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Effects of emotionally valenced working memory taxation on negative memories

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ABSTRACT

Background and objectives: Memories enter a labile state during recollection. Thus, memory changes that occur during recollection can affect future instances of its activation. Having subjects perform a secondary task that taxes working memory while they recall a negative emotional memory often reduces its vividness and emotional intensity during subsequent recollections. However, researchers have not manipulated the emotional valence of the secondary task itself.
Methods: Subjects viewed a video depicting the aftermath of three fatal road traffic accidents, establishing the same negative emotional memory for all subjects. We then tested their memory for the video after randomly assigning them to no secondary task or a delayed match-to-sample secondary task involving photographs of positive, negative, or neutral emotional valence.
Results: The positive secondary task reduced memory for details about the video, whereas negative and neutral tasks did not.
Limitations: We did not assess the vividness and emotionality of the subjects' memory of the video.
Conclusions: Having subjects recall a stressful experience while performing a positively valent secondary task can decrement details of the memory and perhaps its emotionality.

Traumatic events trigger intense negative emotion that facilitates encoding of the central features of the experience, sometimes producing the syndrome of posttraumatic stress disorder (PTSD; McNally, 2003). Victims who develop PTSD experience involuntary, highly distressing reactivations of the traumatic memory whose vivid sensory features make it seem as if the event were recurring. Efficacious psychological treatments for PTSD entail the activation and modification of the traumatic memory so that its emotionality and vividness diminish, thereby attenuating its distressing intrusiveness (Bisson et al., 2007).

Inspired by theory and research on working memory (Baddeley, 2001; Baddeley & Hitch, 1974), clinical investigators have asked subjects to access negative emotional memories while performing a secondary task that taxes working memory (e.g., Gunter & Bodner, 2008; Kavanagh, Freese, Andrade, & May, 2001; van den Hout, Muris, Salemink, & Kindt, 2001). Reactivation requires working memory resources, and the concurrent performance of effortful secondary tasks, such as bilateral eye movements, draws on the same pool of resources. Accordingly, taxing working memory during reactivation should impair the vividness of the traumatic memory, thereby diminishing its negative emotional valence. Hence, the memory should be less vivid and less distressing when it undergoes reconsolidation into long-term store.

Laboratory studies indicate that concurrent tasks that tax working memory reduce the self-reported vividness and negative emotionality associated with distressing memories and aversive visual images (For a review, see van den Hout & Engelhard, 2012). Moreover, secondary tasks that target the visuospatial sketchpad (VSSP) of working memory are more effective than secondary tasks that target the phonological loop (PL) when the memory is visual, and vice versa when the memory is auditory (Kemps & Tiggemann, 2007). However, the magnitude of taxation imposed by the secondary task must neither be too great nor too little (Engelhard, van den Hout, & Smeets, 2011). If the secondary task is too demanding, the subject cannot activate the memory sufficiently. If it is too undemanding, it will fail to decrement the vividness and emotionality of the memory.

To the best of our knowledge, researchers have yet to vary the emotional valence of secondary tasks. Accordingly, we exposed subjects to three filmed scenarios depicting the immediate aftermath of road traffic incidents. We later administered multiple-choice questions testing subjects' memory for the potentially stressful film footage. However, prior to doing so, we randomly

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assigned subjects to undergo the memory test under one of four conditions. Subjects in the *control* group completed the test without performing a secondary task. Subjects in the other three groups answered the memory questions while performing a secondary task designed to tax the VSSP. The secondary task was a visual match-to-sample task whereby subjects viewed a photograph followed by an array of four photographs, the target photograph plus three similar distracter photographs. The subject's task was to identify the photograph in the array that matched the target photograph. Importantly, the emotional valence of the pictures differed across the three groups. Subjects in the *positive* group performed a match-to-sample task comprising pictures of *positive* valence (e.g., smiling babies); subjects in the *negative* group performed the same task with negative pictures (e.g., snakes), and subjects in the *neutral* group performed the same task with neutral pictures (e.g., chairs).

We tested several hypotheses. First, subjects in the neutral task should exhibit more memory impairment than should those in the control group. Second, if the emotional character of the secondary task (irrespective of valence) further consumes resources, then the positive and negative groups should exhibit more memory impairment than the neutral group. Third, on the other hand, positive and negative secondary tasks may have opposing effects on memory for the distressing film. That is, the positive task may be especially potent in reducing memory for the distressing film, not only because it consumes resources, but also because its valence is opposite to that of the film. Yet the valence of the negative task may counteract any memory-decrementing effects that a secondary task might otherwise produce. In sum, our chief aim was to test whether a secondary task having positive valence would be especially potent in decrementing the details of a distressing memory.

