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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 and behavior through implicit and unconscious processes. Thus, ego depletion has been associated with decrements in higher level cognition, increases in automatic processing, and interference from negative feelings that individuals otherwise suppress.

1.2. Working memory and cognitive load

Working memory refers to the use of attention to manage short-term memory or the capacity to manipulate and process transient bits of information, but this capacity is limited insofar as working memory can only handle about seven bits, or three to four chunks, of information at a time (for review, see Cowan, 2008). When working memory is burdened with too much information, conscious processing of additional information suffers and the mind relies increasingly on automatic retrieval from long-term memory. Similarly to ego depletion, cognitive loads impair controlled thinking and increases reliance on intuitive modes of thought (Ariely, 2000; Drolet & Luce, 2004). For example, under cognitive load people tend to rely more on simple principles rather than on complex reasoning when considering a moral decision (Greene, Morelli, Lowenberg, Nystrom, & Cohen, 2008). When working memory resources are burdened by load, learning and problem solving abilities also suffer (see Sweller, 1988; Sweller, Ayres, & Kalyuga, 2011; Sweller et al., 1998; Van Merrienboer & Sweller, 2005). Accordingly, instructional designs that reduce cognitive loads on students have become the cornerstone to improved learning in technology-driven classrooms (Sweller et al., 2011; Sweller et al., 1998; Van Merrienboer & Sweller, 2005).

Whereas ego depletion may undermine the capacity to inhibit negative feelings, cognitive load seems to keep strong emotions—perhaps especially strong negative emotions—out of conscious awareness. For example, cognitive load has been found to protect people from feelings of anxiety associated with complex decision making (Drolet & Luce, 2004) and minor threats (i.e., of shocks, which never occurred; Vytal, Cornwell, Arkin, & Grillon, 2012). Further, fMRI studies have found that cognitive load not only reduces subjective experience of negative emotions but also down-regulates activity in brain regions associated with feelings, including the amygdala (Mitchell et al., 2007; Van Dillen, Heslenfeld, & Koole, 2009). When under cognitive load—particularly a load that does not involve emotional content—emotional information is processed less thoroughly and hence exerts less influence on behavior. Hence one thrust of the present investigation was to establish these seemingly opposite effects of cognitive load and ego depletion on emotional responses to emotional information.

The present investigation also examined effects on pain. Recent work has suggested that the brain processes all negative feelings, including both pain and social distress, in the same areas and systems (for review, see Eisenberger, 2012), quite possibly because evolutionary processes coopted simple pain detection systems for use in managing social life. For example, both physical and emotional pain rely on mu-opioid-related signaling, the somatosensory cortices and posterior insula (which provide sensory information about the painful stimulus), and the dorsal anterior cingulate cortex (dACC) and anterior insula (which provide affective and distress information) (for review, see Eisenberger, 2012). The question of whether perceptions of physical pain are affected by cognitive load and ego depletion in the same way that perceptions of emotional pain are will be addressed by the current research.

1.3. Current research

Past work thus suggests that cognitive load and ego depletion have similar effects on controlled cognition but may have different effects on emotional processing. However, to our knowledge no prior studies have compared the effects of load and depletion directly. The current research compared the effects of cognitive load and self-regulatory depletion on cognitive processing of information with emotional content and subsequent emotional reactions. Based on the findings reviewed above, we predicted that cognitive load would distract attention away from negative emotional information and hence limit its impact, whereas ego depletion would not distract attention from negative information and may in fact weaken defenses against such information—thereby allowing it to remain influential and indeed potentially increase its impact.

Our first specific prediction was that people under cognitive load would be distracted from the experience of pain relative to people under ego depletion (Hypothesis 1). To induce the experience of pain in Study 1, we had student participants complete a cold pressor test, which involves immersing one's hand in ice water for as long as possible. Insofar as cognitive load distracts attention away from the experience of pain, this should enable individuals to persevere longer on the pain test, whereas people under ego depletion should be relatively less likely to persevere through the experience of pain.

In the subsequent two studies we focused on cognitive processes that engage the primary modalities by which instructional material is delivered: visual recognition memory and semantic processing, respectively. Most instructional tools (e.g., books, lectures, films, pictures) rely on visual stimuli, semantic stimuli, or both. Visual memory, including the process of encoding visual information, is modulated by the emotional content and context of what people see. Indeed, prior research has observed that people remember negatively-valenced visual information better than affectively neutral information (Kensinger, Garoff-Eaton, & Schacter, 2007a, 2007b, 2006). For example, negative objects (e.g., snake, grenade) are remembered with more visual detail than neutral objects (e.g., football, blender), due in part to increased activation of the amygdala (Kensinger, Garoff-Eaton, & Schacter, 2007b). Further, people are more likely to remember affective images, and perhaps especially negative affective images, better than neutral ones (Ochsner, 2000), even when they fixate equally long on all the images (Christianson, Loftus, Hoffman, & Loftus, 1991). A person's own emotional state can also affect visual memory. Research has observed that people more deeply encode and more often recollect emotionally arousing events, as indicated by increased amygdala activation and a strengthening of the interaction between the amygdala and temporal lobe regions implicated in memory (for review, see LaBar & Cabeza, 2006).

Semantic processing, including the encoding and accessing of words' meanings and connections, is also moderated by emotional content. For example, people naturally process emotional words, especially negatively-valenced words, more quickly than neutral words (Scott, O'Donnell, Leuthold, & Sereno, 2009). Further, the speed and conscious awareness of emotion word processing depend on top-down processes, motivations, and task demands (for review, see Kissler, Assadollahi, & Herbert, 2006). Like memory for visual information, semantic processing is shaped not only by the emotionality of the target stimulus but also by one's emotional state. For example, people in a negative mood are less likely than people in a positive mood to activate semantically related concepts (e.g., nurse/doctor) from their memories (Haänze & Hesse, 1993). Similarly, depressed individuals are less successful than others at ignoring negative information, even if it is task-irrelevant, when making lexical decisions (Sass et al., 2014).

