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The influence of self-relevant materials on working memory in dysphoric undergraduates

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ABSTRACT

Difficulties in updating working memory (WM) may underlie problems with regulating emotions that contribute to depression. To examine the ability of updating affective materials in WM, 33 dysphoric and 34 non-dysphoric participants were asked to evaluate the self-descriptiveness of emotional adjectives and provide answers to self-relevant questions. Within 3–7 days, they completed a two-back task with a series of self-irrelevant or self-relevant emotional words (they had generated previously) and four conditions (match-set, break-set, perseveration-set, and no-set). After the WM task, an unexpected recall task was administered; controls recalled more positive self-relevant words and intrusions while dysphoric participants recalled more negative self-relevant words and intrusions. In break-set trials of the two-back task, dysphoric individuals showed slower response to self-relevant words regardless of valence. In the match-set and perseveration-set trials, dysphoric participants showed delayed response to self-related negative words. Moreover, longer reaction times for self-relevant negative words were correlated with higher rumination and worse depression. The results suggest that dysphoric undergraduates are interfered more by and have a better memory of self-relevant negative stimuli in WM, which is closely correlated with rumination. This study is among the first to confirm the potential mechanism that could underwrite the involvement of self-schema in effectively regulating negative affect.

1. Introduction

Working memory (WM) is a limited-capacity system that temporarily provides a select set of representations for current cognitive processes (Cowan, 1999; Miyake and Shah, 1999). Experience of negative mood is generally associated with the activation of mood-congruent representations in WM (Pons et al., 2010; Siemer, 2005). Furthermore, difficulty in adaptively updating emotional contents in WM may contribute to the development and perpetuation of mood disorders such as major depressive disorder (MDD). MDD is among the most prevalent and burdensome psychiatric disorders (Gotlib and Hammen, 2008), and it is characterized by difficulties in both emotion regulation and cognitive functioning. Individuals with depression reported pervasive negative thoughts and moods, and problems with memory (Paelecke-Habermann et al., 2005; Rose and Ebmeier, 2006). In fact, participants with MDD indicated lower accuracy and longer reaction times (RTs) during WM tasks (Pu et al., 2011; Rose and Ebmeier, 2006). Thus, WM disturbance may possibly play a critical role in depressive symptoms.

Several studies have confirmed that emotional materials can affect WM (Levens et al., 2011; MacNamara et al., 2012). On conducting the emotional two-back task and the directed forgetting task, participants with depression were found to be slower in disengaging from sad facial expressions and faster in disengaging from happy facial expressions (Joormann and Gotlib, 2008; Levens and Gotlib, 2010). In fact, WM is important not only for the temporary retention of information but also for the acquisition of long-term memory (Marklund et al., 2007). Specifically, the content held in the WM might interact with other long-term emotional materials, such that it becomes more or less positive or negative (Thiruchselvam et al., 2012). Moreover, long-term memory includes autobiographical memory that is correlated with one's self-schema (Rydell et al., 2009). The presence and automatic reactivation of negative self-referent schema about the self, the world, and the future have been considered to play a significant role in the vulnerability to depression (Beck et al., 1996). Thus, it is

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important to observe the influence of self-schema on WM in depression. One earlier study found that the judgment of word color interfered with automatic processing of self-relevant information and resulted in less efficient processing of the self-relevant word, which suggested that working memory was interfered more by self-relevant materials (Yang et al., 2012). However, previous studies on depression have typically used self-irrelevant emotional stimuli, so the WM characteristics of individuals with depression in relation to their own self-schema are not known. This, however, is critical to uncover the potential involvement of negative self-schema in WM of depression, as depression is internal and self-focused.

In addition, rumination is generally believed to be closely related to the disturbance of WM in depression (Joormann et al., 2007; Koster et al., 2013; Vanderhasselt et al., 2013). Cognitive models of depression suggest that a ruminative response style, that is, a stable tendency to respond to negative life events and negative mood states with ruminative thinking and negative automatic thoughts, results in a heightened vulnerability to experience episodes of major depression (Nolen-Hoeksema et al., 1993). Rumination consists of persistent and recurring thoughts that unintentionally enter one's consciousness (Nolen-Hoeksema, 1987) and the tendency to think and rethink the causes and possible consequences of the present affective and physical symptoms (Nolen-Hoeksema and Morrow, 1991). Rumination likely leads to relapse in depression (Spasojevic and Alloy, 2001).

