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Emotional working memory capacity in posttraumatic stress disorder (PTSD)

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ABSTRACT

Participants with a lifetime history of posttraumatic stress disorder (PTSD) and trauma-exposed controls with no PTSD history completed an emotional working memory capacity (eWMC) task. The task required them to remember lists of neutral words over short intervals while simultaneously processing sentences describing dysfunctional trauma-related thoughts (relative to neutral control sentences). The task was designed to operationalise an everyday cognitive challenge for those with mental health problems such as PTSD; namely, the ability to carry out simple, routine tasks with emotionally benign material, while at the same time tackling emotional laden intrusive thoughts and feelings. eWMC performance, indexed as the ability to remember the word lists in the context of trauma sentences, relative to neutral sentences, was poorer overall in the PTSD group compared with controls, suggestive of a particular difficulty employing working memory in emotion-related contexts in those with a history of PTSD. The possible implications for developing affective working memory training as an adjunctive treatment for PTSD are explored.

Sufferers from common mental health problems such as depressive and anxiety disorders ubiquitously report difficulties with everyday mental operations. Many of these difficulties seem to arise because critical amounts of cognitive resources are taken up in dealing with emotionally-laden thoughts, feelings, and behavioural urges that, although intricately linked to the sufferers' problems, are not directly relevant to the task at hand (Mason et al., 2007).

A core mental resource that is implicated when juggling such competing demands is 'working memory capacity' (WMC), defined as the limited capacity to store task-critical information over short retention intervals while simultaneously processing other competing information, or engaging other cognitive operations (Dalgleish et al., 2007; Engle, 2002; Smith & Jonides, 1999). For example, a woman suffering from posttraumatic stress who is endeavouring to comprehend and encode a complex project briefing at work, might at the same time have to struggle to set aside intrusive and distressing thoughts and memories of her trauma, thus drawing heavily on WMC resources.

WMC is typically measured in the laboratory using complex span tasks (Conway et al., 2005). These paradigms assess the ability to carry out a short-term memory test (for example, remembering a list of words), while at the same time performing a competing cognitive operation (for example, solving mathematical equations, evaluating the meaning of sentences, and so on). A compelling corpus of studies using such tasks has identified individual differences in WMC as a powerful explanatory construct in human cognition, strongly overlapping with fluid intelligence (Conway, Kane, & Engle, 2003; Engle, Tuholski, Laughlin, & Conway, 1999), and central to the processing of goal-relevant information in the face of goal-irrelevant distraction (see Barrett, Tugade, & Engle, 2004, for a review).

Almost without exception, traditional complex span tasks require short-term retention of *emotionally-neutral* information in the face of demands to process competing *emotionally-neutral* information (Conway et al., 2005; Schmeichel, Volokhov, & Demaree, 2008). Clearly, any such 'valence-neutral' index of WMC cannot fully capture the nature of more emotionally-laden executive challenges in day-to-day cognition, such as the plight of the aforementioned woman with posttraumatic stress. Nevertheless, studies with valence-neutral complex span measures have illuminated our understanding of important aspects of cognition–emotion interactions in both healthy and clinical participants. For example, Schmeichel et al. (2008) showed that healthy individuals with greater WMC, as assessed by neutral complex span tasks, were better able to regulate expressive and experiential aspects of emotion. Furthermore, Brewin and Smart (2005) reported that lower WMC was associated with decreased resistance to emotional intrusive thoughts in healthy volunteers (see also Brewin & Beaton,

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2002). Similarly, in the clinical domain elevated stress, anxiety and depression have been associated with impoverished WMC on valence-neutral complex span measures (e.g. Ashcraft & Kirk, 2001; Dalgleish et al., 2007; Klein & Boals, 2001).

Our goal here was to extend this promising research using valence-neutral measures of WMC by developing a complex span measure of *emotional working memory capacity* (eWMC) through the introduction of emotionally-laden information into the task protocol. We sought to gather proof-of-principal evidence for the sensitivity of this eWMC construct in a target clinical group – patients with a history of post-traumatic stress disorder (PTSD). Our rationale was that people with a history of common mental health problems such as PTSD are likely to suffer from compromised WMC resources in emotional contexts, compared to healthy individuals in ways that are more marked than any such group differences manifest in valence-neutral contexts. We further reasoned that these emotional impairments would be captured better by complex span measures that instantiated the emotional context in the task design, as opposed to valence-neutral paradigms. To this end, we opted for a reading span task that required participants with a lifetime history of PTSD to memorise and retain short lists of neutral-valence words, while at the same time processing sentences describing dysfunctional thoughts commonly associated with their condition (e.g. "I will never be able to feel normal emotions again"; Foa, Ehlers, Clark, Tolin, & Orsillo, 1999).[1] The longer-term aim in devising a measure of eWMC is to provide a platform for developing an eWMC training protocol that seeks to strengthen capacity in individuals with emotional disorders and that can be offered as a self-paced adjunct to traditional psychological interventions.