Considering these findings and prior research suggesting that cognitive load distracts attention away from emotional information, whereas ego depletion may undermine top-down control over the cognitive and behavioral effects of emotional information, we predicted that cognitive load and ego depletion would differentially affect visual memory (Hypothesis 2) and semantic processing (Hypothesis 3) of negative emotional information. Specifically, we predicted that ego depletion would improve memory for pictures with negative emotional content (Hypothesis 2; Study 2) and increase the likelihood of matching words by negative emotional association (Hypothesis 3; Study 3)—processes implicitly influenced by negative affect—relative to control and cognitive load participants. Further, we predicted that people under cognitive load would report less negative affect than control or depletion participants after exposure to emotional images (Study 2), consistent with the general hypothesis that cognitive load reduces the processing of emotional information. We also tested the extent to which cognitive load reduces negative emotions even when emotions are not explicitly manipulated (Study 3).

2. Study 1: do cognitive load and ego depletion differentially affect the experience of negative physical feelings?

Study 1 tested how cognitive load versus ego depletion affects people's experiences of and capacity to tolerate pain, a negative visceral state that shares neural substrates with emotional pain. Pain elicits a prepotent response tendency to alleviate or escape the experience of pain. Because cognitive load reduces attentional resources, it should reduce attention to the experience of pain, thereby enabling persons to tolerate aversive stimulation for a longer period of time (Hypothesis 1). Ego depletion, in contrast, should undermine the capacity to ignore or attend away from the experience of pain and hence reduce pain tolerance (Hypothesis 1).

2.1. Method

2.1.1. Participants

Sixty-six undergraduate women attended an experiment advertised as an investigation of emotions and physical stamina. (We sampled only women because men show greater variability and longer persistence times on the cold pressor compared to women; Mitchell, MacDonald, & Brodie, 2004). Participants received credit toward a course requirement for attending. They were randomly assigned to a condition in a 2 (Ego Depletion vs. No Depletion) × 2 (Cognitive Load vs. No Load) between-subjects factorial design.

2.1.2. Materials and procedure

Prior to the cold pressor task, participants read a dull and dense passage of text about the workings of the inner ear in one of two randomly-assigned ways (see Vohs & Schmeichel, 2003). In the *no depletion condition*, participants were instructed simply to "read the text out loud in whatever way is normal and natural for you." In contrast, participants in the *depletion condition* were instructed to "read the text out loud in a way that expresses interest and enthusiasm in what you're reading, as if it were one of the most exciting things you have ever read," which requires self-control in overriding the tendency to read normally and in changing this to a different behavior.

After the reading task, participants attempted the cold pressor test. Specifically, participants were asked to immerse their non-dominant hand in cold water ($M = 33.55$ °F, circulated by a pump) and to keep it there for as long as they could or until they deemed the task too uncomfortable to continue. Mindful of participants' health and safety, we imposed a 4-min time limit on cold-pressor persistence but did not tell participants of the limit prior to the start of the task. Using a stopwatch kept out of the participants' view, the experimenter recorded the duration for which participants immersed their non-dominant hand in the near-freezing water. Only one participant persisted to the 4-min limit.

To manipulate cognitive load during the cold pressor test, participants performed the test in one of two randomly assigned ways. Participants in the *cognitive load condition* were instructed to count backwards in increments of 3, beginning at 881, as they kept their hand immersed in the water. Participants assigned to the *no load condition* simply performed the cold pressor test (without mental arithmetic). Thus, one group divided attention during the cold pressor and one group did not.

After performing the cold pressor test, participants rated how closely they had attended to the pain in their hand during the test and how difficult the test had been to perform (both ratings made on scales from 1 = *not at all* to 7 = *very*). Last, participants were debriefed regarding the purpose of the study, thanked, and dismissed.

2.1.3. Results and discussion

2.1.3.1. Cold pressor pain tolerance. A 2 (Depletion vs. No Depletion) × 2 (Cognitive Load vs. No Load) ANOVA on cold pressor persistence yielded two significant findings. See Fig. 1. First, consistent with the prediction that depletion would undermine the capacity to control the effects of negative physical feelings on behavior (Hypothesis 1), we found a main effect for depletion condition indicating that emotionally exaggerated reading resulted in quitting faster on the cold pressor test, $F(1, 62) = 7.09$, $p = 0.01$, $\eta^2 = 0.10$. Second, cognitive load produced a main effect in the opposite direction, such that counting backward during the test increased the duration of holding the hand in ice water, $F(1, 62) = 6.41$, $p = 0.014$, $\eta^2 = 0.09$. This also provides support for Hypothesis 1. The interaction between depletion and cognitive load was not significant, $F(1, 62) = 1.44$, $p = 0.23$, $\eta^2 = 0.02$. Thus, the two effects were purely separate and additive. They did not modify each other.

