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

Max Owens [a,*], Nazanin Derakshan [a,b]

[a] Department of Psychological Sciences, Birkbeck University of London, UK
[b] St John's College Research Centre, St John's College, University of Oxford, UK

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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.

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.

* Corresponding author at: Affective and Cognitive Control Lab, Department of Psychological Sciences, Birkbeck University of London, Malet Street, London, WC1E 7HX, UK. Tel.: +44 2070790773.
E-mail address: maxowensphd@gmail.com (M. Owens).

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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, & Phillipp, 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 are associated with poor performance relative to repeat trials, and trials with long preparation are associated with greater performance than those with short preparation (Meiran, 2010). Switching was examined by comparing performance on trials where the current trial involved an immediate task switch (Switch trials), or was a repeat of the previously performed task (Repeat trials) in a mixed task block (i.e. including both right/left task trials and up/down task trials). To analyse the effect of preparation, the duration of the task cue was varied before presentation of task stimuli (CTI, cue target interval) between periods of short (100 ms), and long preparations (800 ms) as in Yehene et al. (2008). Preparation can reduce task switching effects on accuracy (Meiran, Chorev, & Sapir, 2000). Whitmer and Banich (2007) demonstrated task switching impairment in rumination and dysphoria in general were more closely linked to difficulties inhibiting the currently irrelevant task rather than difficulties in alternating between tasks. As such, typical effects of switching and preparation were expected for dysphoric and high ruminator participants relative to non-dysphorics and low ruminators respectively.

2. Method

2.1. Participants

The study was advertised online through Birkbeck College and University College London automated experiment management systems. 32 participants (12 males and 20 females) were selected for the study. As attention deficits and cognitive inflexibility are typically found for individuals with a moderate level of dysphoria (Channon, 1996; Rokke, Arnell, Koch, & Andrews, 2002) participants for the study were chosen based on their scores from an online survey using the Beck Depression Inventory, BDI-II (Beck, Steer, Ball, & Ranieri, 1996). The BDI-II consists of 21 items assessing the severity of symptoms of depression. Each item has a four point scale ranging from 0 to 3. Participants were allocated to the dysphoric group if their score was greater than or equal to 20 and to the non-dysphoric group if their score was 5 or below. Accordingly, the dysphoric group ($N = 16$, 11 female) had a mean score of $M = 30.25$ ($SD = 7.26$) and the non-dysphoric group ($N = 16$, 9 female) a mean score of $M = 1.75$, ($SD = 1.73$) on the BDI-II. The dysphoric group was significantly younger ($M = 22.06$, $SD = 3.49$) than the non-dysphoric group ($M = 26.50$, $SD = 5.20$), $t(30) = 2.80$, $p < .01$, $r = .44$ (however age did not modulate significant effects of interest, see footnote 3). All participants were tested within two weeks of their first assessment. At testing, each participant was reassessed on the BDI-II. For both groups each participant scored within our initial cut-offs; dysphorics $M = 27.25$ ($SD = 6.29$), and non-dysphorics $M = 1.81$ ($SD = 1.79$).

At testing, participants were also assessed on the short-form Ruminative Response Scale (RRS, Treynor, Gonzalez, & Nolen-Hoeksema, 2003) to determine if trait rumination affected task switching performance. The short-form RRS was specifically chosen over that of the 22 item long-form version of the RRS as its items are not confounded with items on the BDI-II (Treynor et al., 2003). BDI-II scores and RRS scores were not correlated, $r(32) = .18$, $p > .1$ in the current study, suggesting individual differences in rumination within dysphorics and non-dysphorics (see Nolen-Hoeksema et al., 2008 for a similar view). Participants were divided into two equal groups (high-ruminator and low-ruminator) based on a median split of their total scores; high-ruminators ($N = 16$, 9 female), $M = 27.25$, $SD = 3.04$ and low-ruminators ($N = 16$, 11 female), $M = 20.75$, $SD = 2.34$. The high-ruminator group consisted of 9 dysphoric and 7 non-dysphoric individuals; low-ruminators had 7 dysphoric and 9 non-dysphoric individuals. There were no significant age differences between the high-ruminator group ($M = 22.93$, $SD = 3.66$) and the low-ruminator group ($M = 25.62$, $SD = 5.76$), $t(30) = 1.57$, $p = .12$. The proportion of dysphoric participants within the low and high ruminators groups did not differ significantly: χ^2 (1, $n = 32$) = .72, $p = .72$, phi = .12.

2.2. Experimental task and stimuli

Participants were seated in a sound proof room with dimmed lighting, 60 cm from the presentation monitor. Stimuli were presented on a 17 in. LCD with a refresh rate of 16.6 ms. The experimental task was programmed and run using DMDX programming software (Forster & Forster, 2003) on a Dell Optiplex GX520. As highlighted previously, the present study used the task switching paradigm of Yehene et al. (2008). Participants determined the position of a target in a 2×2 grid ($3.4° \times 2.9°$) according to one of two different tasks; up/down or right/left, see Fig. 1. Participants determined whether the target stimulus (an uppercase "T") was located within a square in the upper or the lower half of the grid in the up/down task or whether it was located within a square in the right or left half of the grid in the right/left task. The relevant task was cued in every trial before presentation of the target by arrows ($0.3° \times 0.3°$) outside the grid on the right and left side (right/left) or above and below (up/down) for 100 ms or 800 ms.

Responses were given by pressing one of two keys on a UK/Irish (QWERTY) Dell SK-115 keyboard; "P" button for both up and right responses and "Z" button for down and left responses. For half of the participants the responses were reversed; these participants pressed the "Q" button for up and left responses and the "/" key for down and right. Switch trials in this paradigm are those in which the task on the current trial is different than the task on the previous trial (e.g. up/down, right/left). Repeat trials are those in which at least two consecutive trials were of the same task (e.g. up/down, up/down). There were two Response conditions in both tasks (congruent, incongruent). For congruent response trials both tasks require the same response (e.g. in the "Q","/" mappings if the target is in the upper left corner of the grid both tasks require the button "Q" to be pressed). For incongruent response trials each task required a different response (e.g. in the "Q", "/" mappings if the target is in the bottom left corner right/left task requires to be pressed "Q" and up/down task requires "/" to be pressed). As in Yehene et al. (2008) a directional sticker was placed above each response key to reduce the reliance on memory.