We settled on PTSD as a test-case for this initial study because of its core phenomenology surrounding the presence and impact of unbidden trauma-related intrusive thoughts, images and feelings which (as in our example above) the sufferer has to overcome or ignore in order to carry out routine cognitive operations (cf. Brewin & Beaton, 2002; Brewin & Smart, 2005). Our reasoning was that complex span tasks can operationalise this processing of conflicting mental demands in PTSD as suggested by Conway et al. (2005) in their methodological review of these tasks: "Attention is often captured by events in the environment and by thoughts that intrude into consciousness. Those perceptions and thoughts, in turn, lead inexorably to other thoughts. However, the solution to life's problems often requires that such automatically elicited thoughts, associations, and captured attention be resisted and thought be directed or controlled. We have argued that this ability to control attention and thought represents the common construct measured by tests of WMC" (p. 777).

We focused primarily on lifetime sufferers of PTSD for the current study, rather than selecting only those with a current diagnosis. There were four reasons for this. The first is the small but growing literature indicating that participants with a history of PTSD in full or partial recovery show substantive and significant biases on a wide range of cognitive measures indexing difficulties in processing trauma-related material, relative to never-PTSD trauma-exposed controls. Indeed, in many cases the past PTSD sufferers appear comparable on such measures to those with a current PTSD diagnosis. For example, Halligan, Michaels, Clark and Ehlers (2003), examining victims of assault, found that their recovered PTSD group showed biases in processing assault-related information, self-reported and objective disorganisation in their trauma narrative, maladaptive appraisals of their intrusive experiences and persistent cognitive dissociation, relative to never-PTSD controls, and were not significantly different from their current PTSD group on the majority of these variables.

Our second and related motivation follows form research suggesting that patients with past PTSD have a problem with proactive interference, even with neutral stimuli. Eren-Koçak, Kiliç, Aydin, and Hizli (2009) showed that participants with a PTSD history performed significantly worse than never-PTSD controls, and comparable to participants with current PTSD, in learning lists of words when there is the potential for interference from previous lists that are now no longer relevant. There is now a compelling literature linking such vulnerability to proactive interference with poorer WMC (see Conway et al., 2003). The suggestion is that difficulties in both proactive interference and interference from habitual and distracting task-irrelevant thoughts (as found in those with a history of PTSD) can be seen as different exemplars of a broader interference vulnerability. As Conway et al. (2003) state: "WMC is related to performance in situations in which an executive attention control mechanism is needed to combat some form of salient interference, be it proactive interference, response competition, or habitual but inappropriate responses." (p. 549).

Our third motivation for examining lifetime PTSD relates to the research literature which indicates that maladaptive intrusive trauma-related appraisals (as for example measured on the PTCI) are a feature of PTSD that extends after remission from the diagnostic state (e.g. Halligan et al., 2003) and indeed can even predict PTSD when measured as a general thinking style pre-trauma (Bryant & Guthrie, 2007).

The final component of our reasoning was the emerging data showing that participants with a history of PTSD which is in recovery are nevertheless at risk of PTSD reactivation (relative to the risk of delayed onset PTSD in those who have never had it). For example, Boe, Holgerson and Holen (2011) in a study of disaster survivors followed up over 27 years showed that almost 20% of participants who had recovered from PTSD suffered from reactivation of the disorder. Similar proportions are reported in other studies (e.g. Soloman & Mikulincer, 2006). These data again support the view that those with a history of PTSD remain more disturbed and vulnerable relative to those who have never suffered from the disorder.

For these various reasons we were interested in examining lifetime-PTSD sufferers relative to those who had never suffered from the disorder in terms of WMC performance with trauma-related and neutral material. However, all of the key analyses were also repeated with the subset of current PTSD sufferers, relative to never-PTSD controls.

Our central study hypothesis, then, was that trauma survivors with a lifetime history of PTSD would show impaired WMC on our novel emotional reading span task when the operation component (the sentences) was PTSD-related, compared with a control sample of trauma survivors who had never had PTSD, and relative to their performance with neutral control sentences as the operation component. As noted, we predicted similar findings for the subset of the lifetime-PTSD group who had a current PTSD diagnosis, relative to the control sample. We also planned to conduct exploratory analyses to enquire whether any group differences on emotional relative to neutral WMC were a function of the trial size on the reading span task (i.e. how many to-be-remembered words were presented). This is based on literature suggesting that executive capacity on the processing of emotional information in emotional disorders is likely to vary as a function of task load or

[1] There is a precedent for introducing personally salient information into WMC tasks. Edelstein (2006) showed that WMC was lower among individuals with an avoidant attachment style, but only when remembering lists of attachment-related words, in the face of neutral-valence distraction. We chose a different approach here by examining memory for neutral material in the face of emotionally-laden distraction; a phenomenon that we contend is closer to the core problems that those with emotional disorders face in everyday cognizing.