2.1.3.2. Attention to pain. After the cold pressor test, we asked participants to rate how much attention they had devoted to the pain in their hand during the test. Analyses revealed a main effect of depletion condition, $F(1, 62) = 4.64$, $p = 0.035$, $\eta^2 = 0.07$, such that participants in the exaggerated reading condition ($M = 6.11$, $SD = 1.30$) reported devoting more attention to the pain compared to participants in the natural reading condition ($M = 5.35$,

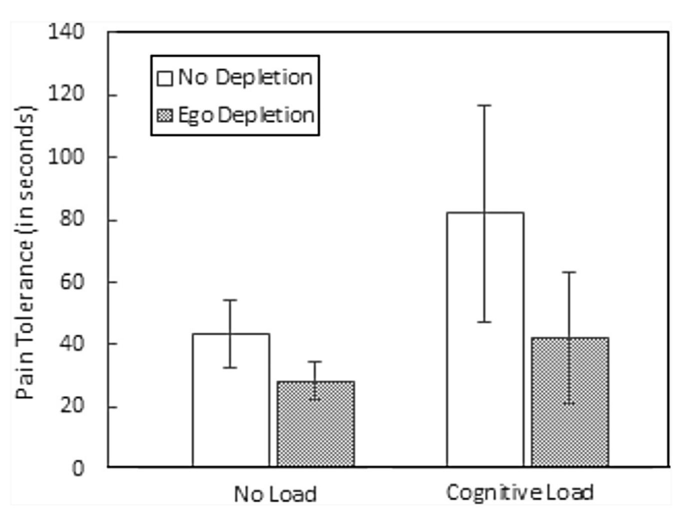

Fig. 1. Cold pressor persistence as a function of condition (Experiment 1). Error bars represent the standard deviation.

$SD = 1.70$). We also observed a marginal effect of cognitive load, $F(1, 62) = 2.37$, $p = 0.13$, $\eta^2 = 0.04$, such that participants in the load condition ($M = 5.50$, $SD = 1.64$) paid somewhat less attention to the pain in their hand relative to participants in the no load condition ($M = 6.03$, $SD = 1.40$). These findings are consistent with reasoning behind Hypothesis 1: cognitive load distracted students from their negative physical feelings, whereas depletion if anything intensified negative feelings. The interaction between depletion and load did not approach statistical significance, $F < 1$, $p = 0.71$, $\eta^2 = 0.002$.

2.1.3.3. Subjective difficulty of cold pressor task. At the end of the experiment, participants rated how difficult it had been to perform the cold pressor test. Analyses revealed only a significant main effect of cognitive load condition, $F(1, 62) = 7.50$, $p = 0.008$, $\eta^2 = 0.11$, such that the cold pressor was rated more difficult when participants counted backwards during the test ($M = 5.82$, $SD = 1.38$) compared to not counting during the test ($M = 4.84$, $SD = 1.41$). The main effect of depletion condition was not significant, $F < 1$, $p = 0.51$, $\eta^2 = 0.007$, and neither was the Depletion × Load interaction, $p = 0.63$. Hence, exaggerated reading prior to the pain test undermined pain tolerance but did not make the pain test subjectively more difficult to perform, whereas cognitive load during the pain test did render the pain test subjectively more difficult to perform but improved pain tolerance.

It may seem illogical that participants rated the cold pressor as more difficult when under cognitive load but also persisted longer under that condition, as compared to the no-load control. Although they were instructed to rate the difficulty of the cold pressor specifically, participants seem to have been responding based on their overall impression, which combined the difficulty of keeping the hand in aversively cold water with the difficulty of mental arithmetic. It is also possible that the high difficulty ratings in the high load condition stemmed directly from their longer perseverance: It is, after all, more difficult to keep one's hand in icy water for 80 s than for 45 s. Indeed, difficulty ratings were significantly correlated with cold pressor duration, $r(64) = -0.377$, $p = 0.002$. Nonetheless, these findings speak against any explanation that doing mental arithmetic made the cold pressor seem easier. Instead, they fit with Hypothesis 1 that cognitive load distracts people from the negative feelings of pain while ego depletion leaves people unable to override the effects of these feelings.

Indeed, people reported paying more attention to their pain after using self-control to "up-regulate" their emotions while reading, whereas people reported paying less attention to their pain under cognitive load, relative to control groups. It could be argued that feigning excitement in the depletion condition primed those participants to be sensitive to emotional and physical feelings, explaining their attention to and more intense experience of pain. We used affectively neutral manipulations in Studies 2 and 3 to mitigate this concern.

3. Study 2: do cognitive load and ego depletion differentially affect feelings and visual recognition memory?

Study 2 extends Study 1 using different procedures. We tested whether cognitive load and ego depletion differentially affect subjective responses to and recognition memory for emotional images. We manipulated ego depletion by having participants write a short essay with difficult directions. Specifically, they had to avoid words using *A* or *N* and then, in a second essay, avoid words using *I* or *O*. This constitutes self-regulation insofar as preparing to write would automatically generate many words using the forbidden letters, thereby requiring the participant to override those responses and replace them with other words. Thus, the writing task demanded repeated overriding of the impulse to use common letters, thereby requiring and depleting self-control (Schmeichel, 2007).

Cognitive load was manipulated by having participants remember a 10-digit string of numbers. Keeping such a long string of numbers in mind requires mentally rehearsing the sequence continuously, thereby taking conscious attention away from other stimuli and activities. The depletion task occurred prior to the dependent measures (i.e., the visual memory task and affect questionnaire) whereas the load task was performed simultaneously with the dependent measures.

Our overarching hypothesis, for which Study 1 furnished initial support, was that people under cognitive load are distracted from negative physical and emotional information, whereas depleted people are relatively unable to inhibit their responses to negative information and thus may feel negative emotions more. We also traced the cognitive effects of depletion versus load by assessing recognition memory for images with varying emotional content. Insofar as negative emotional information enhances visual memory (Kensinger et al., 2007a, 2007b, 2006), we would expect participants under load to recognize negative images less well than other participants (Hypothesis 2). We had no predictions with respect to memory for positive or neutral pictures but included them also for exploratory purposes.

