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VR for Blood-Injection-Injury Phobia

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Abstract: *Virtual reality (VR) exposure therapy has been shown to be successful in treating many types of specific phobias which are mostly visual in nature. However, limited research has been completed on the use of VR therapy for Blood Injection-Injury (BII) phobias, one of the subtypes of Specific Phobia listed in the DSM-IV TR. Since BII phobia may operate by some tactile component, it may respond differently to VR therapy compared to other categories of specific phobias that are largely visually activated. This paper discusses initial development and results from a study on both subjective and objective arousal elicited by a prototype virtual world which has been developed to treat those with BII phobia. The present study evaluated the responses of 20 healthy, non-phobic male and female participants to VR blood and injection stimuli. Initial results are positive and show that the VR world delivers appropriate cues to elicit physiological and self-reported arousal when exposed to the injection scenarios. Correlations between self-reported anxiety and physiological arousal confirm that individuals experiencing greater symptoms of fear in conditions involving blood or injections will exhibit more intense arousal from the virtual stimuli than those who experience reduced symptoms. Findings suggest that the virtual world is an effective method of cue exposure for individuals who experience anxiety in situations related to blood and injections. Future research on the use of VR exposure therapy in the treatment of BII phobia is warranted.*

INTRODUCTION

The DSM-IV TR classifies phobias into three groups: 1) Agoraphobia, 2) Social Phobia, and 3) Specific Phobias. The further subdivision within Specific Phobias is: 1) Blood-Injection-Injury (BII), 2) Animal, 3) Natural Environment, 4) Situational, and 5) "Other".¹ Although VR exposure therapy has been used successfully for more than a decade to treat phobias; including specific phobias, panic disorder and agoraphobia, and social phobia⁽⁴⁻¹³⁾; only one study has attempted VR usage for injection phobia.²

Those who suffer from BII phobias may fear either the sight or the pain of the injection and often begin avoidance of any situation which may cause exposure to an injection, such as donating blood or going to the doctor. In extreme cases, the phobic may even begin to fear driving past a hospital.³ Because BII phobia involves not only visual stimuli which elicit the phobic response, but also tactile stimuli; it may

differ from other specific phobias in how it will respond to VR. In the previous injection study, it was found that VR could be used to successfully elicit subjective (measured with Subjective Units of Distress (SUDs ratings) and physiological arousal (measured with heart rate (HR)) in those with needle phobia, however, the results indicated that the addition of tactile stimuli would have proven to be more advantageous. In addition, the previous study presented the VR environment via a desktop display instead of a more immersive head-mounted display (HMD).² The present study, therefore, sought to investigate elicitation of arousal via a HMD VR system to be used in treating those with BII phobias. As an initial first step, however, we have sought to establish a baseline with those who do not meet the DSM-IV TR criteria for a BII phobia in order to use this arousal level as a baseline comparison for phobic participants exposed to the VR world.

MATERIALS AND METHODS

Participants

Twenty healthy, non-phobic participants (13 females and 7 males) from the San Diego area were recruited for this study. Their mean age was 27 ± 10 , ranging from 20 to 54 years of age.

Virtual World

The low cost VR system was developed to be used on a personal computer (PC) platform with a HMD and tracking system so that the participant could explore the world via head tracking as well as navigation provided via a joystick. The virtual world was modeled after an outpatient clinic in La Jolla, CA and is almost an exact replica of the real life structure. Participants can navigate through the clinic's entrance, lobby, waiting room and exam rooms. Exam rooms are filled with typical phlebotomy lab paraphernalia, including vials of blood. In one of the exam rooms, the participant may sit down and have a "nurse avatar" administer an injection. This is viewed in first person, as if the participant is seated in the exam room chair and viewing his arm while receiving the injection.

Measurements

Objective physiological measures and subjective self-report data were collected from each participant. Physiological data consisted of heart rate and multiple respiration measures collected using VivoMetric's wireless Lifeshirt system; and heart rate, skin conductance and peripheral skin temperature data collected using J & J Engineering's C2 device. Physiological data was collected at baseline and continuously in real-time throughout exposure to the virtual world. Self-report data consisted of a Fear Questionnaire, a Blood Injection Symptoms Scale (BISS), a State Blood Injection Symptoms Scale (S-BISS), and a Post-Experience Questionnaire. The Fear Questionnaire and BISS were administered before baseline, the S-BISS was administered pre- and post-VR exposure, and the Post-Experience Questionnaire, which included questions on presence and simulator sickness, was administered after VR exposure.

