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Visuospatial working memory interference with recollections of trauma

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Objectives. Laboratory research using a working memory framework has shown modality-specific reductions in image vividness and emotionality when concurrent tasks are performed while maintaining the image in consciousness. We extended this research to trauma images in a clinical population awaiting treatment for post-traumatic stress symptoms.

Design. A within-subjects design was used, with each participant completing an imagery task under three concurrent task conditions: side-to-side eye-movements, counting, and exposure only (no concurrent task).

Methods. Eighteen participants selected three images each, the images being those that were the most distressing from participants' trauma memories and most likely to intrude involuntarily. Participants gave baseline ratings of the vividness and emotionality of each of their trauma images. Each image was assigned to a condition. Each condition comprised 8 trials in which participants recollected the appropriate image for 8 s while performing eye-movements, counting or no concurrent task, and then rated its vividness and emotionality. Follow-up ratings were obtained by telephone 1 week later.

Results. The eye-movement task reduced vividness and emotionality of the trauma images relative to the counting task and exposure only, but did so only during the imagery period and not at follow-up. The images were predominantly visual.

Conclusions. Concurrent tasks matched to the modality of trauma images may provide a useful treatment aid for temporarily dampening emotional responses to recollections of trauma.

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Previous research with non-clinical populations shows that visuospatial tasks (e.g. side-to-side eye-movements) temporarily reduce the intensity of emotive images and memories (Andrade, Kavanagh, & Baddeley, 1997; Kavanagh, Freese, Andrade, & May, 2001; Kemps & Tiggemann, 2007; van den Hout, Muris, Salemink, & Kindt, 2001), a finding that may have clinical benefits for treating disorders where intrusive images are problematic. The present study extends these findings to a clinical population awaiting treatment for symptoms consistent with post-traumatic stress disorder (PTSD).

Andrade and colleagues argued that the vividness of recollections is determined in part by the availability of modality-specific working memory resources for maintaining and manipulating information from long-term memory (Andrade *et al.*, 1997; Baddeley & Andrade, 2000). Working memory refers to the system or mechanism underlying the maintenance of task-relevant information during the performance of a cognitive task (Baddeley & Hitch, 1974). The working memory model (Baddeley, 1986; Baddeley & Hitch, 1974) comprises a limited-capacity attentional control system, called the central executive, and limited-capacity slave systems. Of these slave systems, the visuospatial sketchpad (VSSP) is assumed to maintain and manipulate visual information and to be involved in visual imagery, whereas the phonological loop (PL) performs a similar function for auditory and verbal material. The episodic buffer (Baddeley, 2000) temporarily stores multimodal representations and serves as an interface with long-term memory. Research to test this model has used the dual-task interference paradigm, testing whether performance on a primary cognitive task is disrupted by the demands of a concurrent secondary task. Using this technique, Baddeley and Andrade (2000) showed that concurrent verbal tasks reduced the vividness of auditory images relative to visual images, whereas concurrent visual or spatial tasks selectively reduced the vividness of visual images. They interpreted these data as support for PL involvement in auditory imagery and VSSP involvement in visual imagery.

Andrade *et al.* (1997) replicated these findings with emotional images, including images of negatively valenced photographs and recollections of emotive autobiographical memories. Participants were shown a photograph or given a verbal cue for a pre-selected memory. They imaged that photograph or memory for a short period while carrying out a concurrent task, then rated the vividness and emotionality of their image. Pattern tapping and side-to-side eye-movements reduced emotionality as well as vividness of the images. A concurrent verbal task had no effect on ratings of vividness or emotionality of images of photographs (Experiment 2), but the effect of verbal interference on autobiographical recollections was not tested. The finding of reduced vividness and emotionality of recollections with concurrent eye-movements has been replicated by van den Hout *et al.* (2001) and by Kavanagh *et al.* (2001) using a paradigm in which participants underwent repeated periods of generating an image, performing the concurrent task, and then rating the image. This paradigm was designed to mimic repeated imagery as evoked in imaginal exposure treatments, and resulted in larger effects of eye-movements than those observed by Andrade *et al.* (1997) and van den Hout *et al.* (2001). Kavanagh *et al.* (2001) and van den Hout *et al.* (2001) speculated that side-to-side eye-movements may be a useful response aid during treatment of PTSD, reducing vividness sufficiently for clients to recall otherwise unbearable memories of trauma.