2.3. Design

There were four within-subject variables each with two levels, Trial Type (switch trials, repeat trials), Response (congruent, incongruent), cue target interval (CTI: 100 ms, 800 ms), and Task (up/

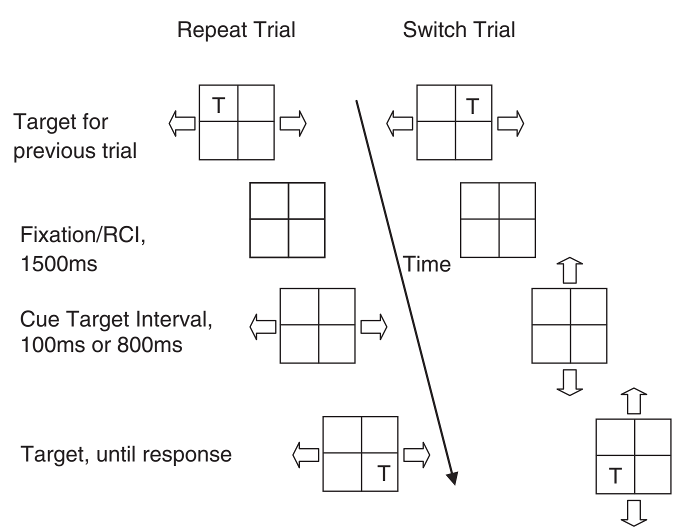

Fig. 1. Example of experimental trials for the present study. The left side shows the sequence of events for a repeat trial in which a right/left task trial is followed by another right/left task trial. The right side of the figure shows a switch trial where a right/left task trial is followed by an up/down task trial.

down, right/left). As there is recent evidence of a performance benefit for the right/left task relative to the up/down task (right–left prevalence, Proctor et al., 2006), Task may be an important factor determining performance so it was also included in the analyses. As shown in Fig. 1 the task in the previous trial was used to determine Trial Type for the current trial. Each level of the Trial Type, CTI, and Response variables were presented equally within blocks.

2.4. Procedure

Before each session participants were given the BDI-II, the short-form RRS, and a short distraction task to undo any mood priming effects of the BDI-II and RRS. The distraction task involved searching for odd numbers and a specific letter (e.g. "L") in two different matrices of letters and number, the task lasted under 5 min to complete. Each session began with instructions for the task. Participants were instructed to use arrows located outside the 2×2 grid to determine the location of the target letter within the grid and respond as quickly and accurately as possible. Participants completed 16 practice trials before the experimental session. The experimental session consisted of 4 blocks of 128 trials.

Each trial began with an empty 2×2 grid that served as fixation and a constant response to cue interval (RCI) for the previous trial. A constant RCI (>1 s) is typically used to minimise the role of passive decay of the previous task set on performance and assess preparation for the upcoming task (Meiran et al., 2000; Yehene et al., 2008). Fixation/RCI lasted for 1500 ms. After the fixation/RCI period participants were cued which task to perform by instructional arrows that were located outside the grid for either 100 ms or 800 ms before the target appeared. The target ("T") could appear in any one of the four positions inside the grid and was displayed until response. Within each block participants were given a short self-timed break after completing half of the trials. The study lasted 60 min; afterwards participants were debriefed and paid £7 for their contribution.

3. Results

3.1. Data reduction

In line with previous research using variants of this paradigm (Meiran & Kessler, 2008; Yehene et al., 2008) reaction time data was trimmed to exclude trials immediately following an error (dysphoric 1%, non-dysphoric 1%) and outliers; reaction times above and below 2.5 standard deviations of a participant's mean were also excluded in the accuracy analysis for each within subject factor. 89% of trials remained for dysphorics and 88% of trials remained for non-dysphorics in the analysis.

3.2. Data analytic plan

Reaction time and accuracy data were first analysed for typical task switching effects in two repeated measures ANOVAs with Task (up/down, right/left), CTI (100 ms, 800 ms), Trial Type (switch, repeat) and Response (congruent, incongruent) as within subject factors. To explore the effect of dysphoria and rumination on accuracy two mixed ANOVAs were conducted with Group (dysphoric/non-dysphoric or high ruminator/low ruminator) as between subject factor and Task (up/down, right/left), CTI (100 ms, 800 ms), Trial Type (switch, repeat) and Response (congruent, incongruent) as within subject factors. Reaction times were also analysed in two mixed ANOVAs. Where appropriate, relevant indices were calculated (i.e. switch cost, congruency and preparation effects; see below for formalization) to follow-up significant interactions involving group.

Table 1
Mean and standard deviation (in parentheses) for reaction time (ms) and accuracy (proportion of correct responses) across participants.

Factor	Level	Mean (SD)	F-value	p-Value	Effect size (η^2)
Task	Up/down	666 (145)	24.71	$p<.001$	.44
	Right/left	619 (115)			
	Up/down	.90 (.12)	6.54	$p=.01$	.17
	Right/left	.96 (.07)			
CTI	100 ms	689 (141)	133.24	$p<.001$	.81
	800 ms	596 (118)			
	100 ms	.92 (.08)	.943	$p=.339$	.03
	800 ms	.93 (.08)			
Trial type	Repeat	618 (118)	50.72	$p<.001$	.62
	Switch	668 (141)			
	Repeat	.95 (.07)	42.01	$p<.001$	.57
	Switch	.91 (.09)			
Response	Congruent	597 (107)	96.91	$p<.001$	.75
	Incongruent	688 (151)			
	Congruent	.99 (.02)	22.28	$p<.001$	.41
	Incongruent	.87 (.15)			

3.3. Analysis of task switching effects

Table 1 shows means, standard deviations and results for the main accuracy and reaction time analyses. Task conflict conditions resulted in poorer accuracy. For Trial Type, switch trials resulted in lower accuracy relative to repeat trials, and for Response, incongruent response trials had lower accuracy than congruent response trials. In line with right–left prevalence effects, there was a main effect of Task showing the up/down task was more difficult to perform than the right/left task. For reaction time, responses were slower for the short CTI interval (100 ms) relative to the long interval (800 ms).[1] For Trial Type and Response, reaction times in task conflict conditions (switch and incongruent) were slower relative to repeat trials and congruent responses respectively.[2] In line with right–left prevalence effects, there was a main effect of Task showing reaction times for the up/down task was slower than the right/left task. Analyses of accuracy and reaction time performance for the Dysphoric group (dysphoric and non-dysphorics) and Rumination group (high-ruminator and low-ruminator) were conducted separately and are reported next.

