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Preventing Post-Traumatic Intrusions using Virtual Reality

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Abstract. Post-Traumatic Stress Disorder (PTSD) research is of upmost importance given the high lifetime risk of experiencing a traumatic event. While there is a successful treatment protocol for PTSD, there can be delays in access and early interventions are lacking. Recent research has suggested that loading working memory with a visuo-spatial task immediately following a traumatic experience can reduce the frequency and development of intrusive trauma-related images. It was hypothesised here that completing a visuo-spatial task in virtual reality could enhance such interventions given its distinct attention-capturing ability. 30 non-clinical participants watched a traumatic film, then engaged in Tetris® on a desktop display, in virtual reality, or sat in silence (control condition). Participants kept a diary of intrusions experienced for the next 7 days. Participants in the virtual reality condition recorded significantly less intrusions over the 7 days than those in the no-task control condition. Using virtual reality was also rated as significantly more engaging than the desktop condition and had the secondary gain of significant post-task mood improvement. Although only initial findings, using virtual reality clearly has the potential to be both a more effective and a more appealing intrusion prevention technique following a trauma.

Keywords: Post-traumatic Stress Disorder; Virtual Reality; Immersive Virtual Environment; Distraction; Attention

1. Introduction

Post-Traumatic Stress Disorder (PTSD) is a classified psychiatric disorder [1]. Characteristic symptomology includes intrusions, avoidance and hyper-arousal. It can be diagnosed at least a month after a traumatic event [2] for which there is a high lifetime risk [3]. Whilst Cognitive Behavioural Therapy (CBT) is the recommended treatment for PTSD [2], the rate of treatment completion is as low as 8.5% and at one-month post-trauma over 95% of patients exhibit at least one barrier to CBT completion [4]. It is therefore imperative that alternative cost-effective interventions are explored.

Recent research has shown that psychological processing immediately after the trauma is critical [5]. Concerns have been raised about the use of early intervention techniques such as pharmacology [6] and debriefing [7]. Researchers have therefore begun to explore alternative early interventions to help minimise the development of PTSD symptoms [8]. The aim of the present research is to specifically reduce the number of intrusions that may occur. Intrusions are involuntary, multi-sensory, highly-detailed, mental images of the traumatic event [9]. Intrusion reduction is important because they are recurrent, distressing, central in a diagnosis of PTSD [2] and a precursor to development of the disorder [10].

Recent studies have demonstrated the efficacy of loading Working Memory (WM) to reduce intrusion development [11]. The WM model proposes that recent visual and spatial information is processed separately from verbal and semantic information, by the visuo-spatial sketchpad (VSSP) [12]. It is hypothesised that interfering with the processing of information held in WM reduces the likelihood this information will be subsequently stored in long-term memory. Given that intrusions are primarily visuo-spatial [13] it was hypothesised that loading the VSSP shortly after experiencing a 'trauma' would therefore reduce intrusions. Holmes *et al.,* had participants watch a traumatic film then either play Tetris® or sit quietly. Participants who had played Tetris® experienced fewer intrusions in the following week than the control condition [11]. The authors concluded that loading the VSSP may therefore be an effective means of reducing intrusions following trauma as hypothesised.

However, it is important to note that domain general distraction may have also played an important role in addition to domain specific effects. Concurrent visuo-spatial tasks often carry a memory load and have a sequencing component (as Tetris® does) [14], and such tasks demand domain general cognitive resources in addition to modality specific resources. The effects of interfering visuo-spatial tasks may reflect both a depletion of general-purpose and domain specific resources. It is therefore important to consider whether loading domain general attentional resources, in addition to the domain specific ones, may have a beneficial effect.

Virtual reality (VR) is a particularly attention-capturing medium [15] which places significant demands on domain general resources. When using VR participants interact with a computer generated world usually presented in a head-mounted display (HMD). This ability to divert attentional resources away from real-life experience has already been exploited as a clinical intervention for acute pain management for over a decade [15]. The study reported here therefore exploited this attention capturing quality of VR to investigate whether the combination of VR and a visuo-spatial task may be more effective than the visuo-spatial task in a less immersive medium (desktop-based), or no intervention at all. If so, then this would be indicative that the recruitment of domain general cognitive resources may provide an additional important benefit when attempting to prevent post-traumatic intrusions.

