energetic after the guided meditation. Findings furthermore indicate that after being exposed to a VR environment, participants felt considerably more tired and sleepy. However, the same effects could also be found in the control condition. These findings have not been expected, because a similar study from Herrero and colleagues (2014) found different results. They were interested in exploring the potential of a VR environment to induce positive emotions in fibromyalgia syndrome patients, a condition characterized by widespread muscle pain. The VR environment was shown on an adaptive display ("EMMA") that illustrated a beach scenario similar to the one that has been used for this study. The results showed that after being exposed to a VR treatment, participants reported significantly higher levels of energy with their motivation for activities being grown. In contrast to the present study, they included melodies with positive valence and high arousal that varied on tempo and mode. That a fast tempo and variation on modes is related to positive moods and higher feelings of energy has been shown in an early research, conducted by Rigg (1940). The present study however only involved a melody with low tempo, little variance and a female narrative voice, which might account for the observed differences on arousal. Besides that, an increased state of fatigue also contradicts the research from Mahalil and colleagues (2014). In their study they proposed a VR-based stress therapy where the user is placed into a forest scene that includes soothing audio and a narrative voice. The results were then compared to a control group that followed an imaginary therapy instead. Their findings show that there was a significant reduction on subjects feelings of tiredness, meanwhile participants in the control condition felt more tired. This can be attributed to the different systems that were used to display the virtual environment. Mahalil and colleagues (2014) made use of Oculus Rift, a high-end HMD, together with the game engine "Cryengine 3". This leads to an environment that appears much more realistic and vivid. In the present study however, a regular smartphone was used to display the virtual environment which displayed the content with a considerably lower graphical quality. Consequently, this caused several subjects to report eye strain and feelings of dizziness what may have contributed to a general state of tiredness after the procedure. Especially the low distance towards the screen and its' brightness might account for eye strain as literature indicates (The Vision Council, 2015).

Analysis of the factor relaxation showed that both conditions reported higher feelings of calmness and contentedness after the intervention. However, there are no indications of a greater improvement over time in the treatment condition compared with the control group. Moreover, in both groups participant's state of stress was reduced considerably. Nonetheless, no interaction effects in favor of the VR treatment could be identified, suggesting that both groups were equally effective. These findings are surprising if compared to a similar research, provided by Riva and colleagues (2007). Their study intended to explore the possibilities of VR as an affective medium by assessing the participant's state of presence and mood. They found that VR is very potent in inducing different moods such as happiness or relaxation. However, the emotional response is highly dependent on participant's feelings of presence. This finding is supported by a different study, conducted by Pallavicini and colleagues (2013). In that the authors state that the environment has to induce high feelings of presence before emotions can be elicited. Without presence, the ability for emotional induction is even lower than in other, cheaper media. This needs to be considered because several participants reported difficulties to acquaint themselves with the beach environment. Therefore, a missing state of presence could have lowered the overall efficacy of VR to induce emotions. Although stress has been reduced considerably, groups did not differ from each other. This has not been expected because VR is widely used for treating stress-related disorders (e.g. Difede et al., 2014; Wolitsky, Fivush, Zimand, Hodges, & Rothbaum, 2005). However, there is a lack of literature on single session VR exposure and its influence on stress reduction, making a direct comparison difficult. This is understandable, because exploring VR is for most of the participants a completely new experience. Instead of focusing on the meditation exercise, some participants preferred to discover the artificial environment instead. In this sense, VR might have had a distracting influence. For future research it is advised to implement several sessions over a longer period of time. In this case the participant has more time to get used to the technology and focus more on the content that is presented.

