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Comparing cognitive load and self-regulatory depletion: Effects on emotions and cognitions

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ABSTRACT

Prior research has found both similar and different effects of self-regulatory resource depletion and cognitive load. To resolve these seeming contradictions, we experimentally compared the effects of cognitive load and self-regulatory depletion. Ego depletion led participants to pay more attention to pain and to persist less on a pain test, whereas load had opposite effects (Study 1). Load distracted people from processing and reacting to negative emotional content of pictures (Study 2), and boosted positive feelings even without an overt emotion induction (Study 3), whereas depletion did not change how people felt relative to control. Depletion and load had equivalent null effects on visual recognition memory (Study 2) but different effects on semantic processing involving emotional connections (Study 3). Taken together, results suggest that load distracts attention away from, whereas ego depletion undermines top-down control over the processing of pain and negatively-valenced content. We discuss implications for learning and instruction.

1. Introduction

Self-regulation and working memory have been at the center of much psychological and educational research and have proven crucial to learning and academic success (Alloway, Gathercole, Kirkwood, & Elliott, 2009; Tangney, Baumeister, & Boone, 2004). Activities that deplete self-regulatory resources or burden working memory capacity can intensely influence both thinking and feeling processes, which may impact learning. Basic research that elucidates and differentiates the effects of self-regulatory depletion and cognitive load thus serves to inform effective teaching and instruction.

In the current research we focused specifically on effects of self-regulatory depletion and cognitive load on the processing of and reaction to emotion-laden information. Often, students must process information that contains emotional content, such as when reading a story for literature class, or that elicits automatic emotional reactions, such as when studying graphic illustrations of the human body in biology class. Learning is not only affected by the extent to which students attend to and process such emotion-laden information, but also by the emotional reactions students have to such information. Positive affect has long been theorized and shown to facilitate whereas negative affect has been thought to undermine educational growth (e.g., Boekaerts, 2007; Buff, Reusser, Rakoczy, & Pauli, 2011). Positive feelings have been linked with improvements in verbal fluency (Carvalho & Ready, 2010), attention to material (Plass & Brünken, 2015), and learning outcomes. Negative feelings have been linked with decrements in motivation, attention to material, overall achievement, and increased shallow processing of important information and task-irrelevant thinking (Pekrun, Goetz, Titz, & Perry, 2002). Limited self-regulatory and working memory resources may differentially affect responding to emotional information. Before developing our hypotheses, we define our terms and review relevant research from psychology on self-regulatory resources and working memory capacity—the two capacities implicated in ego depletion and cognitive load, respectively.

Self-regulation refers to the capacity to override a prepotent response and replace it with a response more in line with one's goals (Baumeister, Vohs, & Tice, 2007; Muraven & Slessareva, 2003). Self-regulation may thus be considered a general purpose capacity to be applied to many different challenges in life, from studying and learning challenging material to losing weight to managing one's emotions. Research has revealed that self-

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regulation is functionally limited: After using it on one task, people perform more poorly on subsequent tasks that also require self-control (Baumeister, Bratslavsky, Muraven, & Tice, 1998). This temporary deficit in the capacity for self-regulation is known as a state of *ego depletion*. To account for the ego depletion effect, theorists have proposed that people use self-regulation as though it relies on a limited inner resource or strength (Baumeister et al., 2007). This resource is temporarily depleted by effortful acts of self-regulation, and in the interim period before the resource is replenished, further efforts at self-regulation are prone to failure.

Working memory refers to the capacity to direct attention and consciously process and manipulate information. Working memory capacity is a reliable predictor of cognitive performance (Engle, 2002). Working memory is also functionally limited: People can manipulate or maintain only about seven pieces (or three or four chunks) of information at a time (Farrington, 2011; Miller, 1956). Procedures or tasks that occupy attention are said to create *cognitive load.* Under cognitive load, fewer processing resources are available for other information. For example, a student solving a new type of math problem must keep in mind the rules and steps by which to solve it, thereby creating a cognitive load that may reduce success at actually solving the problem (Sweller, Van Merrienboer, & Paas, 1998).

Both ego depletion and cognitive load are thought to reduce limited resources and tend to exert similar effects on behavior. For example, both ego depletion and cognitive load have been found to undermine performance on tasks that require deliberate, controlled, and complex cognitive processes (e.g., Ariely, 2000; Drolet & Luce, 2004; Schmeichel, Vohs, & Baumeister, 2003). Despite these commonalities, the present investigation undertook to show that there are important differences between depleting self-regulatory resources and overloading working memory.