3.4. Task performance in dysphoria[3]

3.4.1. Congruency effects

It was predicted that dysphoria would affect accuracy specifically for incongruent response trials. No support was found for this prediction. Dysphorics and non-dysphorics performed similarly on congruent and incongruent response trials. There was no main effect of group for

[1] There was no evidence of a speed accuracy trade-off for preparation effects: $r=.06$, N = 32, NS.

[2] There was a significant Trial Type × CTI interaction $F(1,31)=18.23$, $p<.001$, $\eta^2=.37$. reflecting a reduction in switch cost (SC, switch trials–repeat trials) at long CTI intervals (*M difference* = 28, *SD* = 23) relative to short CTI intervals (*M difference* = 70, *SD* = 64), $t(31)=4.27$, $r=.40$, as this effect is typically taken as evidence of task set reconfiguration we have subsequently interpreted significant CTI effects as reflecting preparatory control (Meiran et al., 2000).

[3] To control for differences in age on performance of dysphoric participants, two separate ANCOVAs were conducted with group (dysphoric and non-dysphoric) as the between subject factor, Task, CTI, Trial Type and Response within subject factors, the dependent variable was performance (accuracy or reaction time) and age as the covariate. For accuracy, there was no main effect of Age, $F(1, 29)=2.31$, $p=.13$ or significant interactions including Age, all *p's* > 1. Significant interactions remained between Group × CTI, $F(1, 29)=6.18$, $p=.01$, $r=.12$, Group × CTI × Trial Type, $F(1, 29)=4.03$, $p=.03$, $r=.15$, Group × CTI × Response, $F(1, 29)=5.03$, $p=.03$, $r=.16$. For reaction times, there was no main effect of Age, $F<1$ or significant interactions involving Age, all *p's* > .1. The significant interaction remained between Group × CTI × Task, $F(1, 29)=4.82$, $p=.03$, $r=.14$. Results indicate that age was unrelated to task performance in dysphoric participants.

accuracy (dysphorics, $M = .92$, $SD = .10$) and (non-dysphorics, $M = .94$, $SD = .05$), $F(1,30) < 1$, N.S. nor a Group × Response interaction, $F < 1$. Specifically, there was no significant difference between dysphorics ($M = .98$, $SD = .02$) and non-dysphorics ($M = .99$, $SD = .00$) on trials with congruent responses, $t < 1$. There were no significant differences for incongruent response trials for dysphorics ($M = .85$, $SD = .18$) compared to non-dysphorics ($M = .89$, $SD = .11$), $t < 1$.

3.4.2. Interactions involving group

3.4.2.1. Accuracy. Preparation has been shown to facilitate accuracy in task switching (Meiran & Daichman, 2005). It was expected that both groups would show typical effects of preparation on switching and task selection. However, significant interaction effects including group were observed for CTI; there was a significant CTI × Group interaction, $F(1,30) = 4.95$, $p = .03$, $\eta^2 = .14$ that was qualified by higher order interactions with Trial Type; CTI × Group × Trial Type, $F(1,30) = 4.40$, $p = .04$, $\eta^2 = .12$ and Response; CTI × Group × Response, $F(1,30) = 7.34$, $p = .01$, $\eta^2 = .19$.

The CTI × Group × Trial Type interaction showed an interaction between CTI × Trial Type for dysphorics, $F(1, 15) = 5.82$, $p = .02$, $\eta^2 = .28$, but no interaction between these factors for non-dysphorics, $F(1,15) < 1$, N.S. Both groups performed near ceiling levels on repeat trials across CTI; dysphorics 100 ms ($M = .94$, $SD = .08$) and 800 ms ($M = .94$, $SD = .10$), non-dysphorics 100 ms ($M = .96$, $SD = .06$) and 800 ms ($M = .96$, $SD = .06$), so our follow-up analysis focused on switch trials.[4] For switch trials dysphorics displayed a benefit of preparation across CTI intervals; for switch trials, short CTI (100 ms; $M = .88$, $SD = .11$) relative to long CTI (800 ms; $M = .91$, $SD = .11$), $t(15) = 2.58$, $p = .02$, $r = .13$. Conversely, non-dysphorics did not show preparation effects for switch trials across short CTI ($M = .93$, $SD = .05$) and long CTI intervals ($M = .92$, $SD = .06$), $t(15) < 1$, N.S.

The CTI × Group × Response interaction showed an interaction between CTI × Response for dysphorics, $F(1, 15) = 4.88$, $p = .04$, $\eta^2 = .24$, and no interaction between these factors for non-dysphorics, $F(1,15) = 2.50$, $p = .13$. Both groups performed at ceiling levels for trials with congruent responses suggesting that the choice of response (e.g., pressing the button for "up/left" for a target in the upper left corner of the grid) for both groups was not affected across CTI; dysphorics 100 ms ($M = .99$, $SD = .02$) and 800 ms ($M = .99$, $SD = .03$), non-dysphorics 100 ms ($M = .99$, $SD = .01$) and 800 ms ($M = .99$, $SD = .01$), so our follow-up analysis focused on incongruent response trials.[5] For incongruent response trials dysphoric participants showed the expected benefit of preparation; showing increased performance from short CTI (100 ms; $M = .83$, $SD = .18$) to long CTI intervals (800 ms; $M = .87$, $SD = .19$), $t(15) = 2.10$, $p = .05$, $r = .10$. Conversely, non-dysphorics did not show preparation effects for incongruent response trials across short CTI ($M = .89$, $SD = .11$) and long CTI intervals ($M = .88$, $SD = .12$), $t(15) = 1.34$, $p = .19$. No other significant interactions were observed for the dysphoria groups on the accuracy data.

