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Individual differences in math anxiety and math self-concept promote forgetting in a directed forgetting paradigm

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ABSTRACT

Students whose math self-concept is threatened in stressful classroom situations activate self-defense mechanisms to forget those experiences, which jeopardize future learning and knowledge retention. External cues to forget might be critical to activate these self-defense mechanisms. We tested this idea by employing a directed-forgetting paradigm using math-related materials. Participants were presented with math problems to enhance anxiety, followed by a list of math-related words with instructions to either remember or forget those words. All participants were then asked to remember a second math list. We predicted that people most vulnerable to experiencing threat—those with high math anxiety and high math self-concept—would have the internal motivation to most effectively carry out the forgetting instructions. Participants with high math anxiety and high math self-concept had a greater forgetting score than other participants. These findings are consistent with a motivated forgetting account and suggest that educational materials are susceptible to forgetting.

1. Introduction

Individuals are capable of intentionally forgetting information that they have encoded into long-term memory. By intentional forgetting, we are referring to a goal-directed process in which individuals suppress previously learned information. One way researchers have studied intentional forgetting is through a directed-forgetting paradigm (Bjork, Laberge, & Legrand, 1968). This paradigm explicitly asks people to forget information that they previously encoded into memory. Using the standard list method, participants are presented with a list of words to remember (List 1). Afterwards, half the participants are asked to forget the list (the forget condition) while the other half are asked to remember the list (the remember condition). Both sets of participants then study a second list of words (List 2). Participants in both conditions are then finally asked to recall all words, regardless of the previous remember or forget instructions. Decades of research using the directed forgetting paradigm show that recall for the List 1 words is worse when individuals are directed to forget rather than to remember (i.e., the cost of forget instructions). Participants also commonly recall more List 2 words in the forget condition than participants in the remember condition (i.e., the benefit of forget instructions), presumably because interference is reduced due to the forgetting of List 1 words (e.g., Bjork, 1970). Similarly, participants in the forget condition often remember the List 2 words at a comparable level to participants in a condition that never received a set of List 1 words (a control condition), suggesting that participants instructed to forget List 1 words are performing as if they had never been exposed to the words in the first place (e.g., Bjork, Bjork, & Anderson, 1998).

Why are humans proficient at intentionally forgetting? Knowledge structures often create competition that requires the suppression of irrelevant information (i.e., forgetting) to better facilitate the retrieval of relevant information (e.g., Bjork, 1970; Bjork, 1989; James, 1890; Storm, Bjork, Bjork, & Nestojko, 2006). From a cognitive perspective, the term "relevant", describes retrieved information that is currently useful or will be used in the future to accomplish a task or goal. However, from a social psychology perspective, the term relevant describes information that serves an important motivational function to the self. Hence, there may exist situations where task values align with important motivational processes and lead individuals to forget information.

1.1. Motivated forgetting as an individual differences factor

The aforementioned directed-forgetting research establishes that individuals can be externally directed to forget. But might there be situations in which individuals self-impose an internal directive (or motive) to forget? A threat-based model of motivated forgetting argues that unpleasant, threatening, or painful experiences can lead some

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individuals to forget memories of such experiences in an effort to protect the self. Motivated forgetting is argued to help enhance one's well-being and mental health by protecting individuals against unpleasant memories (e.g., Anderson & Green, 2001; Conway & Pleydell-Pearce, 2000; DePrince et al., 2012). But individuals do not indiscriminately forget all unpleasant events. Rather, individuals forget (i.e., mentally protect against) memories or experiences that call into question the self-perceptions one is trying to maintain (e.g., Rapaport, Schafer, & Gill, 1946; Turner & Barlow, 1951).

Research, across a variety of disciplines, finds that individuals who hold a favorable perception of themselves also are much more likely to react defensively against threats that challenge those perceptions (Baumeister, Smart, & Boden, 1996; Jones, Pelham, Mirenberg, & Hetts, 2002). For example, when people are given feedback, they selectively forget negative, but not positive feedback, especially when it concerns attributes central to the self as opposed to feedback on attributes that are not central to the self (Green & Sedikides, 2004; Newman, Eccleston, & Oikawa, 2017). Similarly, students who highly identify with their university forget more information when they are presented with information that calls into question the academic status of their university, as compared with students who do not identify with their university (Dalton & Huang, 2014). People also are more likely to forget statements from historical passages when those statements describe atrocities committed by a specific cultural group with whom they identify (i.e., American settler) and not by a cultural group that is distant to their identity (i.e., European settler; Imhoff & Banse, 2009; Rotella & Richeson, 2013; Sahdra & Ross, 2007). We note that the literature has used different terms to describe one's self-concept including perceptions, identity, self-perception, and self-image. While these terms are not identical, they all index people's evaluation of their ability in an academic area. Here, we use the more broad term “self-concept” to describe the extent to which individuals hold a predominantly positive mental representation of themselves for a particular domain (Baumeister, 1998).

