



The effects of dysphoria and rumination on cognitive flexibility and task selection



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ABSTRACT

Executive dysfunction in dysphoria and dysphoric rumination is often reflected as a difficulty to alter behaviour in response to task demands and is associated with performance deficits on measures of cognitive flexibility. In the present study, participants were required to switch between two randomly ordered spatial location tasks in which the position of a target within a 2×2 grid was determined according to a horizontal or vertical dimension. The typical congruency effect in task switching was replicated such that interference from a currently irrelevant task was associated with slower and inaccurate responses for a currently relevant task. High-ruminators, compared with low-ruminators, displayed poor filtering of the currently irrelevant task which in turn resulted in a specific task selection deficit, and a tendency to perform the irrelevant task. Results suggest that an impaired ability in selecting the appropriate task promoted application of the most salient task regardless of relevance. Our findings extend previous research linking impaired inhibition of irrelevant information with cognitive inflexibility in dysphoric rumination, and argue for an independent contribution of dysphoric rumination to cognitive deficits observed in dysphoria.

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1. Introduction

It is argued that executive dysfunction underlies cognitive impairment in depression (Hartlage, Alloy, Vazquez, & Dykman, 1993), where an important function of the central executive is to promote attentional control by overriding habitual or automatic behaviours (Baddeley, 2002). Attentional control is accomplished through the interaction of three main executive processes of inhibition, set switching, and updating (Miyake, Freidman, Emerson, Witzki, & Howerter, 2000). Generally, unimpaired central executive processes result in flexible goal-directed behaviour (Banich, 2009). Evidence of executive dysfunction in depression and dysphoria (non-clinical depression) has been most consistently found on the Wisconsin Card Sort Test (WCST), a measure of cognitive flexibility (e.g. Channon, 1996; see Rogers et al., 2004 for review of early studies).

Often, depressed individuals show more perseverative errors on the WCST relative to non-depressed individuals reflecting an inability to

adapt to task demands. Recently, pioneering research led by Susan Nolen-Hoeksema and colleagues has elucidated how rumination, the maladaptive process of thinking perseveratively about one's feelings and problems, can affect cognitive performance in dysphoria (Davis & Nolen-Hoeksema, 2000; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). The maladaptive characteristics of individuals who ruminate while in a dysphoric mood state typically include difficulties in concentration on academic tasks, and a greater length and severity of depressive episodes (Lyubomirsky, Kasri, & Zehn, 2003; Spasojevic, Alloy, Abramson, MacCoon, & Robinson, 2003). In addition, regardless of levels of dysphoria, rumination has been associated with perseveration on the WCST (Davis & Nolen-Hoeksema, 2000); however it should be noted that, cognitive inflexibility as measured by WCST does not specify which executive processes are impaired (Rogers et al., 2004). As such, there is a need for a more direct assessment of cognitive inflexibility and executive function in depression as dysphoria and rumination can impair inhibitory function (Joormann, Yoon, & Zetsche, 2007). As dysphoria is characterised by a negative bias, factors such as mood state and rumination in particular, may primarily affect inhibitory processes which are instrumental in inhibiting irrelevant negative information from working memory (Joormann & Gotlib, 2008). The effects of rumination have also been shown on tasks measuring cognitive flexibility,

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Whitmer and Banich (2007) found that rumination was associated with impairment in removing irrelevant information from working memory and task switching performance.

Joormann and Gotlib (2008) used a recognition memory task that required participants to first memorise two word lists of either positive or negative words. Instruction was then given to participants that words in one of the lists would be irrelevant to a subsequent recognition task and could be ignored or forgotten. It was found that when presented with instruction that the negative words were now irrelevant, for depressed participants versus controls, the negative words still remained active in working memory. It was also found that rumination was associated with the maintenance of irrelevant negative words supporting the view that it is closely related to inhibitory deficits. Results of Joormann and Gotlib (2008) provide evidence that depression and rumination are characterised by inhibitory deficits that impair the ability to reduce interference from the irrelevant negative information in working memory.

Whitmer and Banich (2007) found similar results in a task switching paradigm that used neutral stimuli, suggesting that the maintenance of irrelevant information in rumination and dysphoria is not restricted to emotional information. Task switching paradigms assess the ability to rapidly switch between two or more tasks, and are typically used to examine, in a more precise manner, the processes that affect cognitive flexibility (Meiran, 2010). In switching tasks a number of cognitive processes are involved that influence performance (Meiran, 2010). A predominant process in task switching involves the suppression of a performed task in order to move on to the next task. However, this suppression or inhibition tends to persist and can delay responses when task demands require an immediate return to the suppressed task (ie: Backward Inhibition, Arbuthnott & Frank, 2000; Mayr & Keele, 2000). Whitmer and Banich (2007) found that ruminators did not show typical reaction time increases associated with backward inhibition indicating that for ruminators the performed task is not inhibited and remains active in working memory even after it is no longer relevant.