3.4.2.2. Reaction time. There was no main effect of group for reaction time: dysphorics ($M = 645$, $SD = 125$) and non-dysphorics ($M = 641$, $SD = 135$), $F(1,30) < 1$, N.S. However, a significant Task × CTI × Group interaction, $F(1,30) = 7.18$, $p = .01$, $\eta^2 = .19$ showed that increasing CTI significantly reduced reaction time for dysphorics in the up/down task (100 ms; $M = 701$, $SD = 143$) and (800 ms; $M = 627$, $SD = 133$), $t(15) = 7.27$, $p < .001$, $r = .25$ and the right/left task (100 ms; $M = 670$, $SD = 129$) and (800 ms; $M = 582$, $SD = 117$), $t(15) = 8.64$, $p < .001$, $r = .33$. For the non-dysphoric group increasing CTI also significantly reduced reaction time for the up/down task (100 ms; $M = 725$, $SD = 186$) and (800 ms; $M = 611$, $SD = 133$), $t(15) = 7.11$, $p < .001$, $r = .33$ and right/left task (100 ms; $M = 661$, $SD = 129$) and (800 ms; $M = 564$, $SD = 104$), $t(15) = 9.40$, $p < .001$, $r = .38$, however non-dysphorics appeared to benefit more from the increase in CTI relative to dysphorics. To test the effect of preparation on reaction times the difference between long and short CTI was calculated (CTI 800 ms minus CTI 100 ms) for both groups in each task.

Preparation was associated with a greater reduction in reaction times in the up/down task for non-dysphorics ($M\ difference = -114$, $SD = 64$) relative to dysphorics ($M\ difference = -73$, $SD = 40$), $t(30) = 2.12$, $p = .04$, $r = .35$ which may reflect more efficient preparation in non-dysphorics for this task. Reaction times for the right/left task were reduced to a similar degree for the non-dysphoric ($M\ difference = -96$, $SD = 41$) and dysphoric group ($M = -88$, $SD = 40$), $t(30) < 1$, N.S. No other significant interactions were observed for the dysphoria groups on the reaction time data.

3.5. Task performance in rumination

3.5.1. Congruency effects

As rumination may also affect the removal of irrelevant information in working memory (Whitmer & Banich, 2007) it was predicted to affect accuracy, specifically for incongruent response trials. A main effect of group, $F(1,30) = 4.39$, $p = .04$, $r = .38$ showed that high-ruminators ($M = .90$, $SD = .10$) were significantly less accurate than low-ruminators ($M = .96$, $SD = .02$). There was a significant Group × Response interaction, $F(1,30) = 4.43$, $p = .04$, $\eta^2 = .12$. High-ruminators ($M = .98$, $SD = .02$) and low-ruminators ($M = .99$, $SD = .00$) performed at ceiling levels on trials with congruent responses. However, for incongruent response trials, high-ruminators had significantly lower accuracy ($M = .81$, $SD = .20$) compared to low-ruminators ($M = .92$, $SD = .04$), $t(30) = 2.11$, $p = .04$, $r = .35$ suggesting impaired filtering of the currently irrelevant task which resulted in a task selection deficit.

3.5.2. Interactions involving group

3.5.2.1. Accuracy. There was a significant Group × Task × Trial Type interaction, $F(1,30) = 8.26$, $p < .01$, $\eta^2 = .21$ which was qualified by a higher order interaction that included Response; Group × Task × Trial Type × Response, $F(1,30) = 5.05$, $p = .032$, $\eta^2 = .14$. The higher order interaction with Response (congruent, incongruent) may indicate that interference from the irrelevant task influenced switching. The Group × Task × Trial Type × Response interaction was followed up to explore the characteristics of task switching performance.

For high-ruminators and low-ruminators accuracy trials with congruent responses were at ceiling levels across Tasks and Trial Types. Follow-up analyses focused on switch and repeat trials for the up/down task and right/left task with incongruent responses. These analyses showed performance was less accurate for switch relative to repeat trials for high-ruminators in the up/down task (repeat, $M = .78$, $SD = .32$) and (switch, $M = .70$, $SD = .33$), $t(15) = 3.10$, $p = .007$, $r = .12$, and right/left task (repeat, $M = .91$, $SD = .14$) and (switch, $M = .85$, $SD = .22$), $t(15) = 2.70$, $p = .01$, $r = .16$. For low-ruminators performance was also less accurate for switch relative to repeat trials in both tasks; up/down task (repeat, $M = .94$, $SD = .05$) and (switch, $M = .83$, $SD = .07$), $t(15) = 10.54$, $p < .001$, $r = .67$ and right/left task (repeat, $M = .98$, $SD = .02$) and (switch, $M = .94$, $SD = .05$), $t(15) = 3.63$, $p = .002$, $r = .46$. However, for low ruminators, in switch trials, there was a greater effect on accuracy for the up/down task relative to the right/left task. Incongruent response trials require filtering the currently relevant task to make an accurate response. The following analysis assessed the degree that interference from the irrelevant

[4] Between group comparisons show that within the CTI × Group × Trial Type interaction was no significant between group differences for switch trials at 100 ms ($t(30) = 1.57$, $p > .1$).

[5] Between group comparisons show that within the CTI × Group × Response interaction there were no significant between group differences for incongruent trials at 100 ms ($t(30) = 1.28$, $p > .2$).

