Journal of Experimental Social Psychology 69 (2017) 65–70

Contents lists available at ScienceDirect

Journal of Experimental Social Psychology

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

Facilitating emotional regulation: The interactive effect of resource availability and reward processing

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HIGHLIGHTS

- Resource availability and reward interact to impact the efficacy of emotion regulation.
- High resource availability facilitates the effect of reward on emotion regulation.
- Low resource availability inhibits the effect of reward on emotion regulation.
- This pattern holds only for high intensity rewards.

ARTICLE INFO

Article history:
Received 23 February 2016
Revised 17 August 2016
Accepted 3 September 2016
Available online 10 September 2016

Keywords:
Emotional regulation
Cognitive control
Mental resources
Reward processing
Self-control
Resource depletion
Mental fatigue
Anxiety

ABSTRACT

Despite a wealth of knowledge on the importance of resource availability and reward processing for emotional regulation, surprisingly little is known about the extent to which these two mechanisms interact. Indeed, while research largely supports a positive association between reward processing and recovering from a negative emotional experience, the research does not make a clear prediction regarding the effect of resource availability on this relationship. In two experiments, we explored the extent to which resource availability impacts the efficacy of reward processing to reduce the aversive emotional experience of anxiety. We manipulated participants' mental resource availability, induced anxiety, and varied exposure to either a rewarding or non-rewarding stimulus. The findings consistently demonstrate an interaction between resource availability and reward processing; specifically, the combination of high resource availability and reward processing facilitated the greatest levels of anxiety reduction. Moreover, this interaction was shown to amplify with the intensity of participants' exposure to the reward stimulus. We discuss the practical contributions of these findings and their generative nature for further clarifying the processes underlying emotional regulation.

Broadly defined, emotional regulation can refer to a variety of strategies that involve heightening, maintaining, coping with, changing, or recovering from an emotional experience (Ochsner & Gross, 2005; Gyurak, Gross, & Etkin, 2011). It is not surprising that emotional regulation utilizes mental resources (Muraven, Tice, & Baumeister, 1998; Pe et al., 2015; Schmeichel, Volokhov, & Demaree, 2008). For instance, researchers have repeatedly linked mental resource availability to the successful suppression of negative emotions (Schmeichel et al., 2008; Unsworth, Heitz, & Engle, 2005; Pe et al., 2015). Furthermore, the lack of available mental resources can weaken a critical emotional regulation pathway and thereby impact individuals' recovery from adverse emotional states (Muraven et al., 1998; Wagner & Heatherton, 2013).[1]

Mental resources may also have more nuanced effects on emotional regulation. Consistent with a balance model of self-regulation, the lack of available mental resources has been shown to weaken the regulation of striatal brain regions associated with reward processing and may allow cravings to further interfere with self-regulation (Kober et al.,

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[1] The literature review in this domain focuses on effects in which emotional regulation is improved when individuals have access to mental resources. As such, we describe this access as stemming from the availability of mental resources to be consistent with recent perspectives that these resources are differentially allocated and thus differentially available based on various factors such as motivation (Inzlicht & Schmeichel, 2012; Molden et al., 2012, 2016), perception (Clarkson et al., 2011), and goal conflict (Kotabe & Hofmann, 2015) (see also Hirt, Clarkson, & Jia, 2016).

http://dx.doi.org/10.1016/j.jesp.2016.09.002
0022-1031/

2010; Wagner, Altman, Boswell, Kelley, & Heatherton, 2013; Giuliani, Mann, Tomiyama, & Berkman, 2014). For example, chronic dieters who viewed appetizing food images when low (versus high) in resource availability showed greater activation in a reward processing region (orbitofrontal cortex) and less functional connectivity to a mental resource region (inferior frontal gyrus) (Wagner et al., 2013).

These effects of resource availability on reward processing are potentially significant for emotional regulation. Whereas much of the relevant research on depleted resource availability suggests that undesirable rewards and urges can lead to spiraling negative emotional regulation consequences, a small number of emotional regulation studies indicate that positive reward processing can be beneficial to emotional regulation. For example, listening to pleasant music is associated with activation of reward-processing regions (Blood, Zatorre, Bermudez, & Evans, 1999) and was found to significantly reduce negative emotions and physiological arousal (Labbé, Schmidt, Babin, & Pharr, 2007). Similarly, several cognitive neuroscience studies show that activation of a pathway between prefrontal cortex cognitive control regions and ventral striatum correlates with successful reappraisal, one of the most effective and well-studied emotional regulation strategies (Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008; McRae et al., 2010; Buhle et al., 2013). The ventral striatum is often associated with reward processing, and the pathway is thought to be involved in the processing of positive appraisals. However, these studies do not manipulate individuals' available mental resources, so it is unclear if the reward processing would still facilitate emotional regulation for individuals who lack available resources.

The present work provides a direct behavioral test of a potential interaction between resource availability and reward processing on emotional regulation. The aforementioned studies agree that a lack of available mental resources impairs emotional regulation; however, the role of reward is unclear, as the studies that find a positive association with emotional regulation do not consider possible interactions with mental resources. Consequently, we test three interaction hypotheses that can be drawn from extant literature.