3.1. Method

3.1.1. Participants

Three hundred and eight adult participants were recruited to participate in this study (135 females; mean age = 34.91, $SD = 10.97$) via Amazon's Mechanical Turk (MTurk), an online system that allows researchers to recruit and pay diverse samples of people to participate in surveys or experiments. Participants received $2 for their participation. Because Study 1 found no interaction between ego depletion and cognitive load, Study 2 omitted the condition that combined both manipulations, leaving a three-cell design (cognitive load, ego depletion, and neutral control).

3.1.2. Materials and procedure

Participants signed up to complete an online study on memory and cognition and were randomly assigned to do a cognitive load task, an ego depletion task, or neither task. Those assigned to the *depletion condition* were asked to write a short essay about a recent trip without using the letters *A* and *N*, and also one about an average day's events without using the letters *I* and *O*. Participants were instructed to continue writing until the program automatically progressed after 5 min for each essay. Participants assigned to the *cognitive load condition* were given 30 s to memorize a 10-digit number to recall after the next task. Therefore, these participants had to use attention and working memory to keep the number in mind during the image viewing task, which came next. Participants assigned to the *control condition* immediately began the image viewing task.

The image viewing task proceeded as follows. We instructed participants to study pictures, to be presented one at a time, in order to be able to recognize them later in the study. Participants then viewed five pictures with negative (unpleasant) content (e.g., a man in a hospital bed, a crying child), five with positive (pleasant) content (e.g., puppies in a basket, a child with ice-cream), and five with neutral content (e.g., a boat on a lake, a landscape) from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008); pictures were presented in a random order. Participants could view each picture for as long as they wanted to for up to 30 s before clicking to move on to the next one. (Participants were not informed of the 30 s viewing limit prior to starting the task.) After viewing the images, participants in the cognitive load condition were asked to recall the number they had memorized, and all participants reported their emotions on the short form positive and negative affect scales (PANAS, Watson, Clark, & Tellegen, 1988; Thompson, 2007). The PANAS presents 10 affective adjectives and asks participants to report the "extent to which you feel this way right now" using a rating scale from *1 = very slightly or not at all* to *5 = extremely*. For each participant, we summed and averaged ratings separately for negative (*upset, hostile, ashamed, nervous, afraid*) and positive (*alert, inspired, determined, attentive, active*) feelings to create composite scores.

After filling out unrelated filler questionnaires for approximately 5 min, participants viewed a second set of pictures, which included the original 15 images plus six new distractor images. Distractor pictures included two negative, two positive, and two neutral pictures from the IAPS that were similar to pictures in the original study set. Participants were presented the images one at a time in a random order and were asked to indicate whether they had seen each image before. After this, participants were thanked, debriefed, and paid.

3.1.3. Results and discussion

3.1.3.1. Feelings. As predicted, we observed significant variations among conditions on both negative and positive affect. See Fig. 2. Regarding negative affect, participants in the cognitive load condition reported the least (M = 13.05, SD = 4.64), and depletion condition participants reported the most (M = 15.13, SD = 6.41), with the control condition falling between the mean of the other two groups (M = 14.97, SD = 6.73), F (2, 306) = 4.37, p = 0.013, η^2 = 0.03. Follow up contrasts revealed that the main effect of condition was driven by the differences between the cognitive load group and the ego depletion group, F (1, 204) = 6.18, p = 0.014, and between the cognitive load group and the control group, F (1, 232) = 6.06, p = 0.013, respectively. The difference in negative affect between the control group and the depletion group did not reach significance, $p > 0.25$.

Regarding positive affect, participants in the cognitive load condition reported the most (M = 28.53, SD = 9.85), and those in the depletion condition reported the least (M = 24.00, SD = 8.70), with the control group (M = 26.51, SD = 8.48) falling between the other two groups, F (2, 305) = 5.90, p = 0.003. Follow up contrasts revealed that the main effect of condition was driven by the difference between the cognitive load group and the ego depletion group, F (1, 204) = 11.69, p = 0.001, with marginal differences between both the control and depletion participants, F (1, 177) = 3.26, p = 0.07, and the control group and the cognitive load group, F (1, 232) = 2.79, p = 0.10.

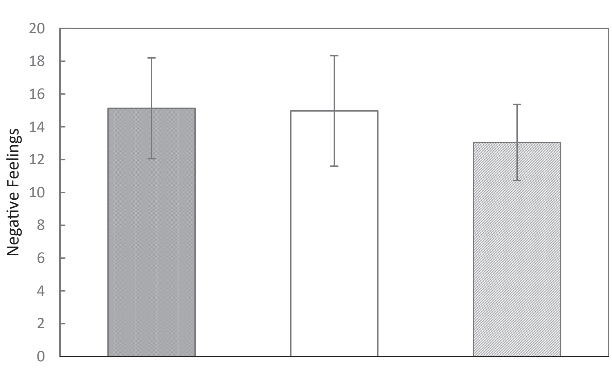

Fig. 2. Negative affect as a function of condition (Experiment 2). The error bars represent standard deviation.

3.1.3.2. Visual recognition memory. The groups did not differ in how long they took to view negative pictures (collapsed across conditions, M = 6.17 s, SD = 5.30), neutral pictures (M = 5.52, SD = 5.11), or positive pictures (M = 6.50, SD = 7.40), all $ps > 0.20$. Regarding subsequent recognition memory for the pictures, contrary to Hypothesis 2 we found no effect of condition on memory for negative pictures or for any picture type, all $ps > 0.40$. Hence, the depletion, cognitive load, and control groups did equally well in recognizing which photos they had (and had not) seen earlier in the study. On average, participants approached the performance ceiling in remembering the five originals and not recognizing the two distractors (for a total of seven memory tests for each picture type): collapsed across conditions, negative M = 6.68, SD = 0.71, positive M = 6.48, SD = 0.96, and neutral M = 6.55, SD = 0.90.