1. Method

1.1. Subjects

Subjects were recruited through emails distributed to Harvard University undergraduate students and students affiliated with the Massachusetts Institute of Technology's Student Financial Services, through notices distributed through the Boston University Student Employment Office, through craigslist postings in the "Volunteers" section, and through fliers posted throughout the greater Boston area. Subjects were also recruited through the Harvard University study pool, most of whom were community members, not undergraduates. Recruitment notices requested subjects who were 18 years or older and who had never received treatment for a mental health problem.

A change in procedure compelled us to exclude the first nine subjects (five male) as pilots. Among 37 men and 46 women who completed the final protocol, we excluded one man and one woman who were inattentive, and one woman who struggled to follow the instructions properly. Hence, we analyzed the data from 36 male and 44 female subjects whose mean age was 29.7 years old (SD = 12.1). Their ethnic backgrounds were Caucasian (43.8%), Asian (31.3%), African-American (15%), Hispanic (5%), Native American (1.3%), and "other" (3.8%). Their highest levels of education were postgraduate (18.8%), bachelor's degree (26.3%), some college (41.3%), and high school diploma (5%), and some high school (3.8%). Undergraduates in Harvard's subject pool received credit for their psychology course, whereas others received $5 upon completion of the study.

1.2. Materials

The stressful stimulus comprised videotaped footage of the immediate aftermath of three fatal motor vehicle accidents drawn from a film (Steil, 1996) used by previous researchers (e.g., Stuart, Holmes, & Brewin, 2006). It lasted six minutes and nine seconds. Each episode began with blank screen during which a man's voice described the accident, followed by footage of emergency workers extricating corpses and survivors. The three accident episodes lasted 1 min and 55 s, 2 min and 17 s, and 1 min and 57 s, respectively.

After viewing the three accident episodes, subjects answered two different audiotaped sets of twelve multiple-choice questions about them (Brewin & Saunders, 2001). To answer these questions, subjects needed to recall scenes from the film. To record the questions, we used Audacity 2.0.0, a free, cross-platform sound editor software installed on a Sony VAIO S-Series laptop. Each set contained four questions per accident, testing subjects' memory for each accident sequentially. At the start of each set, subjects heard the following on the audiotape: "These questions refer to the first scene you saw." Subjects immediately heard the first question followed by the answer options, followed by 5 s of silence before subjects heard the next question in the set. Assessment of subjects' memory for the second and third accident episodes followed thereafter.

To clear the visuospatial sketchpad and prevent rehearsal of the film's contents, we had subjects complete arithmetic problems for one minute after viewing the film and then again between the first and second question set.

With the exception of subjects randomized to the control group, subjects completed a delayed matching-to-sample task (Aggleton, Nicol, Huston, & Fairbairn, 1988), programmed with E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA) on a desktop PC. In each trial of this task, subjects viewed a 500 ms fixation cross, replaced by a target image that remained at center screen for 2 s. Immediately thereafter, four images appeared on the screen: the original target image, plus three similar distracter images. The subject had 2 s to identify the target from the array of four images. Subjects indicated their responses by pressing the 'u,' 'i,' 'j,' or 'k' keys on the computer keyboard; subjects were instructed that these keys respectively corresponded with images in the top left, top right, bottom left, and bottom right of the array.

Depending on their group assignment, subjects saw highly arousing positive images, highly arousing negative images, or minimally arousing neutral images. The target images were from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005). To develop and validate the IAPS images, Lang et al. had raters evaluate each picture on three nine-point scales measuring arousal, valence, and dominance. The first author sorted the IAPS images by valence ratings, and then divided them into three equal parts of positive (high valence rating on the nine-point scale), neutral, and negative valence images (low valence rating on the nine-point scale). She first excluded erotic images, and those related to the September 11th terrorist attacks and motor vehicle accidents. She then selected the 50 images having the highest arousal rating among the positive and negative images, and the 50 least arousing images from the neutral images.

The positive and negative images did not differ significantly in arousal ($M = 6.11$, $SD = .48$ versus $M = 6.00$, $SD = .22$), $t(98) = 1.54$, $p = .13$, but did differ significantly in valence ($M = 7.23$, $SD = .42$ versus $M = 3.22$, $SD = .66$), $t(98) = 36.09$, $p < .001$. The positive and negative valence images together also differed significantly in arousal from the neutral valence images ($M = 2.60$, $SD = .31$), $t(148) = 56.55$, $p < .001$. Furthermore, the positive images differed significantly in valence from the neutral images ($M = 5.00$, $SD = .40$), $t(98) = 26.98$, $p < .001$; likewise, the negative images differed significantly in valence from the neutral images, $t(98) = 16.20$, $p < .001$.