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Reducing involuntary memory by interfering consolidation of stressful auditory information: A pilot study



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ABSTRACT

Background and objectives: Intrusive emotional memories were induced by aversive auditory stimuli and modulated with cognitive tasks performed post-encoding (i.e., during consolidation).

Method: A between-subjects design was used with four conditions; three consolidation-interference tasks (a visuospatial and two verbal interference tasks) and a no-task control condition. Forty-one participants listened to a soundtrack depicting traumatic scenes (e.g., police brutality, torture and rape). Immediately after listening to the soundtrack, the subjects completed a randomly assigned task for 10 min. Intrusions from the soundtrack were reported in a diary during the following seven-day period.

Results: In line with a modality-specific approach to intrusion modulation, auditory intrusions were reduced by verbal tasks compared to both a no-task and a visuospatial interference task.

Limitations: The study did not control for individual differences in imagery ability which may be a feature in intrusion development.

Conclusions: The results provide an increased understanding of how intrusive mental images can be modulated which may have implications for preventive treatment.

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1. Introduction

Stressful experiences and subsequent memories can have severe long-term negative impact on health, as these experiences are associated with a number of disorders ranging from cardiovascular disease (Schwartz et al., 2003) to diagnosed post-traumatic stress disorder (PTSD; American Psychiatric Association, 2013). The general nature of memories related to stressful events is elegantly summed-up by Schwartz et al. (2003): “For most people, little time is actually spent ‘in the heat of the moment.’ However, the greater portion of a lifetime can be spent in anticipation of future stressors and recovery from past stressors, including their repeated cognitive representation.” (p. 28). Mental representations of stressful experiences can come to consciousness either voluntarily, as a deliberate recollection of an event, or involuntarily as an intrusion with no preceding retrieval attempts (Conway, 2001; Conway & Pleydell-Pearce, 2000). Intrusions can be presented on a continuum ranging from common involuntary autobiographical memories to

psychopathological intrusions (Holmes, 2003; Kvavilashvili, 2014). Intrusive recollections of stressful and arousing experiences often consist of sensory images (Arntz, de Groot, & Kindt, 2005; Conway & Pleydell-Pearce, 2000), which seem to have a strong impact on emotion (Lang, 1979; Vrana, Cuthbert, & Lang, 1986). Indeed, Holmes and Mathews (2010) argued that mental images can amplify emotional states and that sensory-perceptual signals may have a more direct link to emotional systems in the brain.

Intrusive memories are associated with a number of disorders including, cardiovascular disease (Schwartz et al., 2003), bipolar disorder (Hammersley et al., 2003), social phobia (Hackmann, Clark, & McManus, 2000), agoraphobia (Day, Holmes, & Hackmann, 2004), major depression (Brewin, Reynolds, & Tata, 1999; Patel et al., 2007; Reynolds & Brewin, 1999), obsessive compulsive disorder (Speckens, Hackmann, Ehlers, & Cuthbert, 2007) psychotic disorders (Morrison, 2001; Steel, Fowler, & Holmes, 2005), and most notably PTSD (Ehlers, Hackmann, & Michael, 2004; Hackmann, Ehlers, Speckens, & Clark, 2004). Although recurrent intrusive memories in PTSD seem to be predominantly visual in their nature, the imagery of auditory information has also been reported as a source of distress (Ehlers et al., 2002; Ehlers & Steil, 1995; Lindley, Carlson, & Sheikh, 2000;

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Salyards, 2006; Van der Kolk & Fisler, 1995). Furthermore, in anxiety disorders such as agoraphobia, social phobia and obsessive compulsive disorder, patients report having recurrent negative images of anxiety evoking situations that linked to past events. The images mainly consist of visual and bodily sensations but auditory intrusions does also occur, such as auditory intrusions of being verbally abused and/or ridiculed (Day et al., 2004; Hackmann et al., 2000; Speckens et al., 2007). In addition, Steel et al. (2005) argued that the cognitive processes underlying intrusive mental images might be the same across different disorders. Thus, increased understanding of the development of intrusions is important in order to further advance treatment interventions.

Research on mental imagery has shown that concurrent modality-specific tasks (i.e., visual or auditory) can reduce the vividness of novel or familiar images when performed during encoding (Baddeley & Andrade, 2000), and decrease emotional intensity if performed during recall of emotive autobiographical memories (Kemps & Tiggemann, 2007). In accordance with the working memory model (Baddeley, 1992, 1996a, 1996b, 2000, 2003; Baddeley & Hitch, 1974), the visuospatial and verbal interference tasks occupy the visuospatial sketchpad (VS) and phonological loop (PL) respectively, competing over limited capacity resources. In addition, based on the same rationale, a general finding from studies using the so-called “trauma film paradigm” (Holmes & Bourne, 2008; for a review) is that performing a visuospatial task during encoding of stressful visual stimuli reduces intrusion frequency compared to control conditions (e.g., Bourne, Frasquilho, Roth, & Holmes, 2010; Holmes, Brewin, & Hennessy, 2004; Stuart, Holmes, & Brewin, 2006). Also, the same pattern of results has been observed when the VS task was performed *after* watching an aversive film, indicating that intrusive memories can be modulated by interfering with consolidation processes (Deeprouse, Zhang, DeJong, Dalgleish, & Holmes, 2012; Holmes, James, Coode-Bate, & Deeprouse, 2009; Holmes, James, Kilford, & Deeprouse, 2010).

