Enhancing Virtual Reality Stress Relief with Haptics: The Virtual Rage Room Use Case

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***Abstract*—EXtended Reality (XR) is already demonstrating its potential beyond the entertainment and gaming industry. One sector clearly benefiting from the advantages of XR is the treatment of stress related mental illnesses by means of Virtual Reality (VR). This is a form of therapy using VR which seeks to help decrease the intensity of the stress responses and anxiety levels due to the various modern-day pressures (e.g., situations, thoughts, or memories which provoke anxiety or fear). While showing promising results, the audiovisual essence of Virtual Reality (VR) can limit the effectiveness of this type of virtual therapy, as the patient's interaction with the environment is constrained to their visual or at most also their audio senses. As such, including in the immersive therapy tactile therapy could enhance the experience and thus the effectiveness of the therapy. However, this has been largely unexplored. The purpose of this paper is to explore the impact of haptic feedback in reducing anxiety for stress relief treatment. Therefore, we present a haptic-enabled subjective methodology. As use case, we selected the booming case of the Virtual Rage Room (VRR), where participants can vent their rage by (virtually) destroying objects. The results of our study highlight the significantly positive impact of incorporating haptic feedback in mitigating anxiety within this context. Moreover, the analysis reassures the intrinsic value of this treatment as a potent tool for anxiety alleviation.**

***Index Terms*—Virtual Reality, Stress, Haptics**

I. Introduction

Escalating stress and anxiety levels in modern society, driven by factors such as social media, increasing workloads, and global unrest, motivate a pressing need for innovative therapeutic solutions [1]. Traditional stress management techniques, while beneficial, often fall short due to their generic approach, spatial and expert availability constraints, and reliance on passive methods like imagination.

In recent years, research identifying VR as a potentially revolutionary tool for the psychological treatment of mental disorders has been mounting [2], [3]. Despite Virtual Reality (VR) therapy environments being mere simulations, users respond to them both psychologically and physiologically in the same way they would in an actual situation [4].

Inspired by Virtual Reality Exposure Therapy (VRET), which utilizes VR to replicate therapeutic scenarios, and in response to challenges of traditional stress and anxiety management techniques, several experiments have been developed to deal with mounting stress problem [5]. However, given the audiovisual essence of VR, the treatments are mostly constrained to only two out of the five senses (i.e., sight and hearing). Enhancing the experience by including a realistic sense of touch (i.e., by means of haptics) could bring the effectiveness of these approaches to a new level. However, the effect of haptic feedback on the effectiveness of VR treatment has mostly remained unexplored [6].

The purpose of this paper is to explore the impact of haptic feedback on Virtual Reality Stress Relief Treatment (VRSRT). Therefore, we present a haptic-enabled subjective methodology for VRSRT; as a use case, we implemented a Virtual Environment (VE) of a very well-known, very popular stress relief approach called the Rage Room. A Rage Room is a designated space where individuals can vent their anger and relieve stress and anxiety by smashing objects in a controlled environment. Virtualization of this space not only circumvents the limitations of physical Rage Rooms, such as high costs, lack of scalability, and environmental concerns, but also leverages VR's immersive capabilities to offer a personalized and engaging therapeutic experience [7]. Incorporating haptic feedback by means of haptic gloves allows for exploring the impact of multimodality on anxiety alleviation.

Moreover, our approach further examines the complex interplay between stress, anxiety, enjoyment levels, and cybersickness.The results of our subjective study highlight the significantly positive impact of incorporating haptic feedback in mitigating anxiety within this context. This analysis reassures the intrinsic value of VRSRT as a potent tool for anxiety alleviation and highlights the potential of haptic feedback to enhance the effects of the therapy.

II. Haptic-enabled Experimental Framework

A. Test-bed architecture

Figure 1 shows an overview of the designed system to evaluate the impact of haptic feedback on VRET. The Meta Quest 2 headset [1] were employed to immerse participants in the VR environment (Figure 1) (1). The application uses Meta Quest Air Link for wireless streaming, supported by a Dell G5 15 gaming laptop with an Intel Core i7 CPU and NVIDIA GeForce RTX 2070 GPU. Furthermore, the SenseGlove Nova[2] haptic gloves (Figure 1(2)) were incorporated to provide users with accurate haptic and force feedback, enhancing the realism

[1]https://www.meta.com/be/en/quest/products/quest-2/
[2]https://www.senseglove.com/

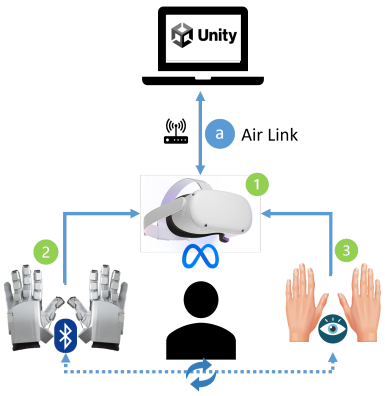


Fig. 1: Haptic-enabled subjective evaluation framework for VRET.

of interactions with virtual objects. Due to the hand-tracking technology of the headset (Figure 1(3)), this setup supports extensive arm movements without the need for external controllers.