These findings suggest that cognitive load and ego depletion differentially affected explicit subjective responses to emotional images but did not affect the basic cognitive processes involved in visual recognition memory. We had expected that the changes in subjective experience would coincide with changes in cognitive performance (Hypothesis 2), but recognition memory for negative images, unlike negative affect in response to those images, was unaffected by cognitive load. Perhaps the fact that participants' performance neared the ceiling on the recognition memory test prevented us from finding the predicted effect of cognitive load. We propose that a more stringent test of visual memory is necessary before abandoning Hypothesis 2.

Further, Hypothesis 2 hinged on the assumption that cognitive load forestalls attention allocation to and processing of target stimuli, but our load manipulation may have been poorly suited for this purpose. The cognitive load manipulation (rehearsing a 10-digit number) likely occupied the auditory sub-system of working memory, whereas the image viewing task presumably depended upon the visuospatial branch of working memory (Baddeley, 1992). The involvement of these two distinct branches of working memory may help to explain the non-significant effect of cognitive load on memory performance; the numerical load may not have interfered with visuospatial processing required for the recognition memory task. A cognitive load manipulation that relies on the visuospatial sketch pad, such as a dot-pattern memory task (e.g., DeNeys & Schaeken, 2007), may have been more likely to undermine visual memory.

Nonetheless, the images did influence participants' feelings in the current study, and we found that people under cognitive load experienced less negative and more positive affect than did depleted participants and control participants. Hence, even though unpleasant content, such as a violent car crash or a sick man in a hospital bed, was intermixed with neutral and more pleasant content, both control participants and depleted participants reported experiencing more negative affect when the viewing task was done than did participants under cognitive load. These findings complement Study 1's findings to indicate that cognitive load reduces negative emotional experience in response to both physical pain and emotional images, whereas ego depletion does not.

4. Study 3: do cognitive load and ego depletion differentially affect semantic processing?

Study 3 tested again the effects of cognitive load and ego depletion on emotion and cognitive processing, this time in the context of a more complex cognitive process than visual recognition memory: semantic processing. A large portion of educational material is delivered via the written word. The extent to which a student processes text in connection to other words and existing cognitive schema affects how well he or she learns, evidenced by a long tradition of semantic network research (e.g., Collins & Quillian, 1972; McClelland & Rogers, 2003). Emotional tone of words can affect how and which connections are made, thereby affecting learning. Ego depletion and cognitive load may differentially effect how emotional diction is processed.

Some research suggests that people try to keep negative thoughts out of conscious awareness, but that this inhibitory process requires self-regulatory resources (e.g., Gailliot et al., 2006). Hence, ego depletion may increase the influence of negative thoughts on feelings and behavior. In contrast, cognitive load appears to prevent the processing of emotional information and may reduce the influence of emotional events on feelings and behavior. In Study 3, we tested these ideas in a new way.

More specifically, we tested the hypothesis that cognitive load and ego depletion differentially affect the way that emotional information influences semantic processing. The semantic processing measure we used was an adapted lexical judgment task based on the work of Niedenthal, Halberstadt, and Innes-Ker (1999) (see Pahlavan et al., 2010). This task requires participants to match a target word with one of two other words: a semantically associated word or an emotionally associated word (associated either by positive or negative feelings). For example, on one trial of the task, participants decided whether the word *suffering* (negative emotional associate) or the word *brush* (semantic associate) best matched the target word *dentist*. The prediction was that people in the depletion group would match more words by emotional associations, perhaps especially negative emotional associations, relative to people in the cognitive load group, with participants in the control groups falling somewhere between the other two (Hypothesis 3).

We also tested again the overarching hypothesis that cognitive load and ego depletion would have different effects on emotional states. Studies 1 and 2 found that participants under cognitive load experienced less negative physical and emotional feelings compared to other participants. Unlike the previous studies, however, Study 3 did not include an explicit emotion induction. Whereas participants in Study 1 experienced pain and participants in Study 2 viewed emotion-laden images, participants in Study 3 simply completed the semantic processing measure, which included emotional words on some trials. We measured emotional states after the semantic processing task to test whether participants felt differently as a function of experimental condition and a subtler source of emotion-related information. Based on the previous studies and the notion that cognitive load minimizes the processing of emotional information, we expected that participants in the cognitive load condition would report being in a less negative emotional state relative to other participants.

4.1. Method

4.1.1. Participants

Two hundred fifty-four adult participants were recruited to participate in this online study (80 undergraduates, 174 mechanical turkers; 134 females; mean age = 30, *SD* = 12.68). College students participated for course credit and mturkers participated for $1.

4.1.2. Materials and procedure

Participants signed up to complete an online study on cognition and word use. After providing informed consent, participants were randomly assigned to do either a cognitive load task, an ego depletion task, or neither. The manipulations were similar to those used in Study 2. People assigned to the *depletion condition* were asked to write a short story about a recent trip without using the letters *A* and *N* (Schmeichel, 2007). Participants assigned to the *cognitive load condition* were given 30 s to memorize a 10-digit number to recall after the next task. Participants assigned to the *control condition* immediately began the next task.

