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Conditioned responses to trauma reminders: How durable are they over time and does memory integration reduce them?



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ABSTRACT

Background and objectives: Stimuli associated with the trauma are important triggers for intrusive memories after a traumatic event. Clinical models assume that fear conditioning for neutral stimuli encountered during traumatic events is a potential cause of these intrusions, and that memory integration has the effect of reducing these associations, thereby also reducing intrusions. This study examines whether conditioned associations lead to intrusive trauma memories and how they are affected by memory integration.

Methods: Forty-eight healthy participants watched a neutral and a “traumatic” film, both containing neutral sounds, and, on the following day, were randomly allocated to memory integration of either the “traumatic” film or the neutral film. Intrusive memories were monitored for one week. Participants repeatedly completed a memory triggering task, in order to assess how durable conditioned intrusive memories are over time.

Results: Trauma-associated sounds elicited intrusive memories and anxiety when encountered directly after film presentation, as well as one and seven days later. Furthermore, enhanced conditionability predicted subsequent ambulatory trauma intrusions. No evidence was found for the assumption that memory integration of the “traumatic” film reduced conditioned reactions.

Limitations: The presented film is a relatively mild stressor as compared to a real-life trauma. Further studies are needed to explore the role of conditioned intrusions for real-life trauma.

Conclusions: This study provides evidence for the assumption that intrusive trauma memories can be explained by conditioned responses to neutral stimuli encountered during the trauma and that these effects are stable over time. Implications for PTSD and its treatment are discussed.

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1. Introduction

Intrusive memories of traumatic events are a hallmark symptom of posttraumatic stress disorder (PTSD; [American Psychiatric Association, 2013](#)). These memories consist of vividly experienced thoughts, images, and perceptions that cause immense distress ([Michael, 2000](#); [Michael, Ehlers, Halligan, & Clark, 2005](#)). Intrusive memories are often triggered by stimuli that have been encountered in the context of the traumatic event even though they do not necessarily have a meaningful relationship to the traumatic event (e.g. a pattern of light, a particular sound; [Brewin, Dalgleish, &](#)

[Joseph, 1996](#); [Ehlers, Hackmann, & Michael, 2004](#); [Foa, Steketee, & Rothbaum, 1989](#)). According to learning or conditioning models of PTSD, temporal co-occurrence causes neutral stimuli to become associated with the aversive experience of the traumatic event and subsequently have the potential to trigger intrusive reexperiencing of the trauma, including memories, emotions, and physiological arousal ([Foa et al., 1989](#); [Keane, Zimering, & Caddell, 1985](#)). Thus, intrusive memories in PTSD are regarded as conditioned reactions (CR) and triggers can be seen as conditioned stimuli (CS) that predict a traumatic event (unconditioned stimulus, UCS; [Foa et al., 1989](#); [Keane et al., 1985](#); [Rothbaum & Davis, 2003](#)).

It has been proposed that, in general, this stimulus-driven retrieval is inhibited when episodic memories are integrated into the autobiographical memory system ([Conway & Pleydell-Pearce, 2000](#); [Conway, 2005](#)). This system is regarded as a representation

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of conceptually organized autobiographical knowledge, regulated by a central control process, the working self, which controls the retrieval and encoding of episodic memories (Conway, 2003, 2005). Based on this model, Ehlers and Clark (2000) have suggested that poor memory integration of the traumatic experience in PTSD patients leads to insufficient inhibition of stimulus-driven retrieval of trauma memories.

Accordingly, memory integration should lead to a reduction of conditioned reactions and intrusive memories triggered by trauma-related stimuli. Indeed, clinical efficacy studies show that intervention techniques that focus on trauma memories and include a verbalization of the traumatic experience (e.g. memory integration through imaginal exposure) provide the best therapeutic outcomes (Bisson et al., 2007). It is not clear, however, whether memory integration actually leads to a reduction of associative learning, the memory processes supposedly underlying intrusive memories.

There is growing evidence for the important role associative learning plays in the development and maintenance of PTSD (Duits et al., 2015). Orr et al. (2000) investigated fear conditioning in PTSD patients and trauma-exposed participants without PTSD using a differential fear conditioning paradigm. Neutral visual stimuli were used as CS and either paired with an electrical stimulus as UCS or not. During acquisition, PTSD patients showed larger differential skin conductance (SC), heart rate (HR), and electromyogram responses to the CS+ (stimulus paired with the UCS) versus the CS- (stimulus not paired with the UCS) compared to trauma-survivors without PTSD. When CS+ and CS- were subsequently repeatedly presented without being followed by the UCS (extinction), only PTSD patients continued to show differential SC responses to CS+ versus CS-. Delayed extinction in PTSD patients compared to trauma-exposed or healthy control groups has also been found in larger heart rate responses (Peri, Ben-Shakhar, Orr, & Shalev, 2000), startle responses (Norrholm et al., 2011), and subjective ratings of valence and US-expectancy (Blechert, Michael, Vriends, Margraf, & Wilhelm, 2007). In a prospective study of soldiers who were tested before and after their deployment, reduced extinction learning was found to be a pre-trauma vulnerability factor for PTSD symptom severity (Lommen, Engelhard, Sijbrandij, van den Hout, & Hermans, 2013). Taken together, these findings indicate that conditioned reactions to trauma reminders play an important role for the development of intrusive reexperiencing. However, so far, fear conditioning for neutral stimuli actually present during the traumatic event could not be investigated directly.