Eye-movements have been used clinically in the form of eye-movement desensitization and reprocessing (EMDR; Shapiro, 1989, 1995). Bold claims were made initially about the efficacy of EMDR (Shapiro, 1995) but these early claims have not been substantiated by subsequent research – while EMDR is a recommended treatment for PTSD (National Institute for Health and Clinical Excellence, 2005), there is no evidence that EMDR is more effective than standard cognitive behavioural treatments (e.g. Seidler & Wagner, 2006). Testing the much subtler hypothesis that eye-movements may help make treatment for PTSD more tolerable for clients with extremely distressing and uncontrollable memories will require carefully designed, large scale studies. Two questions must be addressed before investing such effort: is the visuospatial nature of eye-movement critical for effects on emotive imagery, as predicted by the working memory explanation, and do the findings observed in non-clinical populations with relatively mildly emotive memories translate to a clinical population who have experienced a traumatic event? The present study sought to answer these questions.

Key to the working memory explanation of eye-movement effects on emotive imagery is the observation that a visuospatial task reduces vividness and emotionality of visual memories and images more than a verbal task loading the PL. Only three experiments have directly compared eye-movements with verbal interference, all using undergraduate samples. One required participants to image newspaper photographs rather than autobiographical memories (Andrade *et al.*, 1997, Experiment 2). The second did use autobiographical memories, and confirmed that eye-movements selectively reduced the vividness and emotionality of visual images whereas concurrent articulation selectively impacted on auditory images (Kemps & Tiggeman, 2007, Experiment 2). This is a critical finding – failure to replicate it would refute the working memory framework for this area of research. A recent finding, that eye-movements and auditory shadowing had similar effects on autobiographical imagery and a complex visual task had a larger effect, suggests an explanation in terms of general or executive resource loads instead, but 'does not does not completely rule out the possibility that some of the benefit is due to taxing the VSSP' (Gunter & Bodner, 2008). van den Hout *et al.* (2001) argued that another problem for the working memory explanation is the longevity of eye-movement effects; in their study, reductions in vividness and emotionality persisted into the period immediately after the eye-movement task, a finding that is hard to interpret within the working memory framework. The present study addresses this continued controversy.

In terms of whether the findings observed in non-clinical populations will translate to a clinical population, there are two reasons for suspecting that eye-movements might not affect traumatic images. First, it may be much harder to influence responses to highly distressing memories than to the milder memories used in previous non-clinical studies. Second, memories of trauma in PTSD may be qualitatively different from non-pathological memories (e.g. Ehlers, Hackmann, & Michael, 2004; Hackmann, Ehlers, Speckens, & Clark, 2004). As reviewed by Holmes and Bourne (2008) several authors in the area of PTSD (Brewin, Dalgleish, & Joseph, 1996; Ehlers & Clark, 2000; Conway & Pleydell-Pearce, 2000) converge on a distinction between ordinary verbal/conceptual memories that permit controlled recollection, and sensori-perceptual memories that are predominantly visual images, unprocessed, emotional and uncontrollable, liable to intrude into everyday activities. Flashbacks, that are often symptomatic of PTSD, are thought to reflect the activation of sensori-perceptual memories. Concurrent visuo-spatial tasks can impede the development of visual images, thus reducing subsequent intrusions of distressing material (Holmes, Brewin, & Hennessy, 2004; Stuart, Holmes, & Brewin, 2006). However, the effects of concurrent tasks on conscious recollection of this type of memory are unknown.

