

CLINICAL TRIALS INFORMATION:

Title: Investigating the Neural Systems That Support the Beneficial Effects of Positive Emotion on Stress Regulation

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ASSOCIATED PUBLICATION: **The Future of Immersive Mood Induction in Affective Science: Using Virtual Reality to Test Effects of Mood Context on Task Performance**

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Procedures

Participants came into the lab for one in-person session. Prior to starting the experimental procedures, participants completed informed consent. All procedures were approved by the University of Denver's Institutional Review Board. Participants then completed task training, a practice run of the task in the VR headset, the task itself and then individual difference measures. Participants were then debriefed and compensated for their time.

Materials

Baseline and Post-Experiment Mood Ratings

Before putting on the VR headset and at the end of the experiment, participants used the modified Differential Emotions Scale (mDES; Fredrickson, 2013; Izard, 1977) to rate their current mood. We defined the mDES as a mood measure because it was intended to measure participants' current mood absent of a stimulus intended to evoke an emotional response (Rosenberg, 1998). The mDES consists of 20 questions and is comprised of two sub-scales for positive and negative emotions with 10 questions for each subscale respectively. Scales are comprised of summing all positive scores together and all negative scores together. In our study, participants were asked to rate their current experience of all 20 emotions on a five-point Likert Scale (1 – not at all to 5 – Extremely).

Mood Induction via VR

The virtual environments consisted of a beach scene and an office scene, which were shown to elicit incidental positive and neutral states respectively in our previous studies (see Song et al., 2019). The virtual environments and task were programmed with WebVR (an HTML framework) and JavaScript and displayed with a mounted VR headset (Oculus Rift) that included audio. Participants were instructed to explore the VR for approximately three minutes before the task started. Participants completed the task while still in the VR and while the virtual environments continued to play in the background. The task was programmed such that the images and instructions would appear in the center of the participant's vision regardless of their position in the VR environment.

Post Mood Induction Mood Ratings

After the three minutes of exploring the VR environment, a mood rating scale appeared in front of the participants while still immersed in the environment. Participants were told they would be using a joystick similar to a laser pointer while immersed in the VR environment. Examiners showed the participants the joystick prior to entering the VR and explained how to hold the joystick and make ratings. They were instructed to point at the rating when it appeared in front of them and use their index finger to press a trigger on the joystick to make the rating they wanted. Participants rated how positive (1: not positive at all – 9: very positive) and negative they felt (1: not negative at all – 9: very negative). The mood ratings were displayed for 5s each to account for a potential delay in participants' ratings after exploring the VR environment.

Reappraisal Task and Emotion Ratings

At the beginning of the experiment, participants were trained on the reappraisal task and given instructions about the various trial types (i.e., the look and decrease instructions), and the emotion ratings. During the look instruction, they were told to view the image in front of them and "let yourself react naturally." When given the decrease instruction, they were told to "change your emotions to decrease how negatively you feel about the picture ... reinterpret, or re-frame, or reconsider the meaning of the picture so that it makes you feel a lot more positively or a lot less negatively." The experimenter provided participants with feedback and examples of reappraisals for the decrease instruction. Participants were also instructed on the timing and method for making their emotion ratings inside the VR headset. We defined the ratings participants made after viewing the images as emotions ratings, given we were asking them to rate their emotional response to a stimulus (Rosenberg, 1998). At the end of training, participants were asked to repeat the task instructions in their own words to ensure

they fully comprehended the task. Participants then completed practice trials within the VR headset. Practice trials were intended to give participants experience with the pacing of the task within the VR headset, and practice using the joystick to make ratings.

For the task, participants first saw a cue (2s) then an instruction (3s each) and then the target neutral or negative image (7s each). Participants then rated their positive and negative emotion (3s each) on a scale from 1 (not at all positive/negative) to 9 (very positive/negative). For analyses the positive and negative ratings were (separately) averaged within each trial type for each participant. Therefore, the task constituted a 3×2 mixed factorial design: positive mood context: look-negative, look-neutral, decrease-negative – neutral mood context – look-negative, look-neutral, decrease negative.

The trials were organized into a single block which included a total of 54 images. The images were selected from the International Affective Picture System (IAPS; Lang et al., 2008). Neutral and negative pictures were selected based on the normative ratings available with the stimulus set, which include ratings of valence and arousal on nine-point scales of “1” (low pleasure, i.e., negative) to “9” (high pleasure, i.e., positive) and “1” (low arousal) to “9” (high arousal), respectively. The following distribution was used across condition type: one third look-negative, one third look-neutral, and one third decrease-negative. The images were counterbalanced with instruction type to control for the possibility that certain pictures might have had a greater impact on affect than others. Thus, participants were randomly assigned both to the positive or neutral VR mood context as well as image set. The entire task including the three-minute mood induction was completed in approximately 23 minutes.

Post-Task Individual Difference Measures and Mood Ratings

After the reappraisal task was completed, participants completed a battery of individual difference measures, including general demographics (e.g., age, gender, race) and other individual difference measures of emotion, well-being, and mental health symptoms. Participants also completed the Igroup Presence Questionnaire (IPQ)(Schubert et al., 2001) which is a measure of one’s sense of presence while experiencing a VR environment. The measure consists of 14 items intended to assess various aspects of sense of presence while in VR and includes three subscales: spatial-presence, realism, and involvement. The IPQ asks participants to rate various questions on Likert scales such as “In the computer-generated world I had a sense of ‘being there’” from not at all to very much. Participants also were asked to define each instruction (e.g., look and decrease) and how difficult it was to follow the reappraisal instructions, and what percentage of time they were able to follow the instruction. Lastly, participants completed a final mDES measure of their current mood.

Timing of Mood and Emotion Ratings

Participants rated their mood at several time points. The mDES was used to measure participants’ mood prior to entering the VR and at the very end of the entire experiment once they had completed other post-task individual difference measures. Mood ratings using the positive and negative scales (e.g., “1 not at all positive/negative to 9 very positive/negative”) were also collected after the three-minute VR mood induction. Emotions ratings using the positive/negative Likert scales were collected after each trial of the reappraisal task.

Data Analysis

All analyses were interpreted as significant if they crossed the $p < .05$ threshold and all follow-up t-test analyses were two-tailed.

Several pre-registered exclusion criteria were applied prior to data analysis including: lack of understanding of the task ($N = 5$), missing more than 25% of trial level data ($N = 8$). Additional participants were excluded due to a corrupted data file ($N = 1$) and mixing up the positive and negative ratings ($N = 1$). Lastly, one additional participant was excluded due to outlier scores on several measures including the VR task ratings and most individual difference measures as indicated by scores that were

greater than 3 standard deviations from the mean. This left usable data for a total of 80 participants, which reflects the desired sample indicated in our power analysis for this study (see our preregistration at the Clinical Trials website for more information).