

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Journal of Applied Research in Memory and Cognition

journal homepage: www.elsevier.com/locate/jarmac

Reducing the Consequences of Acute Stress on Memory Retrieval

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Psychological stress has been shown to impair episodic memory retrieval. Implicated in this memory impairment is the physiological stress response, which interferes with retrieval-related neural processing. An important next step in research is to determine how to improve post-stress memory accessibility. In this review, we first consider methodological differences in studies that have examined stress and memory, as they lend insight into the conditions under which stress does and does not impede retrieval. Motivated by these variations in methodology, we advocate for two potential approaches to intervention. One approach is to employ evidence-based techniques that reduce the physiological stress response. A second approach is to target the processes that occur during initial learning to promote the formation of highly accessible memories. Thus, this review serves to both critically evaluate the methods used to examine the effects of stress on memory retrieval and encourage research on interventions for stress-related memory impairment.

General Audience Summary

Psychological stress impairs our ability to remember information. The physiological stress response is implicated in this impairment, as it interferes with neural processing in brain regions that are involved in memory. An important next step in research is to determine how to improve memory in stressful scenarios. In this review article, we advocate for two potential approaches. One approach is to use any of a variety of techniques that help reduce the physiological stress response (e.g., muscle relaxation). A second approach is to use learning strategies that promote the formation of stress-resistant memories (e.g., taking practice tests while learning new information). Discovering interventions for stress-related memory impairment would serve to benefit a host of individuals in their everyday lives, such as professionals in stressful work scenarios and students during high-stakes tests. The interventions described here have not yet been employed as tools for improving memory in the context of psychological stress, and thus we aim to encourage such research in this review.

Keywords: Psychological stress, Retrieval, Memory, Cortisol, Intervention

Psychological stress often results in a paradoxical scenario: when we are under pressure to perform our best, we find ourselves performing our worst. This subjective experience of “choking under pressure” has been repeatedly substantiated by memory research. Specifically, over a dozen experiments and a recent meta-analysis have culminated in the consensus that acute incidences of stress temporarily impair memory

retrieval (Shields, Sazma, McCullough, & Yonelinas, 2017). This area of research is rapidly gaining momentum. Two recent papers provided in-depth discussions of the physiological stress response, the empirical literature on the topic, and the theoretical mechanisms that may underlie the detrimental effects of stress on retrieval (Gagnon & Wagner, 2016; Shields et al., 2017). Despite the great strides that have been made to

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better understand how stress impacts retrieval, there has been little discussion of what might be done to mitigate the negative effects that have been observed.

From a practical perspective, discovering interventions for stress-related memory impairment would serve to benefit a host of individuals in their everyday lives. As examples, interventions that target memory accessibility would benefit professionals in stressful work scenarios and students during stressful, high-stakes tests. Such interventions would also serve to test and refine the current theories surrounding the negative effects of stress on memory retrieval. For instance, Schwabe and colleagues (Schwabe, Joels, Roozendaal, Wolf, & Oitzl, 2012) have hypothesized that stress hormones interact in the basolateral amygdala to induce a “memory formation mode” in the stressed brain. When in this state, neural processes related to the encoding and consolidation of information are prioritized at the expense of retrieval. Interventions that yield successful post-stress retrieval would help specify the conditions under which retrieval is and is not impeded by the stress-induced memory formation mode. In their review, Gagnon and Wagner (2016) discussed another neural mechanism by which stress may influence memory, specifically that stress impairs executive functioning. The studies they reviewed demonstrate that stress increases neural activity in areas such as the amygdala and striatum that are associated with reflexive, habitual actions, while simultaneously decreasing activity in regions such as the hippocampus and PFC that support executive functions such as careful, effortful recollection. Demonstrating ways in which memories can be retrieved even when executive resources are impaired would also help refine this hypothesis. With one exception (Smith, Floerke, & Thomas, 2016), researchers have yet to explore ways in which the negative effects of stress on retrieval might be ameliorated. In this piece, our primary goal is to elicit interest in research on interventions for stress-related memory impairment. We will do so by highlighting two evidence-based approaches that have the potential to attenuate the negative effects of stress on retrieval.