The present study tested the effects of visuospatial interference, relative to verbal interference, on the vividness and emotionality of traumatic memories (i.e. intrusive images) in a clinical sample screened for PTSD symptomatology based on the 17 symptoms of the Diagnostic and Statistical Manual for Mental Disorders (DSM-IV, American Psychiatric Association [APA], 1994). The study included a 1 week telephone follow-up assessment of vividness and emotionality intended to test the longevity of any concurrent task effects. Previous clinical research with a PTSD sample indicates a mean number of 4.1 intrusive images with different content ($SD = 2.4$; Holmes, Grey & Young, 2005). We therefore developed a within-subjects design in which clients identified three separate images related to the same traumatic event, one for each concurrent task condition. Related designs have been used previously in the empirical literature (e.g. Kavanagh *et al.*, 2001; Stuart *et al.*, 2006; van den Hout *et al.*, 2001).

In addition to their relevance to the controversy about EMDR, we chose side-to-side eye-movements for the visuospatial task because eye-movements tend to have larger effects on visuospatial short-term memory (Pearson & Sahraie, 2003) and imagery (Andrade *et al.*, 1997) than other spatial or visual interference tasks. This observation is explicable in terms of eye-movements incorporating visual interference (rapidly changing visual input as the eyes move across the scene) and spatio-motor interference (controlling the movement of the eyes from side to side), whereas most other tasks of this type are predominantly spatial (pattern tapping) or visual (irrelevant pictures or dynamic visual noise, Quinn & McConnell, 1996) but not both.

Method

Design

The study employed a within-subjects design, based on that used by Kavanagh *et al.* (2001) in a non-clinical population. Each of three images, related to the same traumatic event, was allocated to one of three concurrent task conditions: eye-movements (visuospatial task), counting (verbal task), and a control task (exposure only). Each task condition comprised a block of eight imagery trials. The order of task conditions was counterbalanced across participants using a Latin square. The allocation of images to the task conditions was also counterbalanced using initial ratings of emotionality. This ensured that the 'worst' image was not always the subject of the first task. The dependent variables were the rated vividness and emotionality of the image after each exposure trial.

Participants

Twenty-five adult patients referred to a clinical psychology service were identified as potential participants due to the referral letters requesting assessment and treatment for posttraumatic stress symptoms following an index trauma. As part of routine care, each patient was subsequently assessed by an experienced clinician and was judged to have symptoms consistent with a diagnosis of PTSD, and placed on a waiting list for PTSD treatment. While on the PTSD service's waiting list, all of these identified patients completed the post-traumatic stress diagnostic scale (PDS; Foa, 1995). The PDS is a 49-item self-report questionnaire based on the 17 DSM-IV symptoms (APA, 1994). The diagnostic criteria of PTSD was based on exposure to a traumatic event, ratings of onset and duration, and the number of symptoms endorsed with the three symptoms clusters of re-experiencing/intrusiveness, avoidance, and arousal. Each item within the three clusters is scored from 0 to 3, with higher scores indicating greater symptomatology. The psychometric properties of the PDS are good, with a Cronbach's $\alpha = .91$. The PDS has been shown to have strong convergent validity (i.e. 82% predictive power; Foa, Riggs, Dancu, & Rothbaum, 1993) with PTSD diagnosis on the Structured Clinical Interview for DSM-II-R (Spitzer, Williams, & Gibbon, 1987).