First, when mental resources are *unavailable*, a reward stimulus will *harm* emotional regulation. In support of this hypothesis, regulation of reward processing may require the same resources needed for emotional regulation (e.g., Kober et al., 2010). Second, when mental resources are *unavailable*, a reward stimulus will *facilitate* emotional regulation. In support of this hypothesis, a lack of available resources can increase attention towards rewards (Schmeichel, Harmon-Jones, & Harmon-Jones, 2010) which may, in turn, reduce negative emotions (Labbé et al., 2007). Third, when mental resources are *available*, a reward stimulus will *facilitate* emotional regulation. In support of this hypothesis, the aforementioned neuroimaging emotional regulation studies found a relationship between reward processing regions and emotional regulation, and none of those studies reduced participants' resource availability through experimental manipulation (Wager et al., 2008; McRae et al., 2010; Buhle et al., 2013).

Two experiments directly test these hypotheses by manipulating resource availability and the presence or absence of a rewarding stimulus to assess their interactive impact on emotional regulation. Three aspects of our procedure are worth noting. First, we focus on anxiety as a representative negative emotional experience, as numerous studies indicate that anxiety activates a negative appraisal pathway between prefrontal cortex regions and the amygdala (e.g., Ochsner et al., 2004; Banks, Eddy, Angstadt, Nathan, & Phan, 2007; Wager et al., 2008; Heatherton & Wagner, 2011). Importantly, then, we controlled for participants' dispositional tendencies to experience anxiety using the trait anxiety subscale of the State–Trait Anxiety Inventory-Y (Spielberger, Gorsuch, & Lushene, 1970) as well as participants' gender, as prior research shows differences in experienced anxiety across males and females (Feingold, 1994). Second, we did not provide instructions for a specific emotional regulation strategy; instead, we expected participants to pursue spontaneous emotional regulation (Egloff, Schmukle, Burns, & Schwerdtfeger, 2006; Berkman & Lieberman, 2009). Third, the sample size in Experiment 2 was determined by those used in prior experiments on mental resource availability (e.g., Clarkson, Hirt, Jia, & Alexander, 2010; Muraven, Shmueli, & Burkley, 2006), whereas lab demand led to a higher than expected sample size for Experiment 1. Informed consent was obtained from all participants, and all measures, manipulations, and exclusions are reported.

Experiment 1

We conducted an initial experiment to assess the interactive effect of resource availability and reward processing on anxiety reduction. Our manipulation of reward stimulus allowed us to test the role of reward valence by including a control (i.e., no reward) condition.

Method

Participants and design

Three hundred and twenty-six undergraduates (54% Female; $M_{age} = 20.28$), participating for course credit, were randomly assigned to conditions in a 2 (Resource Availability: High or Low) × 3 (Music Exposure: Classical, Heavy Metal, or Silent) between-participant design.

Procedure

Participants were welcomed to the lab where they completed our demographic and STAI-T ($\alpha = 0.90$) background measures. We then exposed participants to our manipulation of resource availability, which we described as a test of cognitive acuity. The task presented participants with a series of six multiple-solution anagrams before being informed that cognitive acuity is either best assessed on this task when respondents pay close attention to the task (*low resource availability*) or when respondents complete the task as they would normally (*high resource availability*). Participants were further told they would have twenty-seconds to generate as many words as possible for each anagram. This manipulation was based on similar instructional sets used to vary resource availability (Baumeister, Bratslavsky, Muraven, & Tice, 1998), as attentional demands reduce resource availability (Baumeister et al., 1998; Clarkson et al., 2010; Muraven et al., 2006).

Following the manipulation of resource availability, participants indicated their current level of mental fatigue on the four-item mental fatigue subscale of the Multidimensional Fatigue Inventory (Smets, Garssen, Bonke, & De Haes, 1995). This subscale assesses one's ability to engage in mental activity (e.g., "It takes a lot of effort to concentrate on things right now."). Responses were obtained on 5-point scales labeled *1 – Not at all true* to *5 – Very true*, and averaged ($\alpha = 0.77$) to form a composite index of mental fatigue, with higher scores indicating greater mental fatigue. This measure served as a manipulation check of resource availability (see Clarkson, Hirt, Chapman, & Jia, 2011).

Participants then completed the anxiety induction task, which was presented as an empathy exercise that described a series of three high anxiety scenarios (e.g., imagine receiving a pop test worth 30% of your course grade). Participants were exposed to each scenario for 2 min, during which they were instructed to experience the scenario as though it were real and to focus on the emotions they would feel. These scenarios were pretested to elicit anxiety and thus served as our situational induction of anxiety given that ruminating on anxiety-provoking stimuli has been shown to heighten the actual experience of anxiety (Tesser, Leone, & Clary, 1978).

After the final scenario, we assessed participants' initial state anxiety using the state anxiety subscale of the STAI-Y (Spielberger et al., 1970). The subscale focuses on the extent to which individuals are currently experiencing anxiety-related symptoms. Responses were obtained on 4-point scales labeled *1 – almost never*, *2 – sometimes*, *3 – often*, and *4*