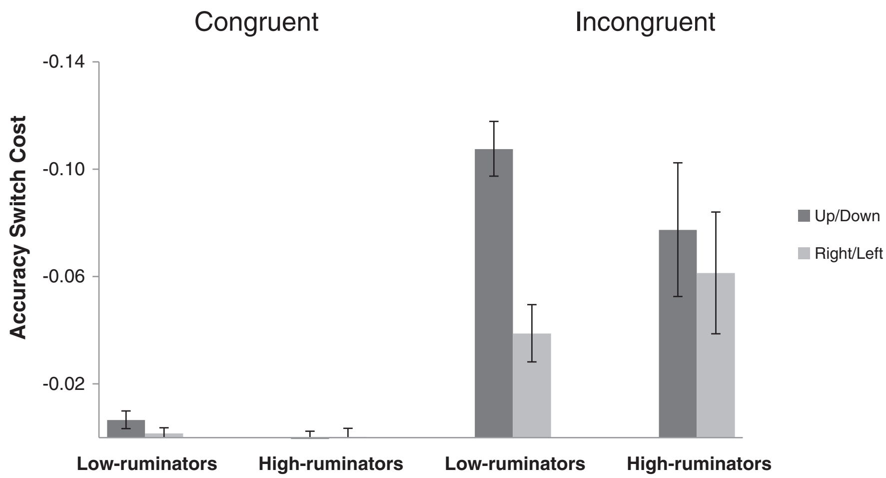

Fig. 2. Accuracy switch cost (switch minus repeat trials) as a function of Group (high-ruminators, low-ruminators), Task (up/down, right/left) and Response (congruent, incongruent) with standard error bars.

task affected accurate task selection for switch relative to repeat trials for high-ruminators and low-ruminators. As switching affects accuracy (e.g. Meiran & Daichman, 2005) the accuracy switch cost (switch minus repeat trials) was calculated for the proportion of correct responses for each task, see Fig. 2.

Low-ruminators had significantly greater accuracy switch cost for the up/down task (M *difference* $= -.11$, $SD = .04$) relative to the right/left task (M *difference* $= -.04$, $SD = .04$), $t(15) = 6.12$, $p < .001$, $r = .65$ thus it may have been more difficult to perform the up/down task because the right/left task was harder to filter, in line with right–left prevalence effects that the right/left task is the predominant task in the paradigm (Proctor et al., 2006). Conversely, high-ruminators did not show a switch related modulation of accuracy between the up/down task (M *difference* $= -.08$, $SD = .10$) and the right/left task (M *difference* $= -.06$, $SD = .09$), $t(15) = <1$, which indicates that high-ruminators did not filter the right/left task to the same degree as low-ruminators. No other significant interactions were observed for the rumination group on the accuracy data.

3.5.2.2. Reaction time. There was no main effect of group on reaction time; high-ruminators ($M = 641$, $SD = 127$), low-ruminators ($M = 644$, $SD = 134$), $F(1,30) < 1$, N.S. However, a significant Group × Task × Response interaction, $F(1,30) = 6.10$, $p < .02$, $\eta^2 = .16$, was observed that was qualified by a higher order Group × Task × Response × CTI interaction, $F(1,30) = 6.53$, $p < .02$, $\eta^2 = .17$, means and standard deviations for this interaction are listed in Table 2. To simplify the Group × Task × Response × CTI interaction, the reaction time congruency effect (RTCE, incongruent–congruent) was calculated. Generally, the RTCE estimates the degree of interference from the currently irrelevant task. As such, a reduction of RTCE as the CTI period is lengthened would indicate reduced interference of the currently irrelevant task as a function preparation. RTCE was analysed by short (100 ms) and long (800 ms) CTI periods for each group. The RTCE for the up/down and right/left task for each CTI period is shown in Fig. 3.

Table 2
Mean reaction time by Ruminator Group, Task, Response, and CTI.

Group	Task	Response	CTI	Mean (SD)
High-ruminators	Up/down	Congruent	100 ms	654 (128)
			800 ms	564 (106)
		Incongruent	100 ms	751 (187)
			800 ms	661 (153)
	Right/left	Congruent	100 ms	618 (94)
			800 ms	546 (107)
		Incongruent	100 ms	729 (157)
			800 ms	608 (129)
Low-ruminators	Up/down	Congruent	100 ms	657 (138)
			800 ms	570 (109)
		Incongruent	100 ms	792 (216)
			800 ms	682 (167)
	Right/left	Congruent	100 ms	625 (115)
			800 ms	543 (97)
		Incongruent	100 ms	689 (115)
			800 ms	595 (116)

As depicted in Fig. 3, results for low-ruminators appear to indicate reduced interference of the currently irrelevant task as a function preparation; they show greater RTCE in the short CTI period relative to the long CTI period when the currently relevant task was up/down or right/left, however this effect was non-significant for the up/down task, $t(15) = 1.65$, $p > .1$ and the right/left task, $t(15) = 1.05$, $p > .2$. In contrast, for high-ruminators this pattern was task specific; they showed similar RTCE across CTI periods when the up/down task was the currently relevant task, $t(15) < 1$, thus the level of interference from the currently irrelevant right/left task did not change. High-ruminators showed significantly reduced interference when the right/left task was the currently relevant task across CTI periods; short CTI (M *difference* $= 111$, $SD = 92$) and long CTI (M *difference* $= 62$, $SD = 39$), $t(15) = 2.89$, $p = .01$, $r = .32$. Together, results for high ruminators suggest that across CTI periods the right/left task was relatively active regardless of which task was currently relevant. No other significant interactions were observed for the rumination group on the reaction time data.

4. Discussion

Impaired inhibition may underlie perseverative behaviour in dysphoria and dysphoric rumination, however it is unclear in what way this disrupts performance for a currently relevant task. The current study chose a task switching paradigm that allowed for a direct analysis of the degree that incomplete filtering of a currently irrelevant task affected accurate task selection and the speed of task rule implementation for a currently relevant task (Yehene et al., 2008). The congruency effect was replicated; trials with incongruent responses were performed less accurately and slower than trials with congruent responses showing the currently irrelevant task was active and interfered with task selection and task rule implementation respectively. It was found that (1) rumination but not dysphoria was associated with poor performance relative to their control group, this was reflected in lower overall accuracy; (2) poor accuracy for high-ruminators was driven by impaired filtering of the currently irrelevant task that resulted in a specific task selection deficit; and (3) high-ruminators showed a tendency to perform the predominant right/left task, irrespective of its relevance, indicative of a performance that showed less flexibility to changing task demands. While low-ruminators