Eighteen patients gave their consent to take part and were included in the main study (11 male and 7 female). These participants ranged in age from 22 to 69 years ($M = 41$), and time since trauma ranged from 18 to 348 months ($M = 109$). All reported experiencing distressing, intrusive images to an index traumatic event. The types of trauma experienced by the sample were as follows: road traffic accident, $N = 6$ (33.3%); military, $N = 4$ (22.2%); sexual assault/abuse, $N = 2$ (11.1%); physical assault/abuse, $N = 2$ (11.1%); destructive event (e.g. fire), $N = 1$ (5.6%); medical event (e.g. traumatic birth), $N = 1$ (5.6%); illness-related, $N = 1$ (5.6%); and other (e.g. traumatic bereavement), $N = 1$ (5.6%). Examples of patients' intrusive traumatic images included seeing the face of the driver before car impact, hearing screams, the sound and sight of an explosion. The participants' mean symptom severity score on the PDS was 34.6 (maximum 51; $SD = 10.8$) and the mean number of symptoms endorsed was 14.8 (maximum 17; $SD = 2.4$). Both means fell within the severe category according to the PDS manual (Foa *et al.*, 1993). The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) was also administered. The HADS is a 14-item self-report questionnaire designed to provide a brief state measure of both anxiety and depression. Each item is scored from 0 to 3, with higher scores indicating higher levels of anxiety and depression. Scores from 8 to 10 on each scale have been taken to indicate possible clinical disorder and from 11 to 21 to indicate probable clinical disorder. Both anxiety (16.0; $SD = 4.3$) and depression (11.2; $SD = 4.3$) scores for participants in this present study fell within the 'probable clinical disorder' range (Zigmond & Snaith, 1983, p. 8).

Apparatus and materials

Using similar methodology to Andrade *et al.* (1997) and Kavanagh *et al.* (2001), eye-movements were generated by asking participants to attend to a letter (in bold type, 4 mm in height) that flashed up for 200 ms on alternate sides of a 30 cm computer screen. This 'flashing letter' had an inter-stimulus interval of 200 ms and a subtended angle of approximately 30°. Alternate presentations of the letter were 25 cm apart. The viewing distance was 30 cm from the screen.

Procedure

The study was approved by the North Nottinghamshire Research Ethics Committee. Participants giving informed consent met individually with the main investigator. During this initial meeting, the investigator provided more detail on the three task conditions, established rapport, and elicited from the participant descriptions of three separate intrusive images from a traumatic event they had experienced. Participants were asked to identify those images that intruded involuntarily and represented the most distressing parts of the memory for the event, i.e. their traumatic hotspots (Ehlers & Clark, 2000; Grey & Holmes, 2008). Once the three separate images were identified, participants were asked to bring each to mind and rate each image for level of distress ('emotionality'), using a visually presented scale anchored with

0 (no disturbance/neutral) to 10 (most distressing). This initial emotionality rating was used to ascertain the order of the images in the experimental session. Participants were then asked to make a judgment on the predominant modality of each image (visual, auditory, somatic/tactile, olfactory, gustatory), by estimating the proportion of each modality for each image, as a percentage.

Another session was arranged approximately 1 week after the initial meeting. This second individual meeting represented the experimental session in which the tasks were to be performed. This session lasted approximately 45–60 min for each participant. Participants were first asked to bring to mind each of the three images that were elicited in the previous session. If required, cue words that were agreed in the first session were used to facilitate recall of the images. For each image, they were asked to rate its vividness, using a visually presented scale anchored with 0 (no image at all) to 10 (perfectly clear), and to use the emotionality scale introduced in the first session to rate the level of distress. These represented baseline ratings.

The concurrent task conditions were: eye-movement condition, in which participants were asked to keep their head still and follow the alternating letter on the computer screen with their eyes while maintaining the image and emotion, (2) counting condition, in which participants were asked to count aloud (from one upwards) as quickly as they could while maintaining the image and emotion, and (3) the control (exposure only) condition, in which participants were asked to fixate their gaze on a spot in the centre of the computer screen while maintaining the image and emotion. At the beginning of the first task condition, the participant was asked to form the image already selected for that condition (and feel the associated emotion) and begin performing the first trial of the task while maintaining the image in mind. Each trial was 8 s in length. After 8 s of performing the task while holding the image in mind, the investigator asked the participant to stop and to re-rate vividness and emotionality using the same visually presented scales. Immediately after ratings were obtained, participants were asked to form and maintain the same image and emotion again and to perform the next 8 s trial, and so on until all eight trials of that task had been performed. The participant then entered immediately into the next task condition using the same procedure. This was the same procedure used in other studies (Andrade *et al.*, 1997; Kavanagh *et al.*, 2001). The experimental session ended after all three tasks conditions were completed and all ratings obtained. A follow-up telephone appointment was arranged 1 week after the experimental session. Participants were asked over the telephone to bring each image to mind once and to rate its vividness and emotionality. These data represented follow-up ratings.