Design

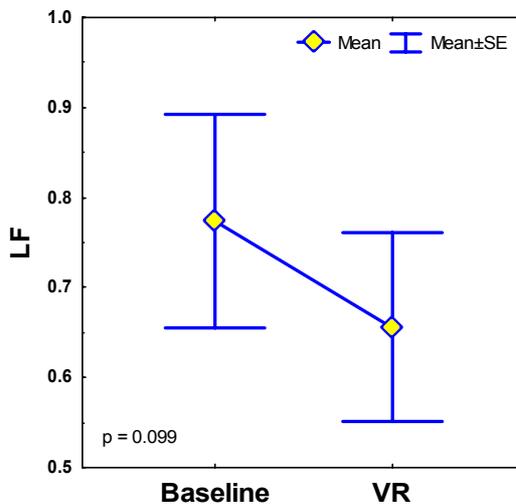
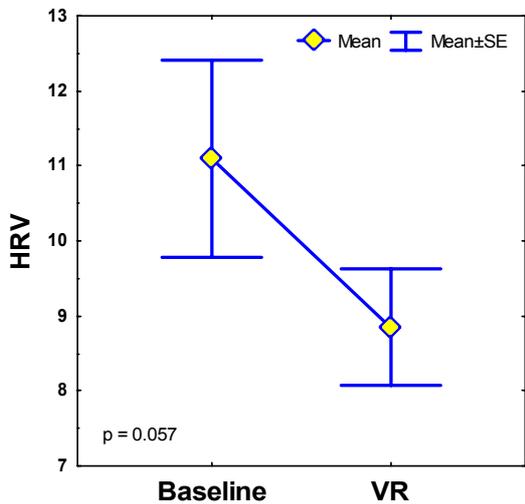
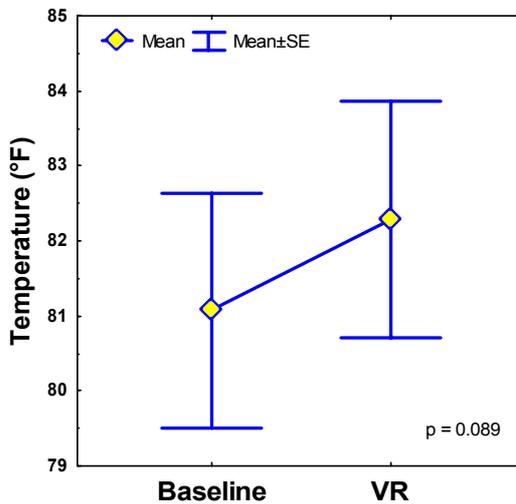
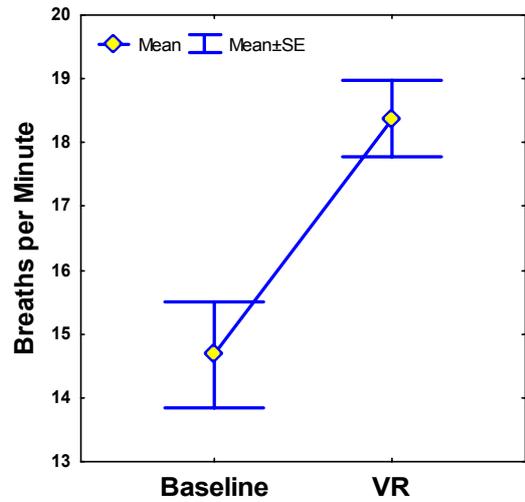
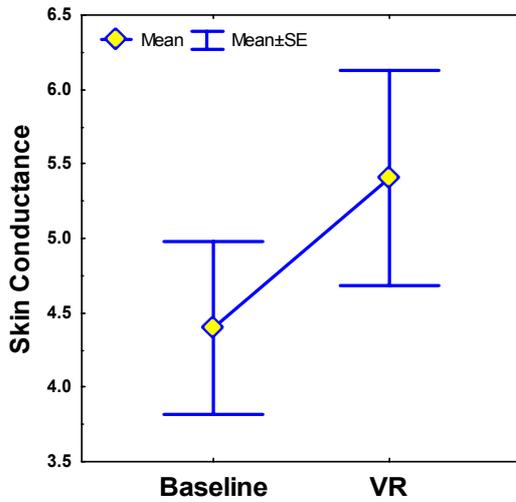
Ten (10) participants were randomly assigned, using a random numbers table, to Group A and 10 were randomly assigned to Group B. Group A was verbally instructed to navigate through the virtual clinic to a specified exam room where they would be seated but was not informed that they would be "receiving an injection". Group B was given the same instructions, but was also notified that they would receive an injection. Outcome measures were analyzed between groups to determine effect of instructions on anxiety (e.g. anticipatory anxiety).

