Consciousness and Cognition 44 (2016) 103–113

Contents lists available at ScienceDirect

Consciousness and Cognition

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

Unwanted reminders: The effects of emotional memory suppression on subsequent neuro-cognitive processing

Ryan Smith *, Anna Alkozei, Richard D. Lane, William D.S. Killgore

Department of Psychiatry, University of Arizona, 1501 N. Campbell Ave, Tucson, AZ 85724-5002, United States

ARTICLE INFO

Article history:
Received 18 February 2016
Revised 27 April 2016
Accepted 24 July 2016

Keywords:
Retrieval suppression
Cognitive control
Insula
Think/No-Think
Emotional interference

ABSTRACT

The neural basis of voluntarily suppressing conscious access to one's own memories (retrieval suppression [RS]) has recently received considerable attention. However, to date there has been limited research examining the effects of RS on subsequent processing of associated retrieval cues. In this study 47 healthy participants completed a Think/No Think task for memories of emotionally unpleasant visual scenes. While undergoing functional magnetic resonance imaging (fMRI), participants were then presented with cues associated with both suppressed ("no-think-cues") and non-suppressed ("think-cues") memories, and then asked to perform simple arithmetic problems. We observed that, compared to think-cues, no-think-cues were associated with greater left mid/anterior insula activation and with greater insula-anterior cingulate functional connectivity; left insula activation also predicted worse arithmetic performance. These results suggest that cues associated with suppressed negative memories may lead to greater activation of the brain's "salience" network, and reduced available cognitive resources for completion of an ongoing goal-directed task.

1. Introduction

The ability to intentionally forget unwanted memories through retrieval suppression has recently been the topic of considerable investigation within the cognitive and neural sciences. Many studies using the Think/No-Think (T/NT) paradigm have now confirmed that this ability exists, and have also begun to construct a model of its neural basis (Depue, 2012). The T/NT paradigm asks participants to first learn a set of cue-target stimulus pairs and then repeatedly presents a subset of the cues (typically during neuroimaging) with the instruction to either remember the target stimulus (retrieval condition) or to keep the target stimulus out of mind (retrieval suppression condition). Other cue-target pairs serve as controls, and cues from these pairs are not presented during the T/NT task after they are learned. After performing this task, it is observed that free recall is worse for suppressed target stimuli relative to control or retrieved target stimuli, suggesting that intentional retrieval suppression results in greater forgetting (e.g., Depue, Curran, & Banich, 2007). This is thought to mimic situations in which a person encounters a reminder to a memory they would rather not think about, and therefore tries to keep it out of their mind.

Studies using the T/NT paradigm find that increased activation of the lateral prefrontal cortex (LPFC; i.e., both dorsal and ventral subregions), primarily in the right hemisphere, is associated with attempting to suppress memory retrieval across

* Corresponding author at: University of Arizona, Department of Psychiatry, 1501 N. Campbell Ave., PO Box 245002, Room 7304B, Tucson, AZ 85724-5002, United States.
E-mail address: rssmith@email.arizona.edu (R. Smith).

http://dx.doi.org/10.1016/j.concog.2016.07.008
1053-8100/

multiple stimulus domains (Anderson et al., 2004; Benoit & Anderson, 2012; Butler & James, 2010; Depue et al., 2007; Gagnepain, Henson, & Anderson, 2014; Levy & Anderson, 2012; Paz-Alonso, Bunge, Anderson, & Ghetti, 2013). In the aforementioned studies, hippocampal (and sometimes surrounding medial temporal lobe) activation simultaneously decreases during suppression trials, suggesting that retrieval suppression may proceed through a process of top-down inhibitory control. This interpretation is further supported by effective connectivity analyses demonstrating that the LPFC has a top-down influence on the hippocampus, and that reductions in hippocampal activation predict later forgetting (Benoit & Anderson, 2012; Gagnepain et al., 2014). Interestingly, LPFC-mediated inhibitory control also appears to interact with content-specific posterior neocortical regions. For example, if the to-be-suppressed memory is visual in nature, cortical regions of the visual system are inhibited (Gagnepain et al., 2014; Kim & Yi, 2013). In these studies, LPFC is also found to be functionally connected with visual cortex during suppression, and this further appears to reduce later visual priming effects (associated with perceptual identification). Thus, retrieval suppression appears to primarily involve right LPFC-mediated inhibition of both hippocampal and neocortical regions associated with memory retrieval.

