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Degrading emotional memories induced by a virtual reality paradigm

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ABSTRACT

Background and objectives: In Eye Movement and Desensitization and Reprocessing (EMDR) therapy, a dual-task approach is used: patients make horizontal eye movements while they recall aversive memories. Studies showed that this reduces memory vividness and/or emotionality. A strong explanation is provided by working memory theory, which suggests that other taxing dual-tasks are also effective. Experiment 1 tested whether a visuospatial task which was carried out while participants were blindfolded taxes working memory. Experiment 2 tested whether this task degrades negative memories induced by a virtual reality (VR) paradigm.

Methods: In experiment 1, participants responded to auditory cues with or without simultaneously carrying out the visuospatial task. In experiment 2, participants recalled negative memories induced by a VR paradigm. The experimental group simultaneously carried out the visuospatial task, and a control group merely recalled the memories. Changes in self-rated memory vividness and emotionality were measured.

Results: The slowing down of reaction times due to the visuospatial task indicated that its cognitive load was greater than the load of the eye movements task in previous studies. The task also led to reductions in emotionality (but not vividness) of memories induced by the VR paradigm.

Limitations: Weaknesses are that only males were tested in experiment 1, and the effectiveness of the VR fear/trauma induction was not assessed with ratings of mood or intrusions in experiment 2.

Conclusions: The results suggest that the visuospatial task may be applicable in clinical settings, and the VR paradigm may provide a useful method of inducing negative memories.

1. Introduction

In the late eighties, Francine Shapiro introduced a new therapy for post-traumatic stress disorder (PTSD) called eye movement desensitization and reprocessing (EMDR; Shapiro, 1989a, 1989b). One of the key components of the protocol, which is unique to EMDR, is a dual-task approach: the patient holds the traumatic memory in mind while making eye movements by simultaneously tracking the therapist's finger as it moves horizontally across the patient's visual field (Shapiro, 2001). Because EMDR also shares many components with well-established interventions, and there was no strong rationale for using eye movements, skeptics suggested that the eye movements component was unnecessary (see Engelhard, 2012). However, a recent meta-analysis has shown that the addition of eye movements leads to superior results (Lee & Cuijpers, 2013).

Various theories were put forward to explain the effects of eye movements in EMDR. For instance, Christman, Garvey, Propper, and Phaneuf (2003) proposed that horizontal eye movements enhance the ability to retrieve memories of traumatic events due to increased interhemispheric interaction, which may enhance effects of techniques such as exposure. A growing body of research, however, indicates that horizontal eye movements do not improve free recall performance (Matzke et al., 2015). Moreover, Gunter and Bodner (2008) found that vertical eye movements were as effective as horizontal eye movements; both led to an equal decrease in vividness and emotionality of memories. Another theory came from Stickgold (2002), who argued that the repetitive redirecting of attention in EMDR induces a neurobiological state that is similar to that of rapid eye movement (REM) sleep. REM sleep seems to be optimally configured to support the integration of traumatic memories into general semantic networks (Stickgold, 2002, 2008). However, as Pitman et al. (1996) mentioned, there is a lack of phenomenological correspondence between the rhythmic eye movements induced by EMDR and the spontaneous, arrhythmic, non-saccadic eye movements that occur during REM sleep.

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Gunter and Bodner (2008) also put another hypothesis to the test derived from working memory (WM) theory. Andrade, Kavanagh, and Baddeley (1997) hypothesized that both making eye movements and keeping a visual image in mind tax the visuospatial sketchpad (VSSP) of WM, which leads to a reduction of the vividness and emotionality of the image. In contrast to this VSSP version of the WM account, Gunter and Bodner (2008) argued that eye movements are effective because they tax the limited capacity of the central executive (CE). These two WM accounts are not incompatible. Research showed that eye movements work better for visual emotional memories and an auditory dual-task works better for auditory memories; yet these modality-specific effects of dual-tasks are superimposed on general effects (Kemps & Tiggemann, 2007; but see Tadmor, McNally, & Engelhard, 2015). The WM account is substantiated by studies that showed that tasks other than eye movements, such as copying the Rey complex figure (Gunter & Bodner, 2008), attentional breathing (van den Hout et al., 2011a) and playing the computergame Tetris (Engelhard, van Uijen, & van den Hout, 2010) are effective as well. Although multiple mechanisms may underlie the effects of eye movements in EMDR (Leeds & Korn, 2012), the WM account provides a solid explanation of the effectiveness of other tasks.