The results of Whitmer and Banich (2007) demonstrated that in rumination and dysphoria cognitive inflexibility was specifically related to an impairment in inhibitory processes that reduce interference from a currently irrelevant task, rather than difficulties alternating between tasks (i.e. set switching). Importantly, the findings of Whitmer and Banich (2007) suggest that inhibitory deficits in depression need not be restricted to negative information (e.g., Joormann & Gotlib, 2008) but can be extended to neutral irrelevant information that can remain active in working memory. While the main finding of Whitmer and Banich (2007) shows that impaired inhibition allowed the currently irrelevant task to remain active for ruminators it remains unclear precisely how impaired inhibition affects behaviour for a currently relevant task.

Within task switching paradigms partial activation of the currently irrelevant task results in less accurate and/or slower responses for a currently relevant task (Kiesel, Wendt, & Peters, 2007). An important function of inhibitory processes is to limit the disruptive influence of irrelevant information on relevant information in working memory (Hasher, Zacks, & May, 1999; Kane, Bleckley, Conway, & Engle, 2001). One way inhibition may do this by filtering out task-irrelevant information (Friedman & Miyake, 2004). In-effective filtering of irrelevant information in dysphoric rumination and dysphoria in general may then affect task switching performance resulting in greater selection of the currently irrelevant task (i.e. reduced accuracy) or by slowing implementation of the currently relevant task (i.e. increased reaction times), or both.

The effect of a currently irrelevant task on performance for a currently relevant task can be best assessed in paradigms that take advantage of the congruency effect (Kiesel et al., 2007). Congruency effects arise when a stimulus requires a different response depending on rule information provided by a task cue (Koch, Gade, Schuch, & Philipp, 2010). Congruency effects can show if the currently irrelevant task is operative and has affected responses on trials for a currently relevant task (Meiran, 2010) and are usually calculated as the difference in

performance between congruent and incongruent response trials. Due to the requirement of selecting the appropriate response, performance on incongruent trials is usually worse than performance on congruent trials. For example, congruent response trials are those in which each task requires the same response (e.g. the letter "P" on a keyboard). Incongruent response trials are those in which each task requires a different response (e.g. one task requires "Z" and the other "P").

To examine congruency effects, the current study used a version of the task switching paradigm presented in Yehene, Meiran, and Soroker (2008). In this paradigm participants are required to switch between two randomly ordered spatial location tasks. Participants were asked to determine the position of a target within a 2×2 grid according to a horizontal (right/left task) or vertical dimension (up/down task). Largely, the right/left task and up/down task are performed equally well (with a performance benefit for the right/left task, indicating that it is the predominant task in the paradigm; right-left prevalence effect, Proctor, Koch, & Vu, 2006). Both tasks are presented randomly within a block of trials (i.e. mixed task blocks). Participants are cued which task to perform at the start of each trial. This design incurs standard decrements and effects associated with task switching, such as switch costs and preparation effects. Switch costs can be measured as performance decrements on switch trials (e.g. performing the right/left task after the performing the up/down task) versus repeat trials (e.g. performing consecutive trials of the right/left task). The preparation effect can be measured as the performance benefit for an upcoming task as the duration of the task cue is increased (e.g. from 100 ms to 800 ms).

In Yehene et al. (2008) performance of patients with lesions involving the basal ganglia, prefrontal cortex, or thalamus, was compared to that of age-matched controls. Patients with basal ganglia lesions showed impaired filtering of irrelevant information. Specifically, basal ganglia patients displayed responses that amounted to randomly guessing task identity and some patients perseverated on a single task by performing it regardless of relevance, while showing unimpaired reaction time congruency effects. Yehene et al.'s (2008) findings supported a disassociation between accuracy and reaction time congruency effects; with reaction time congruency effects primarily reflecting the slow retrieval of task-related information from long-term memory (e.g. task rules) and accuracy congruency effects arising in part from inhibition difficulties (see Meiran & Kessler, 2008, for a similar view). As trait rumination and dysphoria in general are associated with perseverative behaviour (e.g. Channon, 1996; Davis & Nolen-Hoeksema, 2000) we predicted that they may show similar congruency effects as that of basal ganglia patients in Yehene et al. (2008).

While dysphoric participants and participants with a high tendency towards rumination are unlikely to have structural deficits, their performance may mimic the performance of basal ganglia patients in Yehene et al. (2008), due to impaired inhibition. As noted above previous task switching research exploring the congruency effect (e.g. Meiran & Kessler, 2008; Yehene et al., 2008) suggests that impaired inhibition will be associated with reduced accuracy, rather than increased reaction times. Specifically, if dysphoria and high trait rumination are associated with difficulty removing the currently irrelevant task from working memory (Whitmer & Banich, 2007) interference may impair selection of the currently relevant task for each group. On congruent response trials accuracy is usually near ceiling level even in patient populations as both tasks require the same response (Yehene et al., 2008), so it is expected dysphoric and high ruminator participants will perform similarly to their controls on these trials. It is predicted that dysphoric and high ruminator participants will be primarily associated with more errors for incongruent trials relative to non-dysphorics and low ruminators respectively, indicating impaired task selection.

Although the main focus of the current study was to examine congruency effects, the effect of task switching and preparation time were also analysed. Switching is considered an important index of executive function (i.e., set shifting) and preparation is typically associated with changes in task performance (Meiran, 2010). Generally, switch trials

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