B. The Virtual Rage Room Use Case

The Virtual Rage Room (VRR) simulation, developed in Unity[3], ensures an immersive experience crucial for activities like breaking and throwing objects. Segmented into three areas with distinct objects and tasks, the design offers varied feedback types and extensive motion, fully exploiting haptic feedback and hand-tracking, showcased in Figures 2. This comprehensive interaction spectrum enhances immersive experience and therapeutic efficacy. Thereby enhancing the overall immersive experience and therapeutic efficacy. Sections 2a and 2b focus on melee weapon use with fragile and less breakable objects, respectively. The final section includes a flamethrower, automatic weapons, and grenades to simulate diverse interactions.

C. Subjective Study Methodology

As the first step of the session, participants were asked to complete a series of questionnaires to gather information about their demographics, prior experience with VR, stress, and anxiety levels. The Perceived Stress Scale (PSS) assessment was used to determine participants' long-term stress levels prior to the experiment [8], chosen for quantifying initial stress level, allowing for a consistent measurement across participants. To measure changes in anxiety levels, participants completed a brief questionnaire before and after each session, resulting in 3 times an assessment of anxiety levels. For this purpose, the State-Trait Anxiety Inventory (STAI)-6 [9] was chosen due to its efficacy in yielding results that align closely with the comprehensive STAI questionnaire, a recognized and broadly utilized tool in the domain of anxiety measurement [10]. This approach ensured that our anxiety level assessments were both efficient and adherent to established standards of psychological evaluation. Furthermore, participants were asked to respond to the Virtual Reality Neuroscience Questionnaire (VRNQ) after each session to assess the quality of the user experience, game mechanics, in-game support, and VR-Induced Symptoms and Effects (VRISE), which we use as cybersickness score indicator [11].

Subsequently, participants were invited to performed the VR experience twice, once without haptic feedback using the headset's hand-tracking feature and once time with the haptic gloves. To eliminate potential learning effects, participants were divided into two groups, with one group starting without gloves and the other with gloves.

[3]https://unity.com/

III. Evaluation

A. Participants

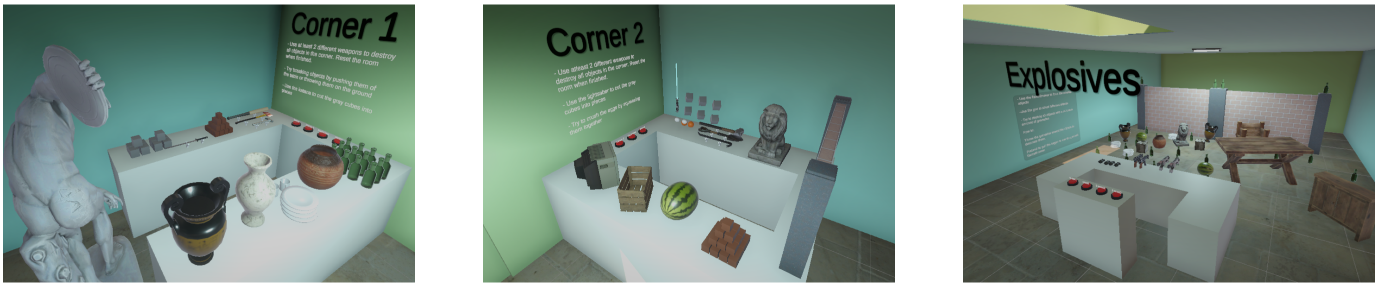
A total of 19 individuals participated as test subjects. None of the test subjects knew the specific purpose of the test procedures beforehand. The ages of the test participants ranged from 17 to 65 years, with an average age of 32.53 years. Regarding gender, there were slightly more males than females in the distribution. Of the 19 test participants, 14 (73.68%) were male, and 5 (26.32 %) were female.

B. Results

1) Virtual rage room for anxiety reduction: In order to analyse the impact of the VRR in anxiety reduction, three aspects were assessed. First, the evolution of the STAI was studied. Second, the initial stress level has been shown to have an effect on the anxiety reduction and the level of enjoyment. Thus, we provide an analysis of this. Finally, the correlation between cybersickness and anxiety reduction was explored.