2. Materials and Method

Participants

Thirty participants completed the study, with 10 allocated randomly to each condition (12 males, 18 females; *M*age = 29.07 yrs; *SD*age = 14.50 yrs). Exclusion criteria included a history of treatment for psychiatric disorders, suffering from motion sickness, a heart condition or other serious medical condition, and pregnancy (or suspected pregnancy). Ethical approval was provided by York St John University

Design

A between participants randomised control trial (RCT) was used, with post-trauma concurrent task as the independent variable: no-task control; Tetris® desktop; and Tetris® VR. Participant experience of intrusive images was the main variable of inter-

est, measured through a diary and a standardized self-report measure. Task engagement was measured in the two intervention conditions as a dependent variable. Additional control measures were also taken (see below).

Materials and procedure

Prior to the experiment participants completed self-report measures to indicate current levels of anxiety and depression, proneness to fainting, blood phobia and previous experience of traumatic events. Once initial measures were completed, participants watched a trauma-film as an experimental equivalent of a traumatic experience [16]. The content reflected that used in previous research [11, 17], with some identical scenes including the road traffic accidents, surgery and blood loss. A 20 minute filler task was then completed to reflect the likely delay in commencing an intervention after a trauma [8]. To ensure consistency with previous research [11, 17] a brief reminder of the film was shown to participants prior to intervention.

Participants were assigned to the no-task control, Tetris® desktop or Tetris® VR condition randomly. Participants were instructed to: sit in silence and not touch anything (no task control); play Tetris® on a desktop computer; or play a Tetris® equivalent (BlockOut Rift [18]) using a HMD, the Oculus Rift Development Kit 2. Each task lasted for 10 minutes

Mood was measured pre-film, post-film and after the task using visual analogue scales (VAS), to ensure equivalent mood change across conditions. Following completion of the task, participants also rated task compliance on a VAS. Participants in the intervention conditions also rated enjoyment and difficulty of the tasks. Additionally, they rated how engaged they felt with the task on a VAS. This provided a measurement of how much attention was engaged with the task and therefore an indication of how much the task distracted from processing of the trauma film images.

In line with previous research [11, 17], participants kept a daily diary of intrusions experienced for the seven days which followed. They also rated how accurately they were able to record their intrusions on a VAS and completed the intrusion subscale from the impact of event scale revised (IESr) [19].

3. Results

Preliminary analyses indicated there were no baseline differences between the groups in terms of age, symptoms of anxiety, depressive symptoms, number of previous traumatic experiences, blood phobia, proneness to fainting or gaming frequency ($p>.05$). These analyses indicate that any significant differences found across conditions are unlikely to be confounded by these variables.

There was a significant deterioration of mood following the trauma film $F(2, 27)=8.17$, $p=.008$, but a significant interaction was not found between this change in mood and condition ($p>.05$). Following completion of the 10 minute task, participants again rated their mood. On the basis of previous literature it was predicted that post-task mood would be equivalent across conditions; contrary to expectations there was a significant difference according to the intervention $F(2, 27) = 3.46$, $p =.042$, $\eta^2=.17$). Post-hoc tests showed a significant difference between the no-task control condition and the VR condition ($p=.008$), no significant differences were found between the

Tetris® condition and the other conditions (p>.05). A large effect size was found for the difference in post-task mood between the no-task and VR conditions (d = 1.62), suggesting engaging in a VR game significantly improves mood following a trauma when compared to not engaging in a task.

Task compliance was rated as equivalent across the three conditions (p>.05). Participants in the Tetris® conditions additionally rated task difficulty and enjoyment, these results were not significantly different across the conditions (p>.05), providing assurances that neither difficulty nor enjoyment differed between these two interventions.