All participants then completed the lexical judgment task (Niedenthal et al., 1999; Pahlavan et al., 2010). Participants saw a target word (e.g., *walk*) and were asked to match this word with one of two other words. One of the option words was tied to the target word by semantic association (e.g., *race*), while the other option word was tied to the target word by positive (e.g., *beauty*) or negative feelings. Of the 31 total triads, 10 included both a semantic option and a positive emotional option, and 10 included both a semantic option and a negative emotional option. Participants also completed a practice triad and 10 neutral triads that helped to mask the purpose of the task. After the lexical judgment task, participants assigned to the cognitive load condition recalled the memorized number, and all participants completed the PANAS. At the end of the study, participants were thanked, debriefed, and paid or given credit for their participation.

4.1.3. Results and discussion

4.1.3.1. Word matching. Consistent with Hypothesis 3, the main effect of condition on word matching in negative versus semantic association trials was significant, $F\ (2, 251) = 3.20$, $p = 0.04$, $\eta^2 = 0.03$. See Fig. 3. Depleted people ($M = 3.81$, $SD = 2.69$) matched the target word with the negative (affective) option rather than the semantic option more often than did control ($M = 3.37$, $SD = 2.38$) and cognitive load ($M = 3.26$, $SD = 1.91$) participants. Follow-up contrast tests indicated that the depletion group differed from the other two: $F\ (1, 251) = 4.34$, $p = 0.04$, and $F\ (1, 251) = 5.83$, $p = 0.02$, respectively. The cognitive load group and control participants did not differ on number of word matches made based on a negative emotional tone rather than definition, $F\ (1, 251) = 0.34$, $p = 0.56$.

The main effect of condition on word matching in positive versus semantic associations did not reach statistical significance, $F\ (2, 251) = 2.11$ $p = 0.12$, $\eta^2 = 0.02$. However, the groups' relative means are consistent with Hypothesis 3. Follow up contrasts revealed that depleted participants ($M = 4.17$, $SD = 3.33$) matched fewer positively emotionally linked words than did control participants ($M = 4.70$, $SD = 2.38$), $F\ (1, 251) = 4.06$, $p = 0.045$. Participants in the cognitive load condition ($M = 4.43$, $SD = 3.01$) did not match words in positive versus semantic association trials significantly differently than depleted, $F (1, 251) = 0.84$, $p = 0.36$, or control participants, $F\ (1, 251) = 1.23$, $p = 0.27$. Thus, depleted people matched words by negative associations more times and by positive associations fewer times than by semantic meanings, as compared to controls.

4.1.3.2. Feelings. Descriptively, participants in the cognitive load condition ($M = 12.90$, $SD = 7.47$) experienced less negative feelings

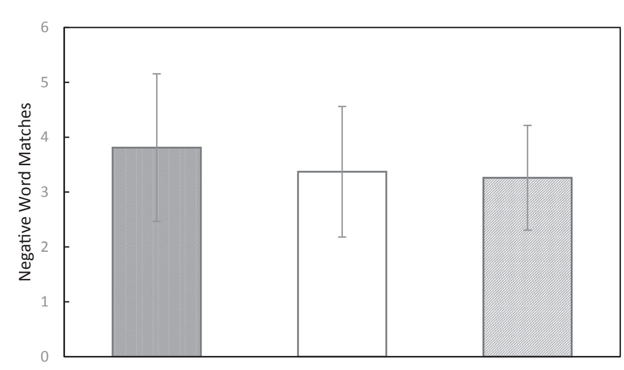

Fig. 3. Negative word matching as a function of condition (Experiment 3). The error bars represent standard deviation.

than did depleted ($M = 14.11$, $SD = 5.34$) or control ($M = 14.32$, $SD = 7.48$) participants. However, the main effect of condition on negative affect was not statistically significant, $F\ (2, 251) = 1.24$, $p = 0.29$. The main effect of condition on positive affect was significant, $F\ (2, 251) = 3.52$, $p = 0.03$, $\eta^2 = 0.03$. Cognitive load participants reported the most positive feelings ($M = 27.78$, $SD = 10.16$), whereas depleted participants felt the least positive feelings ($M = 24.71$, $SD = 8.95$) at the end of the semantic processing task. Control participants' level of positive feelings fell between levels of the other two groups ($M = 26.00$, $SD = 9.01$). Follow up contrast tests reveal that the main effect of condition was driven by the difference between the cognitive load and depletion groups, $F\ (1, 251) = 6.31$, $p = 0.013$, and the difference between the cognitive load and control groups, $F\ (1, 251) = 4.11$, $p = 0.044$. That is, participants under cognitive load reported significantly more positive affect compared to depleted or control participants. Depleted participants and control participants did not differ, $F\ (1, 251) = 0.75$, $p = 0.39$.

Although we did not directly manipulate emotions in Study 3, people under cognitive load nonetheless reported more positive affect at the end of the study relative to both control and depletion condition participants, suggesting that cognitive load boosted positive affect. Depleted participants did not report more negative or less positive emotions than control participants; nevertheless, depleted participants were negatively emotionally biased on the lexical judgment task relative to non-depleted participants (Hypothesis 3). These findings are consistent with but not identical to findings from Studies 1 and 2. One key difference between this study and the prior two studies is that Study 3 did not include an explicit affect induction, such as almost-freezing water or images with highly emotional content. Although the explicit self-report measure of affect did not pick up on depleted participants' more negative and less positive feelings, the subtler lexical decision task did. Further, it is possible that the absence of blatant negative emotional content, combined with the possible reduction in anxiety under cognitive load (Vytal et al., 2012), and the potential for the load task and the lexical task to combine to make a satisfying and rewarding intellectual challenge (for review, see Harter, 1992, pp. 77–114) together produced more positive affect in people under load. These findings require replication before they can be considered conclusive.