Results

The results were analysed using the Statistical Package for the Social Sciences (SPSS 12.0.1).

Modality of images

Table 1 shows the mean proportion of each sensory modality for the images in each condition. For 14 of the 18 participants, at least two of the three selected images were predominantly visual. For the group as a whole, 67% of images were predominantly visual. The modalities relevant to the experimental tasks were analyzed by

3 (task conditions) × 2 (visual or auditory modality) repeated measures ANOVA, which confirmed that images were more visual than auditory ($F_{1,17} = 51.14$, $p < .001$) and that there was no difference across task conditions in the extent to which images were in visual and auditory rather than other modalities ($F_{2,34} = 0.51$, $p = .60$). There was no interaction between task condition and modality ($F_{2,17} = 0.22$, $p = .80$). Thus, the images were predominantly visual and the extent to which they were visual was equivalent for each image assigned to the different tasks.

Table 1. Mean rated (%) modality of the images allocated to conditions (standard deviations in parentheses)

	Visual (See %)	Auditory (Hear %)	Olfactory (Smell %)	Gustatory (Taste %)	Somatic (Feel %)
Exposure only	70.6 (33.6)	14.2 (24.2)	0.0 (0.0)	0.0 (0.0)	15.0 (26.8)
Counting	66.9 (34.7)	23.3 (28.1)	7.1 (23.7)	0.4 (1.8)	2.2 (7.1)
Eye-movement	65.3 (35.1)	16.9 (27.7)	12.8 (24.4)	0.6 (2.4)	4.4 (8.7)

Vividness

Table 2 shows mean vividness and emotionality ratings at baseline, during the experimental period, and at telephone follow-up for images in the three conditions. A three-way repeated measures ANOVA showed main effects of task condition ($F_{2,34} = 7.52$, $p = .002$) and time ($F_{9,153} = 15.57$, $p < .001$, with epsilon correction), and a significant time by condition interaction ($F_{18,306} = 2.30$, $p = .03$, with epsilon correction; Figure 1). This interaction was explored further as follows. Effects at baseline and follow-up were tested in a 3 (condition) × 2 (baseline vs. follow-up) repeated measures ANOVA, which confirmed that image vividness was matched across conditions ($F_{2,34} = 0.64$, $p = .54$) and showed no change in vividness from baseline to follow-up ($F_{1,17} = 2.00$, $p = .18$, with epsilon correction). The interaction was not significant ($F_{2,34} = 0.72$, $p = .49$, with epsilon correction), suggesting no differential effect of condition on ratings at follow-up. Effects of the experimental tasks on vividness were tested by calculating the difference between baseline ratings and mean ratings across the eight experimental trials. A one-way repeated measures ANOVA of these change scores showed a marginal effect of condition ($F_{2,34} = 2.95$, $p = .07$). Paired one-tailed

Table 2. Mean vividness and emotionality ratings across the three conditions (standard deviations in parentheses)

		Mean ratings		
Measure	Condition	Baseline	Eight trials	Follow-up
Vividness	Exposure only	8.56 (1.9)	7.35 (2.3)	8.00 (1.7)
	Counting	8.22 (2.7)	6.63 (2.8)	7.17 (2.5)
	Eye movements	7.94 (2.4)	4.46 (2.8)	7.61 (2.5)
Emotionality	Exposure only	7.67 (2.8)	6.12 (2.6)	6.22 (3.0)
	Counting	7.17 (3.2)	6.70 (2.8)	5.55 (3.2)
	Eye movements	6.89 (2.9)	3.67 (2.8)	6.22 (3.0)