The experiments in which effects of 'recall with dual-tasking' are compared with 'recall only', serve as laboratory models of therapy procedures like EMDR. The recalled memories in these experiments are typically aversive and autobiographical (van den Hout & Engelhard, 2012). The use of autobiographical memories may enhance the ecological validity of inferences, but an obvious disadvantage is that the nature of the recalled memories is not under experimental control and may differ substantially between participants. The use of 'trauma films' relating to e.g. traffic accidents (Holmes & Bourne, 2008) may provide an alternative, but a drawback seems to be that watching film clips is a somewhat passive endeavor and lacks active behavioral engagement. Therefore, in the present study, we explored the utility of a VR paradigm in which participants had to navigate through an immersive VR environment by using a button hand controller. This environment was interactive, as it responded to both the participants' viewing directions and their button input.

In recall with dual-tasking vs. recall only studies, the dual-task most often used consists of eye movements (van den Hout & Engelhard, 2012). Here, we explored the utility of using a non-visual task on VR-induced memories instead of eye movements for two reasons. First, given that the recall with dual-task paradigm serves as an experimental model, it would be worthwhile to have a task that could be used not only during memory recall, but also during exposure to visual reminders of the memorized events. Furthermore, adding non-visual tasks to the library of suitable tasks allows patients with limited or no eyesight to benefit from EMDR therapy as well; the commonly used auditory task in EMDR is far less effective than eye movements, as it requires less concentration and no motor operations (van den Hout & Engelhard, 2012; van den Hout et al., 2011b). We expected that the non-visual task would tax WM, making it useful for the practice of EMDR. Experiment 1 tested whether the task indeed taxes WM. Experiment 2 tested whether the task also reduces vividness and emotionality of emotional memories. We used a VR paradigm to induce negative memories in healthy participants, and compared the influence of the dual-task intervention on the vividness and emotionality of these negative memories to that of recall only.

2. Experiment 1

2.1. Introduction

The non-visual task was a shape sorter task that had to be carried out while being blindfolded. A very similar visuospatial task – shaping plasticine into small cubes and pyramids as fast as possible while the hands are covered with a box – reduced memory vividness and emotionality, as well as intrusion frequency in a previous study (Krans, Näring, Holmes, & Becker, 2010). We tested whether the shape sorter task taxes WM by means of a Reaction Time (RT) task in which participants had to respond to auditory cues. The performance on this task alone was compared to the performance on both tasks simultaneously (WM taxing: single-task vs. dual-task). A slowing down of RTs due to dual-task processing indicates the presence and severity of WM taxing by the shape sorter task (Bower & Clapper, 1989; see also van den Hout & Engelhard, 2012). Because haptic processing of peripersonal space comprises several attention-demanding components, such as identifying the nature of objects (Baddeley, 2001; 2012; Postma, Zuidhoek, Noordzij, & Kappers, 2007), we expected dual-task processing to result in higher RTs.

2.2. Method

2.2.1. Participants

Twenty male coworkers of a Dutch company (Triple IT) participated. One participant's data were excluded from the analysis, because he finished the shape sorter task before the RT task was over. The mean age of the remaining 19 participants was 28.8 years (range 22–45; *SD* = 6.5).

2.2.2. Tasks

2.2.2.1. Random interval repetition (RIR) task. Participants were blindfolded and wearing headphones, and received auditory cues (beeps; 200 Hz) with varying intervals (850 and 1450 ms). They were asked to respond as fast as possible when they heard a beep, by pressing a foot pedal with their right foot. The task contained 20 practice trials followed by 40 experimental trials. RTs below 200 ms were not registered, and responses exceeding 2000 ms were recorded as misses. The RIR provides a valid measure of WM taxation (Vandierendonck, De Vooght, & Van der Goten, 1998; see also van den Hout & Engelhard, 2012).

2.2.2.2. Shape sorter task. A shape box was positioned in front of the participants. The box (150 × 150 × 150 mm) had holes on 4 sides, of which only the front-(4 holes) and topside (3 holes) were used in the experiment. Seven different figures lied in front of the box, and each matched a different hole in the box. Participants were instructed to try to put these figures into the matching holes with their hands. The experimenter stressed that it was important to carefully explore the holes and figures before trying to match them, instead of trying to push the figures through every hole until a match is found. We expected this to lead to greater VSSP taxing, because participants had to identify the nature of the figures and create a conscious image of where objects were.

2.2.3. Procedure

After receiving the task instructions and signing the consent form, participants sat down behind a desk. They were asked to take off their right shoe and place their foot on the foot pedal underneath the desk. When a comfortable position was found, they were blindfolded by a head-mounted display (HMD), so that they would keep their eyes open, and were given headphones to put over their ears. Next, half of the participants (randomly assigned) first carried out the RIR task without the shape sorter task and then carried out both tasks simultaneously. The other half did this in reverse order. After these tasks, participants were debriefed.