All 20 participants provided consent before completing the pre-test questionnaires. All participants completed a 3 minute baseline during which physiological measures were continuously collected. After baseline, participants completed the S-BISS and each group (A and B) received their respective instructions. Participants navigated the virtual world for 3 minutes and physiological data was collected throughout. During VR exposure, investigators recorded time markers, indicating when the injection was received by each participant. After VR exposure, participants completed the post-test questionnaires and subjective feedback was collected by investigators.

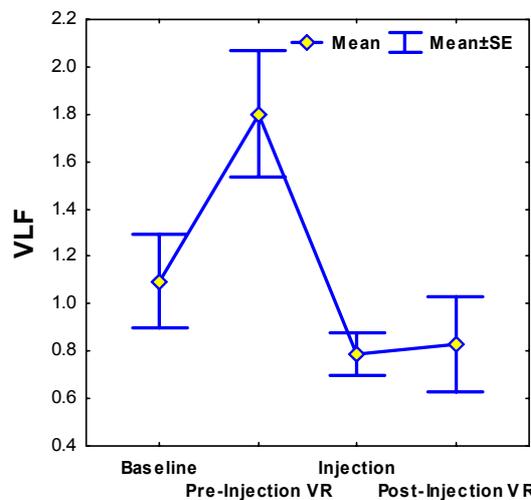
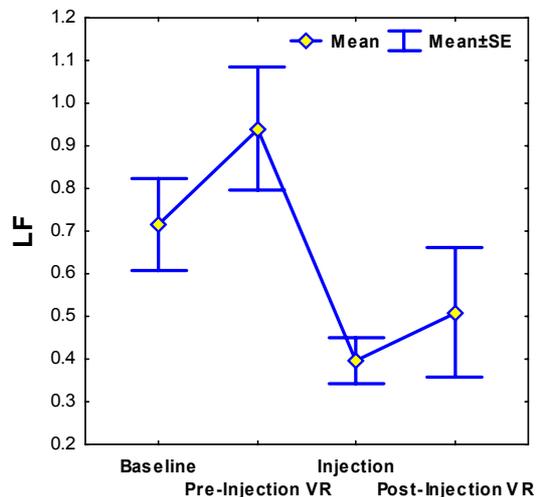
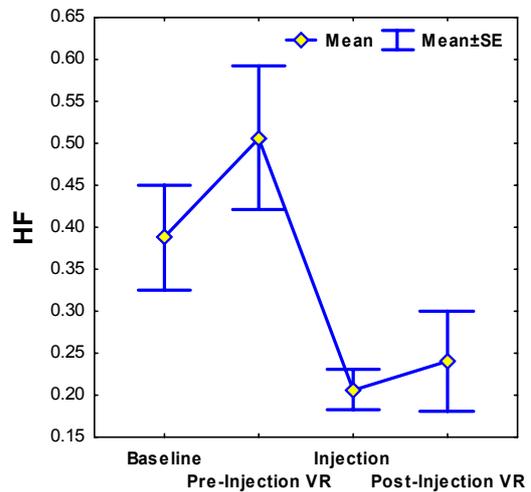
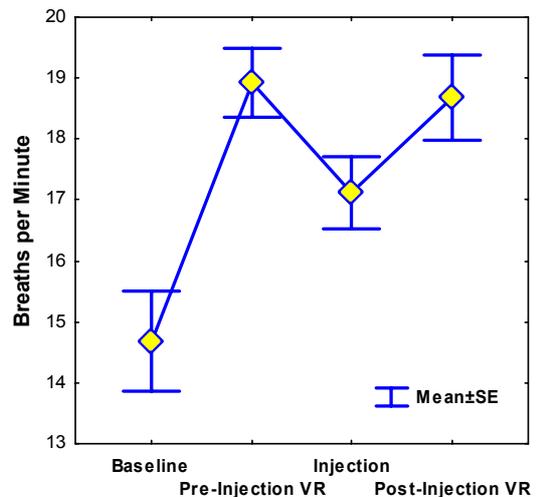
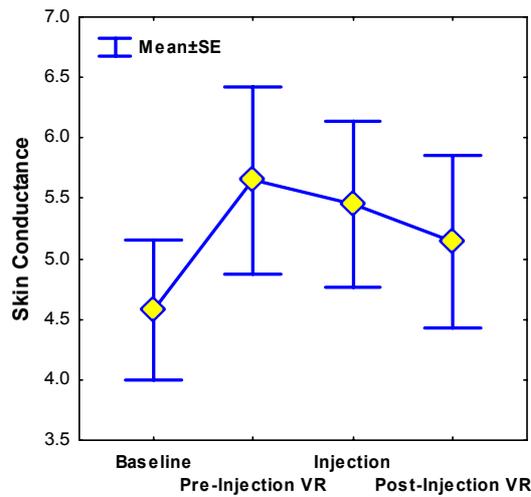
RESULTS