A great deal of research conducted on both animal and human subjects clearly indicates that the vivid and long lasting nature of memories followed by stressful and arousing events can be explained by enhanced consolidation processes (Roosendaal & McGaugh, 2011; for a review). There are several possible mechanisms by which memory consolidation could be enhanced, with catecholamine induced beta-adrenergic activation within amygdala being one of the most important factors (Barsegyan, McGaugh, & Roosendaal, 2014; Pitman & Delahanty, 2005; Roosendaal, Castello, Vedana, Barsegyan, & McGaugh, 2008).

When investigating consolidation processes, Walker, Brakefield, Hobson, and Stickgold (2003) showed that performance on a specific finger-tapping sequence was enhanced following a night of sleep, but impaired if the subjects were trained on a new sequence immediately after the first sequence. Also, the interference effect was abolished when the second sequence was administered 6 h after training of the first sequence, indicating a 6-h window in which newly formed memories can be altered if a competing memory is introduced (Walker et al., 2003). Schiller et al. (2010) demonstrated the malleability of consolidated memories by reactivating a conditioned fear memory followed by the conditioned stimulus (coloured square on a computer screen) being presented without the unconditioned stimulus (electric shock to the wrist), resulting in a blockade of memory expression as measured by skin conductance responses. Changing the expression of a memory is a powerful intervention that has the potential to reduce and prevent psychopathological distress.

Holmes et al. (2009, 2010) proposed a ‘cognitive vaccine’ in the form of a cognitive task that could be administered as an initial intervention at trauma sights, in order to reduce traumatic

flashbacks. This proposition is supported by a series of impressive experiments (Holmes et al., 2009, 2010) during which subjects were exposed to a stressful film depicting scenes of fatal road accidents, drowning and surgery. Those who completed a demanding visuospatial task (the computer game Tetris) after exposure of the scenes had a decreased number of involuntary memories of the film compared to the control participants (no-task or Pub Quiz – a general knowledge verbal computer game). Also, participants in the visuospatial condition had significantly lower impairment on a clinical measure of PTSD symptomology at 1-week. Furthermore, deliberate memory recall of the film was not affected and the overall effect was prevalent even when the task was administered 4 h following encoding (Holmes et al., 2010; experiment two). Similar differences in number of intrusions were found in later experiments using a complex pattern tapping task (Deeprouse et al., 2012), known to be a more established visuospatial task (Baddeley & Andrade, 2000). One major advantage of a non-invasive cognitive task relative to a pharmacological alternative, such as the beta-blocker propranolol (Henry, Fishman, & Youngner, 2007), is that intrusions can be reduced without suppressing voluntary recall. Since the ‘cognitive vaccine’ approach does not result in memory extinction, but merely a reduction of the emotional impact of aversive memories, it can be argued that this is an innovative example of how consolidation interference can change the expression of a memory and reduce the risk of intrusions becoming pathological. However, since the aversive stimuli applied within these studies are mainly visual in their nature, the processing of auditory information and subsequent intrusive memories remains unexplored.

Overall, these findings indicate modality-specific interference effects in relation to intrusion development. This modality-specific approach is partly consistent with dual-process models of PTSD stating that trauma can cause a shift in processing balance from conceptual processing to perceptual processing, enhancing focus on sensory information. Accordingly, this imbalance at encoding is proposed to give rise to intrusive memories of an event (Brewin, 2003; Brewin, Dalgleish, & Joseph, 1996; Holmes & Bourne, 2008). However, studies investigating the role of eye movement desensitization and reprocessing (a procedure involving participants moving their eyes horizontally during reconsolidation of a stressful memory) have shown that other tasks such as counting (Engelhard, Van den Hout, & Smeets, 2011; van den Hout et al., 2010) or verbal shadowing (Gunter & Bodner, 2008) also reduce vividness and emotionality of aversive visual images. These studies indicate that the interference effects are not dependent on the modality of working memory, but simply due to loading on executive processes (EP) of working memory (Baddeley, 1996b, 2000, 2003), suggesting that any form of cognitive load that competes for limited cognitive resources is likely to interfere with memory consolidation of stressful stimuli.

The current study modified the trauma film paradigm by replacing the aversive film with a trauma-analogue soundtrack and thereby examined if the consolidation of *auditory* stressful stimuli could be interfered by performing a cognitive task post-encoding. The main aim was to determine which type of cognitive task (i.e., VS- PL- or EP-task) that is required in order to interfere the consolidation of a stressful auditory stimulus. Adding modality specificity allowed for the investigation of possible interactions between the modality of image and the type of interfering task. If the development and modulation of intrusions could be explained in terms of cognitive load, then any task might be expected to reduce frequency and no modality-specific interference effects could be expected. On the other hand, if the development and modulation of intrusions could be explained in terms of the modality-specific approach, then only an auditory/verbal task is

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