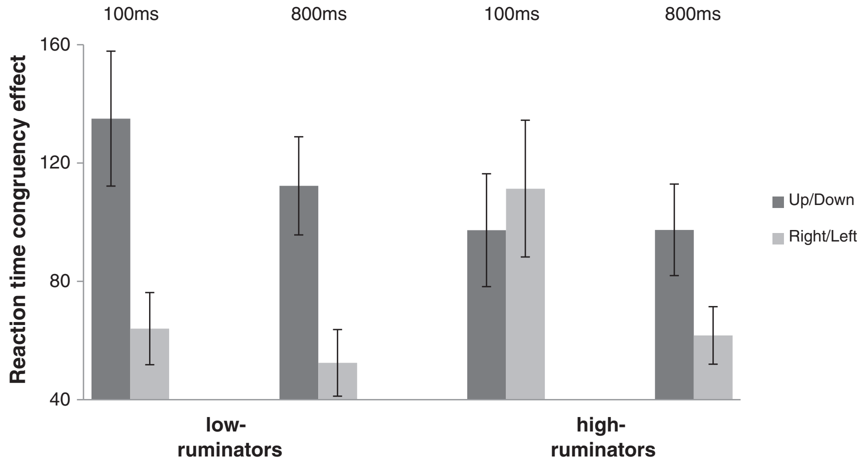

Fig. 3. Reaction Time Congruency Effect (incongruent–congruent) as a function of Group (high-ruminators, low-ruminators), Task (up/down, right/left) and CTI (100 ms, 800 ms) with standard error bars.

adapted responses to specific task demands which in turn facilitated effective goal directed behaviour. Additionally, in the current study it was found that level of dysphoria (BDI-II) and rumination (short-form RRS) was not correlated. The independence of dysphoria and rumination here lend support to proposals that rumination can be regarded as an individual difference factor in dysphoria (Nolen-Hoeksema et al., 2008).

4.1. Effect of rumination on task selection

It was hypothesised that due to impaired filtering of the currently irrelevant task, rumination would be associated with a task selection deficit. Our hypothesis was supported by the results: high trait rumination versus low trait rumination was associated with more errors on incongruent response trials. It has been proposed rumination impairs overall performance (Nolen-Hoeksema et al., 2008). Results of the current study agree with this proposal and extend behavioural findings of Whitmer and Banich (2007) by showing that in high-ruminators, the currently irrelevant task is not filtered, and that this task remains active and results in a task selection deficit for a currently relevant task. To our knowledge this is the first study to demonstrate impaired inhibition of irrelevant information in working memory results in less accurate performance for a currently relevant task.

Low-ruminators flexibly shifted attention between tasks as shown in significant switch costs (Meiran, 1996) that were observed for accuracy and were modulated by Response and Task. Specifically, low ruminators showed significant switch costs for the up/down versus the right/left task within incongruent response trials. Results suggest that low-ruminators actively attempted to filter the more salient right/left task in working memory. An important function of inhibition is to prevent application of a more dominant task to produce effective goal directed behaviour (Friedman & Miyake, 2004). Low-ruminators had more errors and slower responses for the up/down task relative to conditions in which the right/left task was currently relevant. In this respect, the more accurate task selection of low-ruminators versus high-ruminators suggested more effective goal directed behaviour in the low ruminator group.

4.2. The relationship between prepotent response inhibition, perseveration and rumination

The task selection deficit observed in high-ruminators versus low-ruminators highlighted an important relationship between prepotent response inhibition and perseverative behaviour. Specifically, it was found that when given time to prepare for an upcoming task high-ruminators showed less interference from the currently irrelevant task only when it was the up/down task, as indexed by reduced reaction time congruency effects for the currently relevant right/left task from a period of short preparation (100 ms) to a period of long preparation (800 ms). In contrast, when the more dominant right/left task (i.e. right–left prevalence, Proctor et al., 2006) required filtering, high-ruminators did not show a modulation of reaction time congruency effects for the currently relevant up/down task from the short preparation period to the long preparation period. These results suggest that not only does impaired response inhibition result in the maintenance of a particular mode of responding regardless of relevance; but also it determines the focus of the perseverative behaviour. It has been proposed that rumination is the dominant or prepotent response to depression and a manifestation of perseverative behaviour (Davis & Nolen-Hoeksema, 2000; Hertel, 2004). Our results agree with these views. Additionally, understanding why individuals who ruminate find it difficult to control their attention and redirect their thoughts is an important question (Joormann et al., 2007; Koster, De Lissnyder, Derakshan, & De Raedt, 2011). For the current study the dominant right/left task appears to remain relatively active for high-ruminators. The results imply that prepotent response inhibition is the underlying mechanism involved in driving the selection of, and the continued maintenance of, a ruminative response.

The use of tasks with negative stimuli has been used extensively to demonstrate why individuals initiate a cycle of increasingly negative ruminative thinking and intensifying negative affect (Gotlib & Joormann, 2010). For instance, using an affective variant of the paradigm presented in Whitmer and Banich (2007), De Lissnyder, Koster, Derakshan, and De Raedt (2010) have shown that high-rumination versus low-rumination is associated with poor levels of backward inhibition for negative information. However, the current study has provided evidence to show that the use of neutral stimuli can offer valuable information in regard to basic information processing ability in rumination and dysphoria in general. Specifically, impaired inhibition can lead to the impaired filtering of, and inflexible application of dominant responses. Along with previous literature (e.g. Davis & Nolen-Hoeksema, 2000; Meiran, Diamond, Toder, & Nemets, 2010; Whitmer & Banich, 2007) our results show that using measures of cognitive flexibility with neutral stimuli can help elucidate the nature of the fundamental mechanisms and factors associated with impaired attentional control in dysphoric rumination.

4.3. Task switching performance in dysphoria and rumination

It was predicted dysphoria would be associated with impaired task selection. Our hypothesis was not supported by the results as dysphoric participants did not show poor task selection and displayed typical preparation effects on reaction times. Our findings are in line with an overall unimpaired task switching performance in dysphoria (Whitmer & Banich, 2007). Recently, using a variant of the paradigm used in the current study Meiran et al. (2010) explored cognitive flexibility in a sample of nine clinically depressed patients and found that regardless of level of depression, rumination was associated with poor preparation. This was reflected in a failure to show typical reaction time decreases from low to high CTI trials. Together these findings provide further support for an independent and negative contribution of rumination to cognitive performance in depression.