5. General discussion

Three studies investigated the differential effects of ego depletion and cognitive load on cognitive processing of emotional information and subsequent emotional reactions. We found that cognitive load distracts conscious awareness from aversive or negative emotional information, thereby minimizing negative emotional experience and reducing the effects of negative emotion on cognition, whereas ego depletion does not. Furthermore, ego depletion appears to disinhibit negative implicit, automatic, emotional processes that manifest in cognition and behavior (whereas cognitive load does not).

Our first study found support for Hypothesis 1: Persons under cognitive load, whose working memory was busied with a backwards counting task, persevered on a pain test for longer than controls, presumably because they were distracted from the negative feeling of pain. Ego depletion, manipulated by performing an emotion "up-regulation" task prior to the pain test, caused people to withdraw their hands from the cold pressor sooner, likely because depletion undermined their top-down control and allowed automatic processes to guide behavior.

We attempted to conceptually extend these findings in the subsequent two studies using difficult writing tasks for our ego depletion manipulations and number memory tasks for our cognitive load manipulations. In Study 2, persons in the cognitive load condition experienced less negative feelings than those in the ego depletion and control conditions and more positive feelings than those in the depletion condition, but there were no group differences on a visual recognition memory task, which involved pictures with emotional information. Thus, Hypothesis 2 was not supported. However, this conclusion must be qualified by an acknowledgement that performance of all groups on the memory test neared ceiling. Study 3 found that, even without an overt affect manipulation, people under cognitive load reported feeling more positive emotion than control participants. Consistent with Hypothesis 3, ego depletion's disinhibiting effects on automatic negative emotions were not evidenced on the explicit measure of emotions. Rather, that negativity was picked up on in the semantic matching task: the depletion group tended to match words by negative rather than semantic associations more often than people in the cognitive load or control conditions and by positive rather than semantic associations less often than control participants. It is not that the ego depletion tasks increase negative emotion any more than the cognitive load tasks. Rather, those sets of tasks both frustrate people but differentially affect how they process and respond to emotional information. Specifically, these results suggest that cognitive load distracts people from negative emotional content on a conscious level, whereas ego depletion interferes with frontal control over lower-brain automatic emotional processes, which may occur without conscious awareness.

5.1. Implications and future directions

We found some support for our predictions across three studies, which used quite different measures and included both student and non-student samples. Results of the current research have both practical and theoretical implications for learning and instruction. As predicted, we found that ego depletion and cognitive load have different effects on processing information with emotional content and subsequent feelings. These studies furnish the first direct comparisons of depletion and load, and they provide evidence that depletion may strengthen whereas load weakens processing of emotional information and reactive negative feelings. The depletion findings fit with prior evidence that depleted people experience more thoughts of death (Gailliot et al., 2006) and anxiety (Bertrams et al., 2013). The cognitive load findings make sense of why people make more reasonable decisions under load (e.g. Drolet & Luce, 2004). That is, although load sometimes hampers complex thinking, it also blocks negative emotions which can drive irrational decision making The other implication here is that the effects of depletion and cognitive load on cognitive processes are not solely due to changes in mental ability but may also be driven by changes in affective responding, which could be implicit or explicit. Indeed, our findings track with the suggestion that ego depletion shifts neural functioning toward the amygdala and lower brain regions (Heatherton & Wagner, 2011), whereas cognitive load shifts functioning away from the amygdala and lower brain regions (Mitchell et al., 2007).

Further, the observed emotional patterns have consequences for important academic outcomes. Indeed, much prior research has established the central role emotions play in cognition and learning. Positive feelings have been associated with improvements in verbal fluency (Carvalho & Ready, 2010), attention to material (Plass & Brünken, 2015), and learning outcomes. Negative feelings have been associated with decreases in motivation, attention to material, shallow processing of important information, increases in task-irrelevant thinking, and low achievement more generally (Pekrun et al., 2002). Emotions in general contribute to the general assessment of learning, even sometimes creating illusions of having learned (Baumeister, Alquist, & Vohs, 2015).

The inability to override negative sentiments under ego depletion may affect the motivation to challenge oneself, a process key to learning advancement. For example, ego depletion may lead to decrements in academic achievement because depleted students choose easier rather than harder practice problems, reducing the challenge and opportunity to learn (Price & Yates, 2010). Our findings add to the growing body of educational research that highlights the importance of considering and measuring affect in research on learning. They also emphasize the importance of studying implicit emotion as well as overt, explicit emotion.

That semantic processing was affected but visual recognition memory was not affected by limiting cognitive resources has two important implications. First, these findings underscore the importance of using a variety of cognitive measures before declaring cognition or executive function is uniformly affected by cognitive load, ego depletion, or emotions. Although semantic processing presumably was biased by people's implicit feelings, visual memory was not, nor was it biased by explicit feelings. Not all cognitive processes will be supported or undermined by the same feelings in the same way. Generally, positive feelings tend to be associated with better learning, greater motivation, more interest, and better synthesis of information, whereas negative feelings tend to be associated with decrements in academic achievement (Matuliauskaite, 2011). However, other research has painted a more nuanced picture of the effects of feelings on cognition. For example, in addition to its beneficial effects outlined above, positive affect can improve performance on creative fluency tasks but impair performance on cognitive switching tasks (Phillips, Bull, Adams, & Fraser, 2002). Likewise, negative feelings can have positive effects on some cognitive processes, such as design fluency (Bartolic, Basso, Schefft, Glauser, & Titanic-Schefft, 1999), and on learning strategies, such as seeking help (Pekrun et al., 2002).