It is possible that a dysfunction in updating the contents of WM – more specifically an inability to discontinue or reduce elaboration of negative stimuli – leads to difficulties in attending to and processing newly incoming information. This results in rumination, thereby making a depressive episode more likely. Previously, the relationship between negative mood and rumination was confirmed in self-irrelevant emotional stimuli (Joormann et al., 2007; Koster et al., 2013). Although the literature proposed a theoretical relationship between self-schema and rumination (Koster et al., 2011), no study tested it directly. One study confirmed that conscious and unconscious autobiographical memory (which belonged to the self-schema system) was correlated with rumination (Watson et al., 2012), indirectly suggesting a relationship between self-schema and rumination. Thus, without direct substantial evidence, it remains unclear whether self-referent stimuli might more strongly activate rumination during a WM task, and therefore interfere with the updating of WM in depression, which is key to exploring the possible relationship between self-schema and rumination in depression.

In studies on depression, dysphoric individuals were selected as research subjects due to the limited availability of patients with clinical depression. Although an attentional bias for negative stimuli was indicated in dysphoric individuals (Koster et al., 2005; Krompinger and Simons, 2009), the presence of a WM bias in these subjects remained unclear. Thus, it is not known whether WM bias is a state marker of depressive episodes, or whether it is a stable cognitive vulnerability possibly associated with the occurrence of depression. This point is crucial for our understanding of the role of cognitive biases in the development, maintenance, and recurrence of this debilitating disorder, especially in its treatment. Individuals currently in a subclinically depressed state, as defined by mild depressive symptoms in the absence of clinical depression (Fu et al., 2012), might progress to a full clinically depressed state if they fail to adjust their cognitive processing effectively. Therefore, individuals in a subclinically depressed state were included in this investigation, to explore whether negative bias in WM is a stable cognitive risk factor possibly associated with the occurrence of depression.

Several tasks have been used to test WM ability (e.g., directed forgetting task, *N*-back task, match-to-sample task, etc.). Among them, the *N*-back task (Cohen et al., 1997) has been used most frequently. This task involves a continuous performance WM measure that, in its higher cognitive load conditions (i.e., two-back and three-back), makes strong demands on WM. During each trial, the participants must process the presented stimulus, add it to their maintained set of stimuli, discard the stimulus presented several trials earlier, compare the current stimulus with the one presented earlier, and then respond. The *N*-back task taps into updating processes involving manipulation as well as maintenance of information in WM (Meegan et al., 2004; Owen et al., 2005; Ragland et al., 2002). In this task, lower accuracy or longer RTs to stimuli indicate difficulty in one's ability to update WM, which was closely correlated with rumination (Joormann et al., 2007; Koster et al., 2013). In order to observe the effect of emotional material on WM of depression, Levens (Levens and Gotlib, 2010) introduced emotional faces into the two-back task in depression. Based on her design, the following four conditions were set: match-set trials, break-set trials, perseveration-set trials, and no-set trials. The match-set trials reflected the ability to integrate, break-set trials the ability to shift, and perseveration-set trials the ability to perseverate in valence, whereas the no-set trials were set as controls. She found that participants with depression were slower to disengage from sad stimuli and faster to disengage from happy facial expressions. The present study uses this task as a methodological foundation, except for the change in materials from emotional faces (Levens' study) to self-relevant emotional words (the present study).

In sum, the purpose of the present study was to investigate whether self-relevant materials during a WM task activate rumination more strongly and therefore interfere with the updating of WM in depression. These self-relevant stimuli were expected to be different from normed or other-relevant stimuli because they are emotional, interrelated, often meaningful, and associated with self-identity (Wisco, 2009). In particular, it was hypothesized that, in comparison with self-irrelevant materials, self-relevant negative materials in a two-back task would be more strongly related to increased rumination and reduced WM performance in individuals with depression.

2. Methods

2.1. Participants

Two groups of participants (English-speaking adults between the ages of 18 and 45 years) took part in this study: non-dysphoric and dysphoric participants. Participants were included in the psychology subject pool at the University of Michigan, and undergraduates obtained course credits for their participation.

Two questionnaires were used to evaluate the depressive severity in participants. The Beck Depression Inventory-II (BDI-II) (Beck et al., 1996) and the Patient Health Questionnaire (PHQ-9, developed by Pfizer Inc. (Spitzer et al., 1999)) were administered to potential participants in the pool of the University of Michigan. Non-dysphoric and dysphoric participants were selected based on the questionnaire results.

Specifically, the inclusion criteria for non-dysphoric individuals were scores of ≤ 4 on the BDI and PHQ, and no self-reported history of depressive disorder or any other psychological disturbance according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR, (APA, 2000)), through an informal oral inquiry about their psychological illness history (though no formal diagnosis). The inclusion criteria for the dysphoric participants were scores of ≥ 14 on the BDI and ≥ 10 on the PHQ (Bora et al., 2006; Clark et al., 2002), with no self-reported history of depressive disorder or any other psychological disturbances,