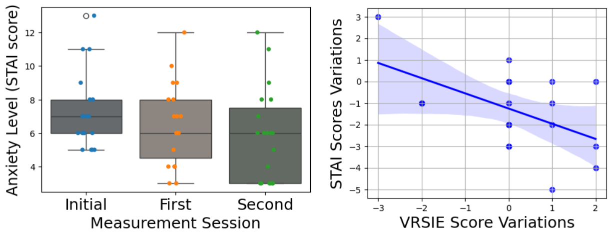
First, Figure 3a illustrates the anxiety levels at three stages during the experiment, indicating a discernible downward trend of anxiety levels. A decrease in STAI-6 (STAI-6) scores from the baseline to after the first VRR experience ($\mu = -0.74$) can be observed, suggesting a minor reduction in anxiety levels. The change in STAI-6 scores from the first to the second experience in the VRR also decreases (average $\mu = -0.63$) indicating continued but slight anxiety reduction. The repeated measures of anxiety levels throughout the experiment were subjected to a Friedman's chi-square test, followed by post-hoc Wilcoxon signed-rank tests. The Friedman test yielded a significant p-value of 0.008, given the significance level of 0.05. This indicates an statistically significant impact on participants' anxiety levels due to the VRSRT. More specifically, significant differences in anxiety levels were revealed by post-hoc Wilcoxon signed-rank tests when comparing the baseline STAI-6 scores to those after the first (p-value: 0.029) and second sessions (p-value: 0.009). Furthermore, a near-significant change (p-value: 0.09) was also noted between the first STAI-6 scores and the scores after the second session. These significant reductions in STAI-6 scores demonstrate the therapeutic effect of the VR immersion experience.

Second, we studied the relation between the stress level and the evolution of STAI. Thus, we performed a correlation



(a) Corner 1 (b) Corner 2 (c) Corner 3

Fig. 2: Illustrate the division of theinto three distinct corners.



(a) STAI-6 at three stages. (b) VRISE vs STAI.

Fig. 3: Results of the subjective evaluations in terms of the STAI (a) and the variation of STAI in relation to cybersickness (VRISE).

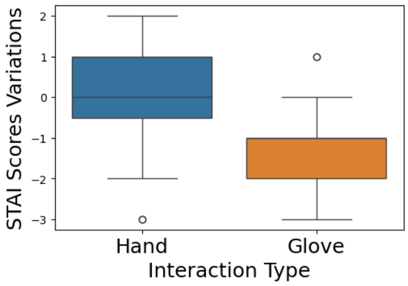


Fig. 4: STAI-6 change comparison with hand tracking and with the haptic glove.

analysis between the stress level and the STAI at the different evaluation points. From the baseline to the first evaluation point the correlation is 0.175. The correlation coefficient between stress Level and STAI-6 change from the first to the second evaluation is -0.291. Although mild to moderate, these correlations suggest that higher initial stress levels are slightly associated with smaller reductions in anxiety (or potentially increases in anxiety) from the first to the second evaluation, though again. This finding underscores the importance of accounting for individual variability in initial stress levels for the design and customization of VR based therapeutic environments.

Finally, we examined the effect of cybersickness on system effectiveness using a regression analysis between changes in cybersickness (VRISE) and anxiety (STAI-6) scores. Figure 3b shows that 25.8% of the variance in anxiety scores is explained by changes in cybersickness (R-squared: 0.258, p-value: 0.026). There is a negative association, indicating that higher cybersickness changes correlate with greater anxiety reduction, possibly due to the immersive VR experience diverting attention from pre-existing anxieties. This complex relationship highlights the need for further investigation to optimize VR-based therapies.

2) Haptic glove vs hand tracking: For the purpose of comparing the effects of haptic gloves and hand-tracking on anxiety reduction within this VE, we analyzed the variations in STAI-6 scores resulting from these interaction modalities. As depicted in Figure 4, the average decrease in STAI-6 scores by using haptic gloves were more pronounced at -1.21, compared to the moderate average reduction of -0.15 using the hand-tracking modality. A Wilcoxon signed-rank test was employed to assess the statistical significance of these observed differences. Anxiety reduction caused by interacting with the VE using haptic gloves significantly (p-value of 0.03) differs from the changes caused by hand-tracking. Therefore, it can be stated that incorporating haptic gloves boosts anxiety reduction in VRSRT, highlighting their considerable potential in enhancing therapeutic effectiveness.

IV. Conclusion

This paper has demonstrated the significant potential of haptic feedback gloves in VRSRT, specifically through a VRR, as a novel means for stress and anxiety reduction. The study involved 19 participants, which indicates promising trends. Extending the research to a larger participant pool and more extensive interaction can further validate and enhance these findings. Furthermore, the investigation into the impact of initial stress levels on the effectiveness of VR therapy has yielded insightful results, suggesting that individual stress profiles may influence therapeutic outcomes. Finally, our analysis of the relationship between cybersickness scores and anxiety reduction has revealed that despite an increase in cybersickness, anxiety levels continued to diminish.

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