Second, considering that semantic but not visual processing was different for people experiencing cognitive load versus ego depletion, instructors may benefit by diversifying the modalities through which they deliver lessons. For example, some researchers have found that mixing visual and auditory lesson materials reduces students' cognitive load to manageable levels (Mousavi, Low, & Sweller, 1995). Future research may benefit by examining how other multiple sensory instructional designs interact with depletion and load. Taken together with extant literature, our findings suggest that instructional materials and educational assignments should strike a balance between loading and depleting students. That is, material may be of the most benefit to students to the extent that it engages (loads) students' attentional resources and lessens negative affect but does not require so much self-control that students become depleted and their implicit processes, rather than top-down control, guide cognition and behavior. Indeed, higher versus lower cognitive load can decrease (Vytal et al., 2012) whereas ego depletion can release students' feelings of anxiety (Bertrams et al., 2013). Likewise, higher load can lessen the negative impact of induced emotions on a task that requires verbal working memory relative to lower load (Li, Ouyang, & Luo, 2012).

Relatedly, our findings hint at the importance of students' educational experiences for enhancing their emotion regulation skills to facilitate learning outcomes. For example, instructing students to reappraise the importance of emotionally arousing events can lead to their learning and remembering more from educational materials relative to students who received different or no directions (Davis, 2009). Future research may profit by exploring which modes of emotion regulation most benefit students.

Last, our research has an important theoretical implication that is understated in the extant literature. Some research may seem to suggest that because load and depletion both undermine complex thinking or because extended cognitive load can be depleting, those cognitive states rely on the same resource. However, the current evidence for predictable differences in some emotional and cognitive outcomes suggests that the distinction between the resources limited by ego depletion and cognitive load—self-regulatory resources and working memory, respectively—is an important one. Of course, people may use self-control to focus their attention, such as when a student regulates herself to focus during a math exam. Further, attention to the environment may allow students to use self-control better, such as when students paying attention to where their distracting classmates sit regulate their learning more effectively by turning their chairs away from such distractions. However, the capacity to use those two resources in concert does not undermine the current research's implications for the importance of theoretical and empirical distinctions between self-control and attention. Future research should take this distinction into consideration. Thus, our findings highlight the importance of considering whether students are dealing with emotion-laden information, how researchers and educators can capitalize on the differences between ego depletion and cognitive load, and future directions for research.

5.2. Limitations

Several factors limit the conclusions that can be drawn from the current research until findings have been replicated and extended. First, all participants were adults. Although there are no theoretical reasons to assume that the observed effects of ego depletion and cognitive load would be different for younger people, variations in cognitive development may vary the threshold for depletion or load effects, and thus generalizations to younger student populations should be made with caution. Accordingly, future research may benefit by comparing the effects of limited self-regulation and working memory on emotions and cognition in younger samples. Second, although we have suggested that depleted persons' implicit emotions guide cognition and behavior, we measured feelings only with subjective self-reports. Myriad research relies on self-reported affect, yet other research indicates people are not good at introspection (Wilson & Schooler, 1991) and that implicit, rather than explicit, emotions are stronger predictors of behavioral outcomes (Hofmann, Rauch, & Gawronski, 2007).

Further, although we propose load and depletion's differential effects on emotions affect subsequent cognition, we did not design our studies to test for mechanistic factors. Do deficits in cognition during ego depletion or cognitive load result from their direct effects on emotional information processing? Or, do feelings that emerge when people are depleted or loaded and processing emotional information directly cause deficits in cognition, and how? Some research suggests that changes in serotonin and dopamine associated with negative and positive moods, respectively, affect cognition through action in the prefrontal cortex (Mitchell & Phillips, 2007). Other research suggests physiological results of negative feelings, such as changes in heart rate, affect the extent to which people can concentrate and therefore learn (Matuliauskaite, 2011). Do these same biological mechanisms underlie changes that result from ego depletion or cognitive load as well? Future research may profitably examine the causal links between feelings and cognitions when people have limited self-regulatory and attentional resources. Notwithstanding these limitations, to the best of our knowledge, the current research is the first to systematically compare the effects of limited self-regulation and working memory on feelings and cognition, particularly visual memory and semantic processing.

5.3. Concluding remarks

In summary, cognitive load distracts attention away from processing negative emotional information, thereby attenuating the experience of negative physical and emotional feelings, whereas ego depletion may undermine top-down inhibition of implicit affective processes. People under load were able to persevere through pain, while depleted people could not help but attend to and give up because of their pain. Neither burdening working memory nor depleting self-regulation impaired visual recognition memory. In contrast, semantic processing was biased in favor of negative emotional information by ego depletion but not cognitive load. Thus, not all cognitive processes are impaired by burdening attention or depleting self-control. Further, our findings implicate that the effects of how students process emotion-laden information on learning are complicated by the state of their working memory and self-regulatory resources. Depending on the emotional valence of the information and whether students are cognitively loaded, ego depleted, or both, they will differentially process and react to educational materials. Indeed, research has observed that emotions play a significant role in motivation, learning strategies, and academic achievement (Pekrun et al., 2002). Accordingly, the relationships among limited cognitive resources, the processing of emotional information, and feelings should be more consistently incorporated into related educational theories.

Author Contributions

H.M. Maranges designed the overarching hypothesis. B.J. Schmeichel designed, oversaw data collection, and conducted analyses for Study 1. H.M. Maranges designed, oversaw data collection, and conducted analyses for Studies 2 and 3. R.F. Baumeister advised the study design and implementation processes. H.M. Maranges prepared the first draft of the manuscript, and all authors contributed to and approved the final version of the manuscript for submission.

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