Physiological data from both conditions (A and B) was averaged and differences between baseline and VR were compared using a paired t-test ($\alpha = 0.05$). Analyses indicated a significant increase in skin conductance ($df = 1, 17$; $p = 0.018$) and respiration rate ($df = 1, 18$; $p = 0.0003$) during VR. Temperature also increased during VR, but the difference was not statistically significant ($df = 1, 18$; $p = 0.089$). Combined group data exhibited a decrease in HRV ($df = 1, 18$; $p = 0.057$) and LF ($df = 1, 18$; $p = 0.099$) during VR, but neither difference was statistically significant. T-tests determined that differences in heart rate ($df=1, 18$; $p=0.631$), VLF ($df = 1, 18$; $p = 0.672$) and HF ($df = 1, 18$; $p = 0.0442$) measurements were not significant.

Combined group data from VR exposure was averaged into three distinct segments and analyzed; period before injection (VR1), injection



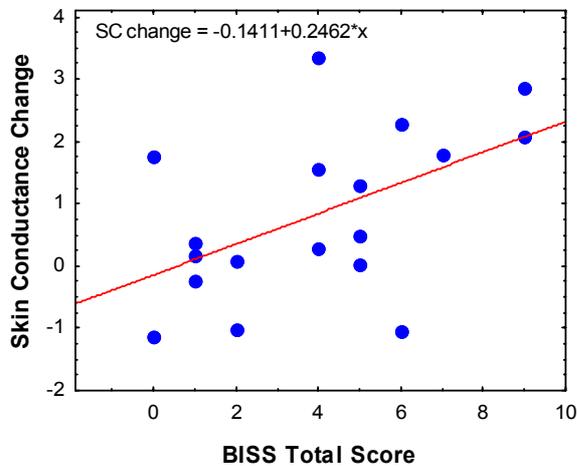
(VR2), and period after injection (VR3). A repeated measures ANOVA analysis of baseline and each VR segment revealed a significant increase in skin conductance from baseline during VR1 and VR2. Skin conductance also increased during VR3, but the change from baseline was not significant. A similar analysis of respiration rate indicated that BPM (breaths per minute) during baseline was significantly lower than VR1 and VR3, but not significantly different from VR2 (df = 3, 51; $p < 0.0001$). An analysis of VLF data revealed that VR1 was significantly higher than baseline, VR2, and VR3 (df = 3, 51; $p < 0.0001$). Both HF (df = 3, 51; $p < 0.0001$) and LF (df = 3, 51; $p = 0.0002$) data exhibited a statistically significant increase dur-



ing VR1 compared to VR2 and VR3. HRV was lower during each of the VR segments, indicating increased anxiety, but differences were not significant. Analysis of heart rate data indicated no significant difference between baseline and VR segments ($df = 3, 51; p = 0.256$ and $df = 3, 51$).