Why would holding a higher self-concept increase one's vulnerability to threat? Self-Affirmation Theory argues that individuals are motivated to maintain their self-integrity by viewing themselves as good, capable, and worthy (Aronson et al., 1999; Sherman & Cohen, 2006). In the context of education, disfluent learning experiences (i.e., extremely difficult tasks, negative comments, stress and anxiety) in a valued domain can feel quite threatening to students who are motivated to feel capable. These experiences can produce a defensive response that is designed to ultimately minimize the threat. Individuals can respond to these threats using a variety of protective biases that alter attitudes, behaviors, attention, as well as memory processes such as forgetting. Threat-based theories suggest that individual differences in factors that create disfluent learning experiences and high domain-specific self-concept might serve as key ingredients in creating a defensive reaction that leads to forgetting. Hence, even though motivated forgetting is meant to be protective, we wondered whether it also might come at an unintended cost when it occurs for educationally relevant content.

1.2. Motivated forgetting in education

Learning and memory maintenance within educational contexts can be shaped by a variety of competing experiences. For instance, college students develop their intellectual and domain self-concept in a highly stressful environment that often challenges the self-concept they developed during high school (Marsh & Parker, 1984). Several examples of motivated forgetting have been demonstrated for educationally relevant material. For instance, threatening experiences have been found to lead students to forget historical passages (Rotella & Richeson, 2013), personal STEM perceptions (Major, Spencer, Schmader, Wolfe, & Crocker, 1998; Nussbaum & Steele, 2007; Osborne, 1997), and ability judgments (Necka, Sokolowski, & Lyons, 2015).

One recent study asked whether stressful classroom experiences might lead college students to forget math content once the course was over. Ramirez, McDonough, and Jin (2017) began by measuring individual differences in students' math self-concept at the beginning of an academic quarter. They then asked students to report every week how much course stress they experienced. Individual differences in math self-concept positively predicted performance on the final exam, consistent with intuitive notions that math self-concepts are rooted in students' true math ability. However, neither average course stress nor the interaction between average course stress and math self-concept predicted how well students performed on the final exam, presumably because students felt it was unwise to forget course relevant content when they were still participating in the course. The novel finding of this study was revealed two weeks after the course was over: Students with high math self-concept who reported undergoing a stressful course experience exhibited the largest drop in exam performance (i.e., the most forgetting) and even reported that they actively avoided thinking of the course within that two-week time span after the course was over. Ongoing stress was argued to challenge the math self-concept students wanted to maintain, which created a motivation to forget the experience surrounding the course at a time that was most opportune—the summer break. Thus, this study suggests that acute stress is a critical factor that leads to forgetting selectively for students with high math self-concept.

1.3. The relationship between math self-concept and math anxiety

Whereas the aforementioned study by Ramirez et al. (2017) tested the combined influence of math self-concept and course-related stress on forgetting of math content, it also could be the case that trait-related factors, such as math anxiety, enhance defensive mechanisms of forgetting as well. Math anxiety can be defined as a fear or apprehension for situations that involve math. Math anxiety harms math outcomes by creating worries that disrupt working memory and contribute to disfluent learning (Vukovic, Kieffer, Bailey, & Harari, 2013) and performance experiences (Ashcraft & Kirk, 2001). Math anxiety also creates a tendency to avoid experiences that might involve math (Hembree, 1990).

Critically, math anxiety has been shown to be related to, but distinct from, math self-concept (Bai, Wang, Pan, & Frey, 2009; Krinzinger, Kaufmann, & Willmes, 2009). Math anxiety is not synonymous to feeling threatened in the domain of math as some math anxious individuals also are low in math self-concept (Ahmed, Minnaert, Kuyper, & van der Werf, 2012; Jameson, 2014). We also observe that a high degree of math anxiety is found even among individuals with relatively high math self-concept, high math competency, and greater math education (Foley et al., 2017; Hembree, 1990; Ramirez, 2017). Nevertheless, when considering the acute affective reactions and disfluent performance caused by math anxiety, people with high math self-concept may be particularly vulnerable to experiencing threat and subsequent threat-based motivated forgetting. Current evidence suggests that the interaction between math anxiety and math self-concept can create threat-based defensive reactions that lead college students to distort their skill level (Necka et al., 2015) and reduce children's learning across a school year (Ramirez, 2017).

1.4. Current study

The present study builds on previous research to test whether individual differences in math self-concept and math anxiety interact to create threat-based motivated forgetting of math-relevant material. A major assumption made by much of the previous work on motivated forgetting in math is that students only give in to their motivation to forget at opportune times (e.g., during an academic break period, at the end of a research study). This research has assumed that when the learned content is perceived to be irrelevant, students will give in to