Task engagement was rated by participants in the Tetris® conditions, it was found to be significantly different (t(18) = -3.22; p = .005; d = -1.44), suggesting any differences found for the number of intrusions experienced may due to the level of engagement with the task and thereby the ability of the task to distract from processing of the intrusive images. Participants reported being more engaged with the Tetris® VR condition then the Tetris® desktop condition.

Intrusive images

The key dependent variable was the number of intrusions experienced in the seven days following the experiment. Primary analyses found no significant differences across conditions for scores on the IESr scale (p>.05). However, the number of intrusions recorded in diaries in the seven days after viewing the trauma film were significantly different across conditions F(2, 27) = 7.27, p=.003, η^2=.16. Post-hoc tests indicated a significant difference between the no-task condition and Tetris® VR condition (p=.002). Participants in the Tetris® VR condition reported a lower number of intrusions (*M*=1.7) compared to the control condition (*M*=6.8). No significant differences were found between the Tetris® desktop condition and the other conditions (p>.05).

Supplementary analyses investigated differences in the number of intrusions across the seven days. A significant difference in the number of intrusions experienced over time was found (F(6,162) = 32.51; p <.001); time and condition significantly interacted (F(12,162 = 4.59; p = .001) suggesting intrusions reduced at different rates across conditions. These results need to be interpreted with caution as variance in each condition was not equivalent. Follow-up tests were completed to look into the pattern of intrusions experienced. A significant difference in the number of intrusions reported on day one and day two was found (day one p=.004; day two p = .017), differences in intrusions experienced across the other days was not significant (p>.05).

The difference in intrusions experienced across conditions on day one was large (η^2=.34) with a slightly smaller effect size found for day two (η^2=.26). Post-hoc tests showed the significant differences were between the no-task control condition and the Tetris® VR condition, with a large effect size on day one (d = 1.68) and day two (d = 1.67); there were no significant differences between desktop Tetris® and the other conditions (p>.05). The results suggest engaging in a VR game shortly after experiencing a trauma significantly lowers the number of intrusions experienced in the following two days, compared to not completing a task. A significant difference was not found across the other days (p>.05), the number of intrusions experienced in all conditions on these days was very low (less than 1) implying a floor effect.

A final analysis confirmed participants' compliance with completion of the intrusion diary did not significantly differ across conditions (p>.05).

4. Discussion

The purpose of this research was to investigate whether delivering a visuo-spatial task using VR would reduce the number of intrusions experienced post-trauma. Participants that played Tetris® using VR recorded less intrusions, particularly across day one and day two, reported being more engaged with the medium, and reported improved mood after the task. The Tetris® VR condition was therefore an efficient clinical distractor in comparison to the control condition. The results have important clinical implications since it has been shown that the more intrusions experienced within a day of a traumatic experience, the greater the likelihood of developing PTSD [20]. These results imply VR has the potential to reduce the later development of clinical symptoms.

Contrary to expectations, using VR was not shown to be more effective than Tetris® played through a desktop. The low number of participants per condition (n=10) and high variance within the number of intrusions may go some way to explain the null findings. Given this limitation it is not possible to definitively conclude whether domain-specific or domain-general resource interference in WM is the key to intrusion prevention; the finding that VR performed significantly better than the no-task control but desktop Tetris® did not, does suggest that optimising domain-general distraction may be crucial. Nevertheless, further research is clearly needed.

Unlike in previous research post-task mood and number of intrusions experienced were different across the VR and no-task conditions. Post-task mood did not differ in similar research that utilised a desktop version of Tetris® and no-task control condition [cf. 11, 17] implying VR is a medium capable of improving mood following a laboratory-presented trauma. Improvement in mood was also commensurate with increased engagement when using VR [21].

Conclusions

This study has extended the use of VR to intrusion prevention following a trauma. VR was found to significantly reduce the number of intrusions in the seven days following a trauma-film relative to a no-task control condition. Small sample size and high variance within experimental conditions limit the conclusions that can be drawn here. However VR was shown to be significantly more engaging than the desktop Tetris® and was the only intervention condition shown to have a significant advantage over the no-task control group. These findings provide some support for the suggestion that additionally engaging domain-general cognitive resources to a large extent may contribute significantly to intrusion reduction.

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