Total scores from the BISS were positively correlated to a change in skin conductance between baseline and VR exposure. Higher self-reported BISS totals were correlated to a greater change in skin conductance values between baseline and VR ($r = 0.5411, p = 0.025$).

Change in skin conductance from baseline to VR



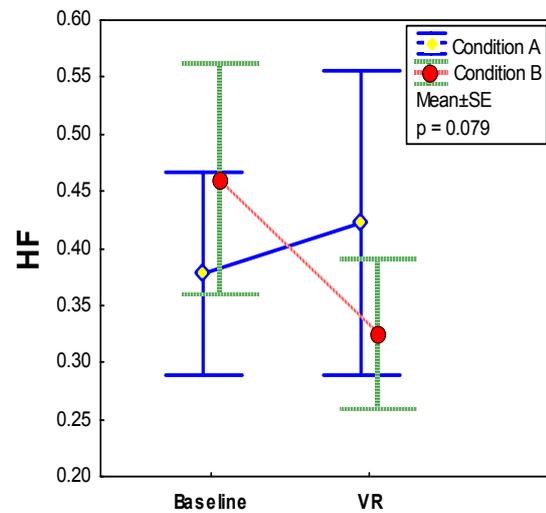
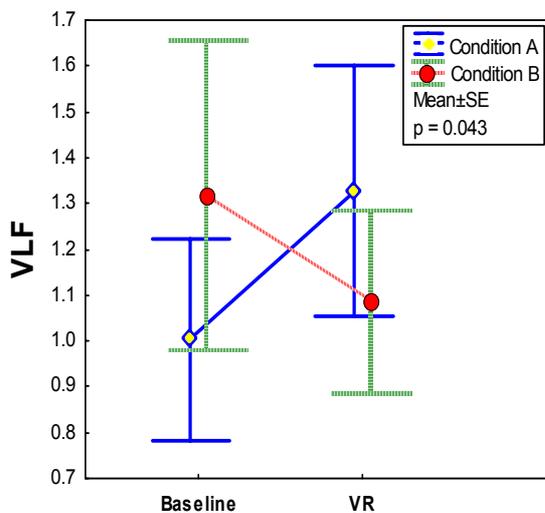
Repeated measures ANOVAs ($\alpha=0.05$) were used to evaluate treatment effects. Analyses were conducted comparing baseline and VR as well as baseline, VR1, VR2, and VR3. Analysis of VLF between baseline and VR revealed significant interaction effects between conditions. HF data also demonstrated interaction effects, but the interaction was not found to be significant. An evaluation of baseline and VR segment averages revealed that Group B exhibited a larger increase in skin conductance values from baseline than Group A, but the difference

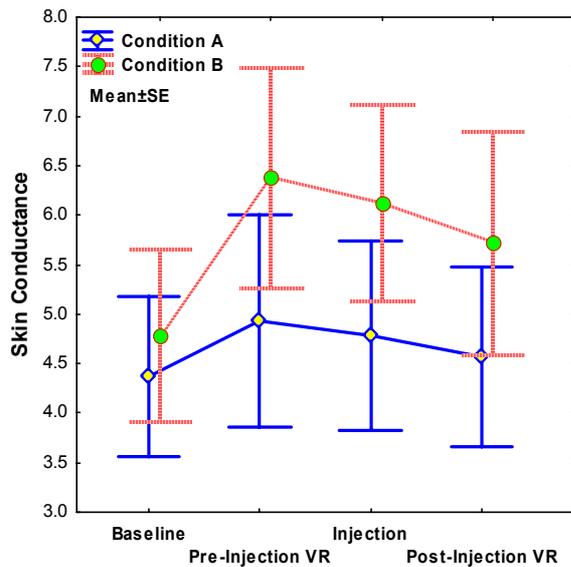
was not significant. All other measurements indicated no significant interaction.