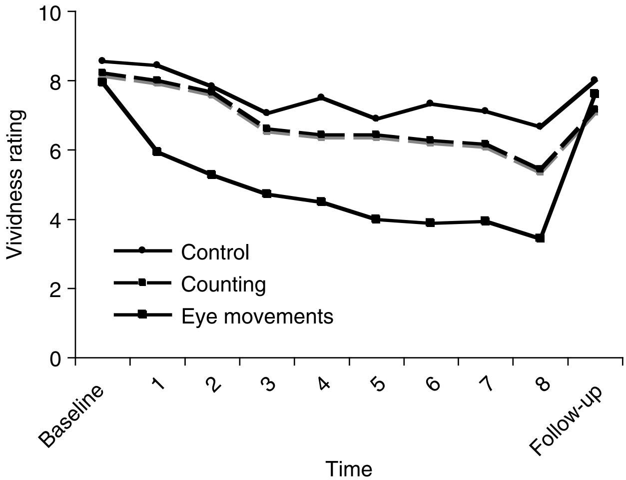

Figure 1. Change in vividness of memories over time, by condition.

t tests confirmed the predicted reduction in vividness with concurrent eye-movements relative to concurrent counting ($t_{17} = 2.21$, $p = .02$) or the no-task control condition ($t_{17} = 2.15$, $p = .02$). Change scores in the counting and control conditions did not differ ($t_{17} = 0.36$, $p = .72$). To check for variations in effects of condition over time, vividness ratings for the eight experimental trials were subjected to a 3 (condition) × 8 (time) repeated measures ANOVA. This analysis showed reduced vividness over time ($F_{7,119} = 14.57$, $p < .001$, with epsilon correction) and confirmed the effect of condition, ($F_{2,34} = 7.61$, $p = .002$, with epsilon correction). The interaction was not significant, ($F_{14,238} = 0.57$, $p = 0.72$, with epsilon correction), indicating consistent effects of condition on vividness over the experimental trials.

Emotionality

The emotionality data showed a similar pattern to the vividness data. A three-way repeated measures ANOVA showed main effects of task condition ($F_{2,34} = 6.61$, $p = .004$) and time ($F_{9,153} = 13.76, p < .001$, with epsilon correction), and a significant time by condition interaction ($F_{18,306} = 2.37$, $p = .03$, with epsilon correction; Figure 2). This interaction was explored as before. Effects at baseline and follow-up were tested in a 3 (condition) × 2 (baseline vs. follow-up) repeated measures ANOVA, which confirmed that emotionality of images was matched across conditions ($F_{2,34} = 0.45$, $p = .64$). In contrast to the vividness ratings, the emotionality ratings showed a marginally significant decrease from baseline to follow-up ($F_{1,17} = 4.32, p = .053$, with epsilon correction), suggesting some desensitization to the images. The interaction was not significant ($F_{2,34} = 1.18$, $p = .32$, with epsilon correction), again suggesting no lasting effect of the experimental conditions on the follow-up ratings. Effects of the experimental tasks on emotionality were tested by calculating the difference between baseline ratings and mean ratings across the eight experimental trials. A one-way repeated measures ANOVA of these change scores showed an effect of condition ($F_{2,34} = 5.18$, $p = .01$). Paired one-tailed *t* tests confirmed the predicted reduction in emotionality with concurrent eye-movements relative to concurrent counting ($t_{17} = 3.10$, $p = .003$) or the no-task control condition ($t_{17} = 2.52$, $p = .01$).