Another limitation of fear conditioning experiments is their relatively poor ecological validity. The UCSs implemented to simulate a traumatic event in the laboratory are electrical stimulation or aversive noises (Duits et al., 2015; Lissek et al., 2005). These stimuli are suitable for investigating conditioned fear reactions like SCR, but allow no inferences about the question whether fear conditioning underlies intrusive trauma memories. Because of these shortcomings, Wegerer, Blechert, Kerschbaum, and Wilhelm (2013) have recently developed the conditioned intrusion paradigm. In this paradigm, neutral sounds are either paired with short aversive film clips (CS+) or presented alone (CS-; for a similar approach see Kunze, Arntz, & Kindt, 2015). Subsequently, the CS+ when presented again while embedded in a neutral background soundscape triggered intrusive memories, and induced anxiety and physiological arousal (as indexed by SC levels) as a conditioned reaction (CR). Furthermore, conditionability of subjective valence ratings and fear reactions in this task was associated with later ambulatory intrusive memories. This paradigm was an important step toward investigating fear conditioning in a more naturalistic laboratory setting, as it was the first study to show that intrusive trauma memories can occur as a CR to a CS+. However, it does not resemble the typical time course of a

traumatic event.

A more naturalistic laboratory analogue of traumatic experiences is the trauma film paradigm (for a review see Holmes & Bourne, 2008). In this paradigm healthy participants are exposed to a stressful film (typical duration: 8–12 min), depicting traumatic events, such as actual or threatened death and serious physical injuries. Over the following days, participants keep a diary to document their intrusive memories of the presented film. In a recent meta-analysis of 458 participants the mean number of intrusive memories in the week following a “traumatic” film was 5.53 (SD = 6.52) (Clark, Mackay, & Holmes, 2015). There is a broad consensus that the trauma film paradigm provides a valuable experimental tool for investigating memory processes underlying PTSD with high ecological validity (Holmes & Bourne, 2008).

In order to examine how stable conditioned responses to trauma reminders are over time, and how they are affected by memory integration (Michael & Ehlers, 2007), we combined the conditioned intrusions paradigm from Wegerer et al. (2013) with the standard trauma film paradigm. Specifically, neutral sounds were repeatedly presented during either a “traumatic” film clip (CS+) depicting interpersonal violence or a neutral control film (CS-) depicting neutral social interactions. To test whether trauma-associated sounds (CS+) trigger traumatic memories and increase anxiety as conditioned responses, the memory triggering task, developed by Wegerer et al. (2013), was performed after presentation of a well-established trauma film paradigm (Streb, Mecklinger, Anderson, Lass-Hennemann, & Michael, 2016). To examine how durable these conditioned responses are over time, we implemented the memory triggering task again one day and one week after presenting the film. To study whether fear conditioning plays a role in the effects of memory integration, one day after seeing the film, participants were instructed to imagine and verbalize either the events of the “traumatic” or neutral film, following Ehlers' (1999) rationale for imaginal exposure. Our design has the advantage of using the well-established standard trauma film paradigm that is known to reliably induce analogue trauma intrusions and allows experimental control of which neutral stimuli are present during the analogue trauma, as in a fear conditioning paradigm. It therefore enables the investigation of associative learning for neutral stimuli present during traumatic events in a relatively natural setting. Additionally, by having participants repeatedly perform the memory triggering task after the “traumatic” film, we are able to assess whether intrusive memories as a conditioned response (CR) to trauma reminders (CS+) remain stable over a longer time span and how they are impacted by early memory integration.

This experimental analogue study had two main aims: (1) Investigating associative learning for intrusive memories and conditioned fear in a traumatic context and (2) examining the effects of memory integration on differential conditioning and subsequent intrusive trauma memories.

Regarding conditioned fear reactions, we expected that neutral sound stimuli repeatedly presented during a “traumatic” film (CS+), would lead, when presented again in a neutral context, to more intense intrusive memories, more anxiety, and greater physiological arousal (as indexed by enhanced skin conductance levels and heart rates) as compared to neutral stimuli that were originally presented during a neutral film (CS-). This effect was expected to be observed directly after film presentation (t1), on the following day (t2, t3), and one week after film presentation (t4). Furthermore, enhanced conditionability, as assessed by differential conditioned reactions (CS+ minus CS-) directly after film presentation (t1), was expected to predict the intensity of subsequent ambulatory intrusive trauma memories, assessed with an electronic diary over the following seven days. Concerning the effects of memory integration, we expected reduced differential conditioning

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