DISCUSSION

This study shows a general pattern of arousal during VR exposure. Skin conductance and respiration rate values increased from baseline to VR, indicating an increase in arousal due to VR exposure. The significant difference in skin conductance values of VR1 and VR2 (but not VR3) compared to baseline may suggest that the initial experience of the virtual world and the injection were the most stimulating segments of the VR exposure. This finding may also indicate that participants became relaxed after the injection, which resulted in a physiological response that was closer to baseline levels.

The significant change in skin conductance values during VR1 and VR2 may also be evidence of anticipatory anxiety exhibited by participants. Participants may have been stressed by the thought of visiting a hospital clinic and the thought of an injection (Group B only), which resulted in an initial increase in arousal (VR1 and VR2) and a subsequent stabilization of physiological response over time (VR3). This interpretation is supported by the differences exhibited between the two experimental conditions. While no statistically significant differences were determined, Group B revealed a larger increase in initial skin conductance values from baseline compared to Group A, which





may be due to greater anticipatory anxiety resulting from being told they would receive an injection. Group A was not notified of the injection and demonstrated less physiological arousal during initial exposure to the virtual world.

The respiration rate data demonstrates a different arousal pattern from the skin conductance results, but provides evidence of general arousal during VR exposure that is similar to the skin conductance data. The significant increase in BPM during VR1 and VR3 compared to baseline suggests that the virtual world produced a sustained state of heightened arousal in study participants. Unlike skin conductance data, BPM measures suggest that participant's physiology did not return to baseline levels after the injection, as BPM remained significantly higher than baseline at the beginning and end of VR exposure. The non-significant increase in BPM during VR2 can be explained by many factors and may provide evidence that participants held their breath while the shot was administered. Generally, lower BPM correlates to reduced arousal, but this association is inconsistent with the rest of the collected data, as VR exposure produced heightened arousal. Consequently, the lower respiration rate during the injection (VR2) may be better interpreted by behavioral factors, like holding one's breath, rather than state of arousal.

Heart rate increases were not found to be statistically significant between baseline and VR exposure. This has also been found in other VR studies which concluded that VR exposure may not be powerful enough to effectively trigger the behavioral activation system (BAS), measured here via heart rate, but does successfully trigger the behavioral inhibition system (BIS) which is measured here via skin conductance. There was, however, some significance found when looking at different frequency bands of heart rate variability, indicating that this measure may prove sensitive enough for future studies.

This study also shows a significant correlation between self-reported anxiety and objective physiological measures of anxiety. Participants who scored higher on the BISS indicated that they were generally more anxious about blood and injection stimuli (though not reaching levels diagnosable as phobic), which was consistent with the increase in skin conductance levels during VR exposure. This association suggests that participants who report greater symptoms of fear in situations involving blood or injections will exhibit a larger physiological response to the virtual world than those reporting reduced symptoms. This finding also reveals the efficacy of the virtual environment at providing potent blood and injection cues, and at generating an appropriate psychological and physiological stimulus response in participants who report symptoms of fear.

CONCLUSION

In this study we determined that the virtual cues produced significant changes in physiological arousal in normal non-phobic participants. Increased arousal levels resulting from VR exposure suggest that the virtual world is an effective method of cue exposure for individuals who report symptoms of fear in situations involving blood or injections. However, the results of this study are not conclusive and additional analysis must be completed to better determine the cause of the physiological changes that result from VR blood and injection stimuli. In addition, future research should evaluate the capacity to which the virtual environment can be generalized to larger populations, including phobic individuals.

FUTURE WORK

Future studies should include the presentation of the current VR world to those who meet DSM-IV TR criteria for BII phobia. In addition, comparison studies should include presentation via both a flat screen and a HMD to determine if indeed the more immersive HMD increases presence, immersion, and arousal. A comparison study should also be included to determine if tactile feedback done in reality which corresponds to the VR visual stimuli would increase initial arousal and possibly result in a more efficient method of treatment. Finally, given advances in wireless technology for physiological monitoring, it would be interesting to test participants in both the actual real world setting and compare results to those elicited in VR exposure.

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