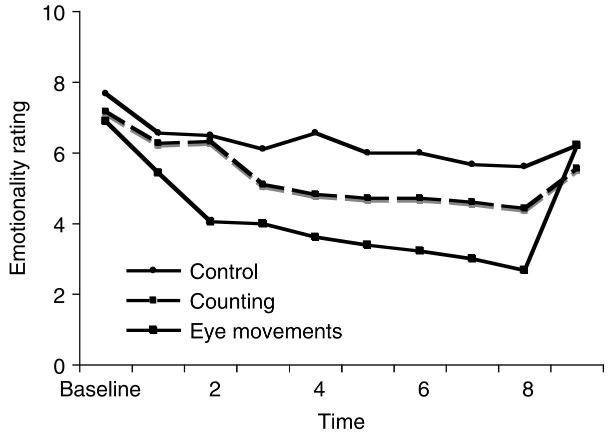

Figure 2. Change in emotionality of memories over time, by condition.

Change scores in the counting and control conditions did not differ ($t_{17} = 1.08$, $p = .15$). To check for variations in effects of condition over time, emotionality ratings for the eight experimental trials were subjected to a 3 (condition) × 8 (time) repeated measures ANOVA. This analysis showed reduced emotionality over time, ($F_{7,119} = 14.92$, $p < .001$, with epsilon correction) and confirmed the effect of condition, ($F_{2,34} = 7.43$, $p = .003$, with epsilon correction). The interaction was not significant, ($F_{14,238} = 1.37$, $p = .26$, with epsilon correction), indicating consistent effects of condition on emotionality over the experimental trials.

Discussion

This study showed a reduction in the vividness and emotionality of predominantly visual traumatic images during a concurrent side-to-side eye-movement task, but not during a concurrent verbal task. These findings replicate those of Andrade *et al.* (1997), and Kemps and Tiggemann (2007), and extend them to a clinical sample with distressing and intrusive images of an index traumatic event. The findings support the specificity hypothesis, derived from the working memory framework, that a visuospatial eye-movement task will reduce the vividness of visual traumatic images, whereas a task that loads the PL will have no effect. Thus the counting task had no effect on vividness compared to exposure only, suggesting that the eye-movement task had a specific effect rather than serving as a general distractor. Related findings from other areas where visual imagery is implicated also show selective effects of visuospatial tasks relative to verbal tasks, for example on intrusive image development (Holmes *et al.*, 2004; Stuart *et al.*, 2006) and on reduction of cravings (Kemps, Tiggemann, Woods, & Soekov, 2004; Versland & Rosenberg, 2007). We interpret the current results as showing that the eye-movement task reduced image vividness by temporarily disrupting active maintenance and manipulation of traumatic images in the VSSP of working memory. The emotionality ratings showed a similar pattern of statistically significant reduction with concurrent eye-movements but not with concurrent counting. It is worth noting, though, that emotionality ratings (and to a lesser extent vividness ratings) tended to be numerically lower with concurrent counting than in the no-task control condition. This tendency may reflect effects of counting on auditory components of trauma imagery (e.g. hearing screams). Although the working memory model does not make predictions of effects on emotionality, other recent research suggests a close link between imagery and emotion similar to that observed here. Reductions in image vividness are associated with reduced emotional impact for positive as well as negative memories (Andrade *et al.*, 1997; Kemps & Tiggemann, 2007; van den Hout *et al.*, 2001). More emotive stimuli are imaged more vividly than less emotive stimuli (Bywaters, Andrade, & Turpin, 2004) and imagery enhances the emotional impact of texts relative to verbal processing (Holmes & Mathews, 2005; Holmes, Mathews, Mackintosh, & Dalgleish, 2008).

There was a return-to-baseline in vividness ratings at 1 week after the experimental session. Emotionality ratings were slightly lower at follow-up than at baseline, but the reduction was comparable across conditions. This is consistent with the findings of Kavanagh *et al.* (2001) in which there was a small reduction in emotionality ratings from baseline to 1 week follow-up, but there was no differential effects across conditions. It is possible that the small reduction in our study was due to habituation effects. However, it should be noted that we were only able to conduct the follow-up testing by telephone, and this may well have limited the sensitivity of the follow-up ratings and thus limit any conclusions about persistence of task effects. Moreover, we did not attempt to replicate findings of changes persisting briefly after the eye-movement task had ceased (e.g. van den Hout *et al.*, 2001). Overall, the pattern of data is consistent with the effects of eye-movements being limited to within-task changes, which suggests that eye-movements may exert only a temporary effect, one that might be used to aid treatment during a therapy session but would not persist outside that session.