In contrast to our findings, Meiran and colleagues found that depressed patients versus controls showed increased "fade-out effects"; typically in single-task blocks (e.g. all "up/down task" trials) reaction times become shorter over the course of the block. The "fadeout" effect reflects the rate of disengagement from a switching mode. The relatively high "fadeout" effect for depressed patients indicates a cognitive inflexibility as the single block did not require switching (Meiran et al., 2010). Also, unlike the current study, no significant congruency effects were observed in Meiran et al. (2010), although the authors acknowledge small sample size and current medication status may have contributed to null findings. Nonetheless, there is growing evidence that task switching paradigms offer a reliable way to observe the specific contribution of the mood state and rumination to cognitive inflexibility in depression.

4.4. Inhibition and working memory in dysphoria and rumination

Importantly, impaired performance on incongruent response trials, where performance was modulated by the ability to filter irrelevant information, may help shed light on brain mechanisms associated with inhibitory deficits in rumination and dysphoria in general. In Yehene et al. (2008) patients with lesions involving basal ganglia were associated with increased task selection errors. The authors interpreted these findings as an implication of the basal ganglia's role in the inhibition of irrelevant information. Recent fMRI work has provided support for this interpretation showing that basal ganglia is important for controlling the access of irrelevant information in working memory (McNab & Klingberg, 2008). The filtering of irrelevant information and the capacity to maintain relevant information in working memory is highly correlated (Vogel, McCollough, & Machizawa, 2005). Using a lateralised ERP technique of Vogel and colleagues, we (Owens, Koster, & Derakshan, 2012) recently observed a specific dysphoria-related impairment in the efficient filtering of irrelevant information in visual working memory that was associated with reduced capacity to maintain relevant information. Although the effect of rumination was not considered in this study findings suggest that executive related sub-cortical functions are impaired in dysphoria in general.

4.5. Limitations

Future studies using a larger sample of participants may help further elucidate the relationship between a dysphoric mood state, rumination and cognitive inflexibility. In addition, as the current study only used mixed task blocks, potential deficits may have been masked for dysphoric participants. It is important to note that typically the use of a dysphoric sample can limit generalisability of results to a clinically depressed population, though there is recent compelling evidence by Whitmer and Gotlib (2012) that suggests our findings are analogous to attention deficits observed in clinical depression. Using a backward inhibition paradigm similar to that of Whitmer and Banich (2007), Whitmer and Gotlib (2012) showed that in major depressive disorder trait rumination impairs inhibition during task switching. Results mirrored findings observed for the dysphoric sample of Whitmer and Banich (2007); showing that in clinical depression trait rumination is also associated with maintenance of a performed task in working memory even after it is no longer relevant. If anything, our findings may provide an overestimation of filtering ability and task selection in rumination and depression in general as a relatively high-functioning student population was tested who had depression scores lower than that typically observed in clinical samples. However, our results agree with previous behavioural findings for rumination and are in line with proposals that argue for an independent contribution of rumination to the cognitive deficits observed in depression and dysphoria (Joormann et al., 2007; Nolen-Hoeksema et al., 2008; Whitmer & Banich, 2007; Whitmer & Gotlib, 2012).

Lastly, a potential of limitation of the current study and previous depression research in general is a lack of consideration for the influence of anxiety. Given the comorbidity between anxiety and depression, it is important for future research to examine the independent and interactive effects of anxiety and depression in task switching.

4.6. Conclusions

While there is debate over whether rumination is an adaptive response to depression (e.g. Martin & Tesser, 1996) results show overall rumination is maladaptive in instances where flexible behaviour is necessary for effective behaviour. Specifically, we have shown that high-rumination is associated with impaired task selection. Cognitive inflexibility in high-rumination is characterised by an active maintenance, and tendency to perform, a dominant task. Cognitive flexibility is important in daily life, and as shown by the current findings for low-ruminators can help facilitate effective goal directed behaviour. Without such control the most salient task is allowed more control over behaviour and may facilitate application of goals counter to an individual's intent. Thus, impaired inhibition may drive individuals in continuing to ruminate even after it is perceived as unhelpful, exposing them to longer and more severe episodes depression, anxiety and destructive behaviours (Nolen-Hoeksema, 2004).

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References

Arbuthnott, K., & Frank, J. (2000). Executive control in set switching: Residual switch cost and task-set inhibition. *Canadian Journal of Experimental Psychology*, *54*, 33–41.
Baddeley, A. D. (2002). Is working memory still working? *European Psychologist*, *7*, 85–97.
Banich, M. T. (2009). Executive function: The search for an integrated account. *Current Directions in Psychological Science*, *18*, 89–94.
Beck, A., Steer, R., Ball, R., & Ranieri, W. (1996). Comparison of Beck Depression Inventories-IA and -II in psychiatric outpatients. *Journal of Personality Assessment*, *67*, 588–597.
Channon, S. (1996). Executive dysfunction in depression: The Wisconsin Card Sorting Test. *Journal of Affective Disorders*, *39*, 107–114.
Davis, R., & Nolen-Hoeksema, S. (2000). Cognitive inflexibility among ruminators and non-ruminators. *Cognitive Therapy and Research*, *24*, 699–711.
De Lissnyder, E., Koster, E., Derakshan, N., & De Raedt, R. (2010). The association between depressive symptoms and executive control impairments in response to emotional and non-emotional information. *Cognition & Emotion*, *24*, 264–280.
Forster, K. I., & Forster, J. C. (2003). DMDX: A windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers*, *35*, 116–124.
Friedman, N., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology. General*, *133*, 101–135.
Gotlib, I. H., & Joormann, J. (2010). Cognition and depression: Current status and future directions. *Annual Review of Clinical Psychology*, *6*, 285–312.
Hartlage, S., Alloy, L., Vazquez, C., & Dykman, B. (1993). Automatic and effortful processing in depression. *Psychological Bulletin*, *113*, 247–278.
Hasher, L., Zacks, R., & May, C. (1999). Inhibitory control, circadian arousal, and age. *Attention and Performance*, *17*, 653–675.