The Scope of the Present Review

In the present review, we use the term *intervention* to refer to a technique that could be used to improve memory accessibility in situations where psychological stress poses a threat to memory retrieval. Generally, the term *intervention* is used in scenarios in which one wishes to modify the outcome of some event. Here, interventions are tools that may modify the memory impairment (outcome) that results from stress (event). Thus, in this context, the term *intervention* may refer to a real-world scenario in which an individual employs a technique to reduce the consequences of stress on her memory, or to an experimental scenario in which a researcher manipulates the use of such a technique in a tightly controlled setting. Because the interventions mentioned in the present review have not yet been examined for their efficacy in stress-and-memory paradigms, the intention of this review is to encourage researchers to explore the use of interventions in experimental settings. By fostering experimental research, we

hope that the broader application of these interventions, such as in clinical or educational settings, will eventually be possible.

The literature reviewed here specifically examines the effects of acute, isolated instances of psychological stress on episodic memory retrieval in healthy adults (for reviews of chronic stress, see Conrad, 2010; Finsterwald & Alberini, 2014). Psychological stress is commonly defined as an uncontrollable and/or unpredictable threat to the physical or social self (Dickerson & Kemeny, 2004). This threat is accompanied by a subjective feeling of mental stress and a physiological response that increases levels of the stress hormone cortisol. Episodic memory refers to memory of events that are associated with a particular time and place. Memory *retrieval* is the phase of episodic memory in which information is recollected after going through the processes of encoding and consolidation. Researchers have examined the impact of inducing stress at various phases of episodic memory (see Gagnon & Wagner, 2016; Schwabe et al., 2012; Shields et al., 2017), but in the wealth of research conducted, retrieval is the only phase of episodic memory that has consistently been negatively affected by stress. Thus, we focus the present review on the deleterious effects of stress on retrieval and the potential for interventions to mitigate those undesirable effects.

The Physiological Stress Response and Memory Retrieval

In their recent meta-analysis, Shields et al. (2017) confirmed a growing consensus: stress impairs memory retrieval. Further, this impairment was greatest for negatively- and positively-valenced stimuli than for neutral stimuli. The detrimental effects of psychological stress on retrieval are, in part, a consequence of the human stress response. The stress response is characterized by different phases of hormone release, the first of which is initiated by the hypothalamus after a threat has been perceived (Everly & Lating, 2013). From here, preganglionic sympathetic nerves carry neural impulses to the adrenal medulla (Raven, Raven, & Chew, 2010). The stimulated adrenal medulla then serves as the postganglionic release point for epinephrine, prompting the “fight-or-flight” response that prepares the body to take defensive action. Though epinephrine cannot cross the blood-brain barrier to directly affect neural activity, increases in epinephrine initiate a chain of stimulation from the vagus nerve to the solitary nucleus in the medulla to the basolateral amygdala (BLA; Williams & Clayton, 2001). The BLA modulates the learning and consolidation of information, particularly emotional information (McGaugh, Cahill, & Roozendaal, 1996). Thus, memory consolidation is often enhanced after stress (e.g., Andreano & Cahill, 2006; McCullough & Yonelinas, 2013; Smeets, Otgaar, Candel, & Wolf, 2008). During a brief period after the onset of stress (<10 min), memory retrieval may also be enhanced (e.g., Hupbach & Fieman, 2012) or otherwise unaffected (e.g., Schonfeld, Ackermann, & Schwabe, 2014), though literature examining retrieval immediately post-stress is sparse.

The second phase of the stress response is longer lasting and occurs via a different mechanism, referred to as the hypothalamic-pituitary-adrenal (HPA) axis (Everly & Lating, 2013). While the hypothalamus activates the adrenal medulla

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