It is plausible that the temporary reduction in the intensity of the image offered by a visuospatial task such as eye-movements may be harnessed in PTSD treatment. For example, such as task could be used to aid tolerance of deliberately bringing highly emotional trauma memories to mind, a process which is critical in evidence-based trauma-focused cognitive therapies (National Institute for Health and Clinical Excellence, 2005). This would be consistent with Kavanagh *et al.*'s (2001) assertion that concurrent tasks may act as a treatment aid, helping to create for example, a stepwise exposure protocol. Clinical studies of the effects of concurrent tasks on image tolerance and treatment compliance have not yet tested this suggestion. The present findings imply that, if the concurrent tasks used during EMDR also work by loading the VSSP of working memory, then their effects may be limited to the temporary reduction in vividness and emotionality during the process in which patients are asked to attend to the target image, although reduction may aid the efficacy of other treatment components.

Limitations

The lack of verification of a PTSD diagnosis may weaken the study's conclusions beyond a trauma-exposed sample to a PTSD population. Another potential problem is that it is difficult to be certain that participants maintained their focus on the one instructed image, particularly as the images were related to the same trauma memory. Some contamination across images (and thus ratings) cannot be ruled out, but would have weakened rather than artefactually strengthened our results. While the authors acknowledge the difficulty in finding a PTSD sample in which there are no co-morbid symptoms of anxiety or depression, the potential effect of comorbid symptoms on imagery may require further investigation, a recommendation supported elsewhere (e.g. Reynolds & Brewin, 1999).

We made an assumption, on the basis of previous experimental research, that the eye-movement task was a relatively pure visuospatial task that loaded on the VSSP, and that the counting task was of comparable demand but loaded on the PL of working memory. However, the problems of ensuring equivalent cognitive demands of tasks that load on different slave systems are acknowledged elsewhere (e.g. Miyake *et al.*, 2001). Unlike previous studies in the literature, participants in this study were asked to estimate the contributions of different sensory modalities to their trauma memories, but we acknowledge that these estimates were rather crude and need refining. Conducting the follow-up interview by telephone was not ideal. While the ratings obtained at follow-up were consistent with those reported in the face-to-face meetings, future studies should use consistent procedures for all ratings.

Further research

Future research should explore the potential utility of a concurrent visuospatial task within trauma memory recall in a clinical population formally diagnosed with PTSD for eventual translation to trauma treatment. Meanwhile, much experimental work is still required, for example studies that focus on predominantly non-visual images (e.g. auditory) will add to our understanding of the role of working memory in recollections of trauma. For example, Kavanagh *et al.* (2001) suggested that dual tasks that load on the PL of working memory might have some clinical utility in traumatic images that have a substantial auditory component (gunshots, screams, explosions, etc). This suggestion is supported by recent results from an undergraduate population (Kemps & Tiggemann, 2007) but has not been tested in a clinical population. Future research should seek to equate the general resource load imposed by interference tasks in different modalities. It would be of value to investigate more systematically the use of concurrent tasks as a potential therapeutic aid by, for example, using an extended trial over a course of sessions that compares imaginal exposure with concurrent task and imaginal exposure alone. This might shed light on the longer-term effects of concurrent tasks in disrupting the quality of traumatic memories, beyond temporary reductions in vividness and emotionality achieved during the performance of a concurrent task.

Summary

For most of the participants in this study, their intrusive emotional images of traumatic events were in the visual modality. As predicted from the working memory framework, a concurrent visuospatial task – side-to-side eye-movements – selectively and temporarily reduced the vividness and emotional intensity of these images, relative to verbal concurrent task and no-task control conditions. The present results extend previous findings from undergraduates to a clinical sample and moreover shed light on the type of task that might be effective treatment aids for clients with PTSD.

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