Strengths and limitations of the study

One important strength of the study is the total sample size of 80 participants. This can be regarded as a relatively big sample, especially compared to other related research where much fewer subjects were recruited (e.g. Baños et. al, 2012; Mahalil et al, 2014). The sample size has implication for both, the precision of the estimates and the studies' power to draw conclusions. Another strong factor is the implementation of an active control group. The control group served as a benchmark by allowing to compare the results with the experimental group. By doing that, it could be determined if the intervention had the desired effect. Besides that, the effectiveness of the virtual environment to induce relaxation was compared with one of the most supported approaches for stress reduction, mindfulness-meditation, as suggested by a Grossman and colleagues (2004). An additional strength is the use of theory-based measures for the outcome variables of stress and arousal which had positive

impact on the validity of this study. However, there are also some limitations that need to be considered. First, the generalizability of the findings to a broader population is reduced, due to its limitation in the current pilot study. The sample had a very high educational level because it mostly consisted of students (55%) which is not representative for the target group (a general public). Due to the approach of convenience sampling, the study failed to implement an equally distributed sample of the normal population. With respect to the resources available, this had to be taken into account. Another implication for the interpretation of the findings is that the data comes from a single VR-treatment without the evaluation of a long-term effect. Most of the subjects had no experience with VR prior to the intervention. This led in many cases to participants who were very excited and curious about exploring the new technology. In spite of this positive attitude people have towards VR, it is rather unfavorable for answering the research question of this study. Instead of focusing on the meditation, some participants were eager to investigate the virtual surrounding which may have influenced the outcome. Additionally, stress and arousal have been measured by using self-report questionnaires only. Even if the assessment tools were validated, the use of physiological measurements may be useful for more details on the user's emotional response. Moreover, due to the low graphical quality of the software, some participants had difficulties to immerse into the virtual environment. A few participants also reported the HMD was uncomfortable to wear. Those two factors can have respectable impact on the level of presence, which may have put a limit on the ability to induce a state of relaxation.

Suggestions for further research

From this study, several theoretical implications arise that needs to be addressed in future research. It has been shown that a meditation exercise in VR is able to induce certain emotions such as relaxation or contentedness. To this date it is uncertain how long these induced emotions last. With regard to long-term effects of a positive VR intervention, this topic seems to be of special interest. Another theoretical question arose from the degree of presence participants experienced within the virtual environment. In earlier studies it has been shown that the degree of presence determines the emotional response a virtual environment is able to elicit (Riva et al., 2007, Pallavicini et al., 2013). Since presence is a subjective experience, it would be interesting to explore on what basis participants make judgments about it. On basis of this study it is proposed that technical hard- and software have serious implications for participant's experience of presence. Of course, this thesis needs further empirical confirmation. For future research it is suggested to conduct a multiple sessions intervention that measure the changes of stress and arousal for a longer period of time. Although Google Cardboard has certain advantageous like the cheap acquisition cost and being easy to use, a higher quality HMD (such as HTC Vive or Oculus Rift) is recommended. The rapid technological development is reducing the price of the required equipment what makes it more affordable in the near future. Further studies should also implement physiological measurements that give biofeedback so that subject's emotional

responses can be detected more precisely. By doing that it could be investigated if a long term positive VR intervention would also affect physiological means.

Implications

This is one of the first studies testing a VR procedure for the relief of stress and arousal in a general public. Given the importance of stress in nowadays society, these types of studies are an important step for the improvement of mental health in the broad population. A professional therapy to reduce high loads of stress is often a costly and time-consuming undertaking that only a small portion of the public can afford. In addition to that, people often lack the knowledge and will to address their high states of stress. People's enthusiasm to use technologies may however encourage them to seek more alternative ways of treatment which involve the use of VR. Moreover, the possibilities of using VR for a variety of new applications to improve mental health are vast. These allow individuals to draw upon positive experiences and promote unexpected psychological resources. In times where worldwide healthcare services have to find new accessible, engaging and cost-effective tools, it is VR that may provide the answer to those needs (Coyle, Doherty, Matthews, & Sharry, 2007),.

In conclusion, results showed a significant reduction on stress, meanwhile participant's state of relaxation increased. However, a meditation in a virtual environment had no significant beneficial effects on stress reduction when compared to a control group. As this research shows, VR is a promising approach for positive mental health treatments and worthy of further study. Since stress is a major threat to people's quality of life, it becomes necessary to have strategies oriented to promote relaxing states. In that sense, positive technologies and VR may provide the necessary resources to address this global problem properly

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