As suppressing retrieval appears to have a long-term influence on both the implicit and explicit influences of a stored memory, the ability to do so is thought to represent one effective means by which executive control can down-regulate intrusive memories and help an individual adapt in the wake of traumatic experience (Anderson & Levy, 2009; Levy & Anderson, 2008, 2012). As the studies discussed above find individual differences in this ability, it is also possible that such differences may help explain different cognitive/emotional reactions to adverse events. For example, suppression ability appears to decline with age in a manner that may relate to age-related changes in emotion regulation ability (Anderson, Reinholz, Kuhl, & Mayr, 2011); suppression ability also improves over the course of childhood development (Paz-Alonso, Ghetti, Matlen, Anderson, & Bunge, 2009). Further, individuals with post-traumatic stress disorder (PTSD) have been found to display deficits in the ability to suppress unwanted memories within the T/NT paradigm (relative to trauma-exposed control participants), suggesting that this top-down inhibitory ability may be compromised in PTSD (Catarino, Küpper, Werner-Seidler, Dalgleish, & Anderson, 2015). These results highlight the potentially beneficial effects of keeping unwanted emotional thoughts/memories out of mind when appropriate. They are also consistent with other work suggesting benefits of the broader strategy of repressive coping, in which individuals avoid unwanted memories, thoughts, and emotions (reviewed in Bonanno, 2004); such work suggests that this strategy may increase resilience to highly traumatic events. For example, relative to non-repressors, those who use repressive coping show better adjustment following childhood sexual abuse (Bonanno, Noll, Putnam, O'Neill, & Trickett, 2003) and lower lifetime prevalence of psychopathology (Lane, Merikangas, Schwartz, Huang, & Prusoff, 1990). Thus, suppression appears capable of providing important adaptive benefits.

However, to date there has been little work using the T/NT paradigm to assess the possible negative effects of suppressing unpleasant memories. Even if retrieval suppression does result in important benefits, it could also have costs. In fact, many clinical psychologists have traditionally viewed suppressive strategies as unhelpful and maladaptive. This view motivates multiple "third-wave" psychotherapeutic interventions, which stress acceptance/mindfulness (e.g., Hayes, Strosahl, & Wilson, 2003; Segal, Williams, & Teasdale, 2001); well-validated exposure therapies for PTSD (Foa, Hembree, & Rothbaum, 2007) also treat avoidance of reminders as unhelpful, and instead promote prolonged conscious processing of emotional memories. The view that suppression is maladaptive may stem, in part, from a separate body of work suggesting that suppressive/avoidant strategies for dealing with unpleasant thoughts and feelings can have unhealthy and/or undesired effects in both normative and clinical populations (Dalgleish, Hauer, & Kuyken, 2008; Purdon, 1999; Wegner, 1994; Wegner, Erber, & Zanakos, 1993; Wenzlaff & Wegner, 2000). For example, suppressing the expression of emotion can increase physiological responses to affective stimuli and can also impair certain aspects of memory and social functioning (e.g., Gross, 2007, 1998a, 1998b). Suppressing thoughts can instead have unwanted "rebound effects," in which the to-be-suppressed thoughts increase in frequency instead (Wenzlaff & Wegner, 2000). The aforementioned findings have not used the T/NT paradigm, however, and typically involve suppressing automatic reactions in domains outside that of declarative memory (e.g., emotional feelings, emotional expressions, thoughts, etc.). Thus, it is presently unclear whether suppressing unpleasant memories also has similar cognitive costs.

One possibility is that cues to suppressed unpleasant memories are still unconsciously appraised as emotionally relevant. If so, although the memory itself may not enter consciousness, these unconscious appraisal processes might still trigger an affective reaction in response to the cue, and this could reduce available cognitive resources. This possibility is supported by work demonstrating that affective stimuli need not enter consciousness to trigger affective influences on cognition (Bargh & Morsella, 2008; Tamietto & de Gelder, 2010; Winkielman & Berridge, 2004), and by work suggesting that some of the neural mechanisms associated with emotion-antecedent appraisal can operate independent of attention (reviewed in Brosch & Sander, 2013). It is also consistent with a recent review article on the neural basis of emotion (Smith & Lane, 2015); the model proposed in this review suggests that bodily/emotional reactions can be registered unconsciously within the anterior insula (AI), which is a primary hub of the "salience" network. The salience network also includes the anterior cingulate cortex (ACC) and is implicated in the use of emotional signals from the body to guide the allocation of cognitive/attentional resources (Barrett & Satpute, 2013; Oosterwijk et al., 2012; Yeo et al., 2011).[1] Thus, although reductions in conscious memory retrieval may have important benefits, the previous work just reviewed suggests that cues to suppressed memories might still

[1] It should be clarified, however, that a substantial literature implicates the AI and ACC separately in many functions (for reviews, see Craig, 2009; Silvetti, Alexander, Verguts, & Brown, 2014), and that not all of these functional contributions may be clearly captured by the broader "salience network" concept.