Briefly, ego depletion and cognitive load differ insofar as they have different time courses: Ego depletion refers to a lagged or hang-over type effect (i.e., due to prior self-regulatory efforts), whereas cognitive load refers to a concurrent effect (i.e., due to concurrent cognitive processing). Recovery from ego depletion typically requires time for mental rest (Tyler & Burns, 2009), but a cognitive load can be lifted instantaneously (e.g., by processing requirements). Moreover, cognitive load may prevent even relatively simple cognitive processes such as short-term memory maintenance and attention to peripheral information (Lavie, Hirst, De Fockert, & Viding, 2004). Ego depletion, in contrast, does not interfere with attention or short-term memory (e.g., Schmeichel, 2007). Rather, ego depletion reduces the capacity to control attention effectively.

If attention can be conceived as a spotlight, then ego depletion undermines the capacity to control where the light shines, whereas cognitive load reduces the circumference of the spot. Put differently, the student under cognitive load (e.g., reading a new text message during a lecture) may forget what her instructor just said, whereas the student under ego depletion (e.g., having just resisted buying a tempting snack at the vending machine) may have increased difficulty managing her emotional response to a provocative question posed by a fellow student. With these considerations in mind, we conducted a series of experiments to compare cognitive load and self-regulatory depletion with regard to their respective effects on diverse responses to emotion-laden information, which may have important implications for learning and instruction.

1.1. Self-regulation and ego depletion

After initial efforts at self-regulation, people may become less motivated or less able to exercise self-control on further tasks. Myriad experiments and field studies have supported the idea that self-regulatory capacities are limited and subject to short-term depletion or fatigue (for review, see Maranges & Baumeister, 2016, pp. 42–61). Although in modernity, and especially in the West, few people ever encounter the actual danger of exhausting their physical biological energy resources (e.g., glucose), the brain manages them as if it were vital to conserve. As with muscle tissue, the brain keeps track of its own energy expenditures. Via biological and physiological fatigue signals, the brain enforces conservation of resources by allotting fewer resources to metabolically expensive top-down cognitive processes, such as self-control (for a recent review, see Evans, Boggero, & Segerstrom, 2015). Other top-down influences such as motivation and rewards can override such signals to some extent because the resources are not actually limited (e.g., Baumeister et al., 2007). In this way, self-regulation is functionally limited. This state of limited self-regulatory capacity or energy is referred to as *ego depletion*, a term that pays homage to Freud, who was one of the first (and only) scientists to theorize an energy model for the self (Freud, 1923/1961, 1933/1961).

During ego depletion, automatic and intuitive thinking processes remain largely intact, but people tend to make cognitive errors because the capacity for conscious, deliberate, complex thinking is hampered (Masicampo & Baumeister, 2008; Pocheptsova, Amir, Dhar, & Baumeister, 2009). For example, depleted people perform more poorly relative to controls on logical reasoning, deduction, and inference tasks, but perform as well as control participants on simple, automatic cognitive tasks, such as rote memorization or retrieving general knowledge (Schmeichel et al., 2003). These findings fit with models of long-term memory insofar as information or procedures that have been deeply encoded in memory may arise and function automatically, even when the person is not consciously searching memory stores (Atkinson & Shiffrin, 1968; Shiffrin & Atkinson, 1969). The operation of long-term memory thus remains relatively unaffected under ego depletion, which appears to bias information processing toward heuristics, or mental shortcuts, to solve problems (Pohl, Erdfelder, Hilbig, Liebke, & Stahlberg, 2013) at the expense of more controlled or effortful processes.

Ego depletion also influences emotional processes, presumably by reducing success at emotion regulation and inhibition. For example, although negative feelings associated with thoughts of death are usually kept out of conscious awareness, ego depletion disinhibits thoughts and feelings associated with death (Gailliot, Schmeichel, & Baumeister, 2006). Similarly, individuals may suppress feelings of anxiety when taking consequential tests or exams, but this suppression becomes less successful under ego depletion. In one set of studies, depleted people with test anxiety were less successful at ignoring distracting worries and anxious feelings, which led them to perform more poorly on verbal learning and mental arithmetic tasks relative to non-depleted people (Bertrams, Englert, Dickhäuser, & Baumeister, 2013). Hence, ego depletion may have particular relevance for learning and performance in the context of negative emotional information.

A recent review of the neuroscience of self-regulation suggested that ego depletion disrupts top-down, frontal cortices-mediated control over automatic and implicit emotional processes resulting from lower brain regions, such as the amygdala (Heatherton & Wagner, 2011). In this view, top-down control keeps negative affect from interfering with other cognitive processes, but self-regulatory depletion undermines this process and hence may result in increased interference from negative affect. This shift toward automatic, emotional processes instead of more deliberate processes is not necessarily conscious. Indeed, Heatherton and Wagner (2011) proposed that when people are depleted, they become sensitized to cues in the environment that affect cognition

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