Hertel, P. T. (2004). Memory for emotional and nonemotional events in depression: A question of habit? In D. Reisberg & P. Hertel (Eds.), *Memory and emotion* (pp. 186–216). New York, NY, US: Oxford University Press.
Joormann, J., & Gotlib, I. H. (2008). Updating the contents of working memory in depression: Interference from irrelevant negative material. *Journal of Abnormal Psychology*, *117*, 182–192.
Joormann, J., Yoon, K., & Zetsche, U. (2007). Cognitive inhibition in depression. *Applied and Preventive Psychology*, *12*, 128–139.
Kane, M., Bleckley, M., Conway, A., & Engle, R. (2001). A controlled-attention view of working-memory capacity. *Journal of Experimental Psychology. General*, *130*, 169–183.
Kiesel, A., Wendt, M., & Peters, A. (2007). Task switching: On the origin of response congruency effects. *Psychological Research*, *71*, 117–125.
Koch, I., Gade, M., Schuch, S., & Phillipp, A. (2010). The role of inhibition in task switching: A review. *Psychonomic Bulletin & Review*, *17*, 1–14.
Koster, E. H. W., De Lissnyder, E., Derakshan, N., & De Raedt, R. (2011). Understanding depressive rumination from a cognitive science perspective: The impaired disengagement hypothesis. *Clinical Psychology Review*, *31*, 138–145.
Lyubomirsky, S., Kasri, F., & Zehn, K. (2003). Dysphoric rumination impairs concentration on academic tasks. *Cognitive Therapy and Research*, *27*, 309–330.
Martin, L., & Tesser, A. (1996). Some ruminative thoughts. In R. S. WyerJr. (Ed.), *Ruminative thoughts* (pp. 1–47). Mahwah, NJ: Erlbaum.
Mayr, U., & Keele, S. (2000). Changing internal constraints on action: The role of backward inhibition. *Journal of Experimental Psychology. General*, *129*, 4–26.
McNab, F., & Klingberg, T. (2008). Prefrontal cortex and basal ganglia control access to working memory. *Nature Neuroscience*, *11*, 103–107.
Meiran, N. (1996). Reconfiguration of processing mode prior to task performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 1423–1442.
Meiran, N. (2010). Task switching: Mechanisms underlying rigid vs. flexible self-control. In R. Hassin, K. Ochsner, & Y. Trope (Eds.), *Social cognition and social neuroscience*. New York: Oxford University Press.
Meiran, N., Chorev, Z., & Sapir, A. (2000). Component processes in task switching. *Cognitive Psychology*, *41*, 211–253.
Meiran, N., & Daichman, A. (2005). Advance task preparation reduces task error rate in the cueing task-switching paradigm. *Memory and Cognition*, *33*, 1272–1288.
Meiran, N., Diamond, G., Toder, D., & Nemets, B. (2010). Cognitive rigidity in unipolar depression and obsessive compulsive disorder: Examination of task switching, stroop, working memory updating and post-conflict adaption. *Psychiatry Research*, *185*, 149–156.
Meiran, N., & Kessler, Y. (2008). The task rule congruency effect in task switching reflects activated long-term memory. *Journal of Experimental Psychology. Human Perception and Performance*, *34*, 137–157.
Miyake, A., Freidman, N., Emerson, M., Witzki, A., & Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100.
Nolen-Hoeksema, S. (2004). The response styles theory. In C. Papageourgiou & A. Wells (Eds.), *Depressive rumination: Nature, theory, and treatment* (pp. 107–124). New York: Wiley.
Nolen-Hoeksema, S., Wisco, B., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on Psychological Science*, *3*, 400–424.
Owens, M., Koster, E. H. W., & Derakshan, N. (2012). Impaired filtering of irrelevant information in dysphoria: An ERP study. *Social Cognitive and Affective Neuroscience*, *7*, 752–763 (First published online September 6, 2011).
Proctor, R., Koch, I., & Vu, K. (2006). Effects of precuing horizontal and vertical dimensions on right-left prevalence. *Memory and Cognition*, *34*, 949–958.
Rogers, M., Kasai, K., Koji, M., Fukuda, R., Iwanami, A., Nakagome, K., et al. (2004). Executive and prefrontal dysfunction in unipolar depression: A review of neuropsychological and imaging evidence. *Neuroscience Research*, *50*, 1–11.
Rokke, P., Arnell, K., Koch, M., & Andrews, J. (2002). Dual-task attention deficits in dysphoric mood. *Journal of Abnormal Psychology*, *111*, 370–379.
Spasojevic, J., Alloy, L. B., Abramson, L. Y., MacCoon, D. G., & Robinson, M. S. (2003). Reactive rumination: Outcomes, mechanisms, and developmental antecedents. In C. Papageourgiou & A. Wells (Eds.), *Depressive rumination: Nature, theory, and treatment* (pp. 43–58). New York: Wiley.
Treynor, W., Gonzalez, R., & Nolen-Hoeksema, S. (2003). Rumination reconsidered: A psychometric analysis. *Cognitive Therapy and Research*, *27*, 247–259.
Vogel, E., McCollough, A., & Machizawa, M. (2005). Neural measures reveal individual differences in controlling access to working memory. *Nature*, *438*, 500–503.
Whitmer, A., & Banich, M. (2007). Inhibition versus switching deficits in different forms of rumination. *Psychological Science*, *18*, 546–553.
Whitmer, A., & Gotlib, I. H. (2012). Switching and backward inhibition in major depressive disorder: The role of rumination. *Journal of Abnormal Psychology*, *121*, 570–578.
Yehene, E., Meiran, N., & Soroker, N. (2008). Basal ganglia play a unique role in task switching within the frontal–subcortical circuits: Evidence from patients with focal lesions. *Journal of Cognitive Neuroscience*, *20*, 1079–1093.