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Induced rumination dampens executive processes in dysphoric young adults

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Abstract

Self-focused, analytical mental rumination constitutes a central process in depression. It has been hypothesized that such rumination depletes executive resources that are necessary for an efficient cognitive regulation of emotion and behavior. However, most of the research supporting this hypothesis is of correlational nature. The present study examined the effects of induced rumination versus distraction on executive capacities in dysphoric and nondsyphoric college students. Executive functioning was measured with the Stroop task. Results indicate that induced rumination decreases inhibition capacities in dysphoric individuals only. The flexibility facet of executive functioning was not affected by induced rumination. However, dysphoric individuals demonstrated a fundamental impairment in this latter capacity, independent of rumination induction. The implications for the facets of executive functioning affected by depression and by rumination are discussed.

Keywords: Rumination; Depression; Executive deficits; Inhibition; Flexibility

1. Introduction

Mental rumination is thought to be a key process in the generation and maintenance of dysphoric mood (Nolen-Hoeksema & Morrow, 1991, 1993; Watkins & Baracaia, 2001). Nolen-Hoeksema (1991) has identified a form of rumination, consisting of focusing on dysphoric symptoms, their causes and consequences, as being especially detrimental for

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mood. Similarly, Watkins and Teasdale (2001) have demonstrated that analytical self-focused rumination (thinking of the causes and consequences of one's present state) has deleterious consequences for dysphoric individuals. In contrast, distraction has been found to have positive effects on mood in the aforementioned research.

In dysphoric individuals, the effects of self-focused analytical rumination are manifold. It increases negative mood (Morrow & Nolen-Hoeksema, 1990; Nolen-Hoeksema & Morrow, 1993) and pessimistic thoughts (Lyubomirsky, Caldwell & Nolen-Hoeksema, 1998), it reduces effective problem solving (Ward, Lyubomirsky, Sousa & Nolen-Hoeksema, 2003), and it generates an overgeneral retrieval style of autobiographical memories (Watkins & Teasdale, 2001). Studies that have experimentally manipulated rumination generally found that these deleterious effects were observed only in dysphoric individuals. Thus, it seems that the depressogenic effect of rumination is only operant in people who are depressed or vulnerable to depression.

One hypothesis accounting for these observations is that self-focused analytical rumination depletes executive resources (Davis & Nolen-Hoeksema, 2000; Watkins & Baracaia, 2001). The executive system is constituted by a set of processes that are called for when usual routines become inadequate and when a task requires controlled processes (Van der Linden et al., 2002). They comprise processes of attention allocation, of behavior planning, of flexible switch of strategies, and of inhibition of irrelevant behavior or information (Damasio, 1995; Duncan, 1986; Shallice, 1982). It has been documented that depressed individuals present a chronic deficit in executive resources (Elliott, 1998; Veiel, 1997). Such impairment is likely to impact upon ruminative thinking. In particular, inhibitory and flexibility deficits would impair the person's ability, respectively, to suppress negative thoughts (Joormann, 2004) and to switch from the over-trained ruminative pattern to a new train of thoughts (Hertel, 2004). In addition, rumination in itself, as a form of automatic thinking, might deplete cognitive resources (McNally, 1995), as it requires sustained attention on a specific content. These combined deficits would favor the installation of a cognitive interlock in which over-trained negative thoughts feed back in one another (Teasdale, Dritschel, Taylor, & Mezzich, 1995). This cognitive interlocked loop would maintain rumination and a vicious circle would be initiated, depriving the depressed individuals of the possibility to adopt another perspective on their situation.

However, to date, there has been little experimental research on the effect of induced rumination on executive functions. One notable exception is the study by Watkins and Brown (2002) in which depressed patients and non-depressed controls were compared on a random number generation task, performed after either a rumination or a distraction induction. Compared with the distraction induction, the rumination induction produced a significant increase in stereotyped counting responses (thought to reflect a failure of inhibitory executive control) in depressed patients but not in controls. However, after distraction, no difference was found between the two groups. The authors concluded that executive functioning might not be fundamentally impaired in depressed patients, as often assumed in the literature, but that the rumination induction seemed to interfere with concurrent executive processing. This interpretation thus suggests that depressive rumination is not a consequence of an executive deficit, but rather that the executive impairment observed in depressed individual might result from their ruminative tendencies.

Watkins and Brown's (2002) results are however limited by the task they used to assess executive functions. Indeed, the random number generation task yields only one general

score, and it is not clear what facet of executive control is exactly measured (Klauer & Zhao, 2004; Towse & Valentine, 1997). In a meta-analysis, Veiel (1997) has demonstrated that depressed individuals were particularly impaired in the Stroop task (Stroop, 1935) and in the trail making task (Army Individual Test Battery, 1944; Reitan & Wolfson, 1993). These two tests have in common to be particularly sensitive to the flexibility and the inhibition components of executive functions. Inhibition is the ability to deliberately inhibit dominant, automatic, or prepotent responses when necessary. Flexibility concerns the ability of shifting back and forth among multiple tasks, operations, or mental sets (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000).

This suggests that the observation of Watkins and Brown (2002), that self-focused rumination depletes executive resources in dysphoric individuals, would gain to be replicated with a task evaluating both the flexibility and inhibition components of executive functions, such as the Stroop task. Indeed, the Stroop task yields two scores: one measuring the dominant response inhibition (inhibition) and one measuring task switching (flexibility) (Van der Linden et al., 2002). In addition, the use of the Stroop task will allow to test whether Watkins and Brown (2002) are correct in assuming that executive functioning is not fundamentally impaired in dysphoric patients or whether their conclusion is dependent upon the task they used (random number generation). Finally, rather than using a mixed design, we used a full between-subject design that is less sensitive to methodological biases. Following Watkins and Brown (2002), the main hypothesis is that a depletion of executive resources should be observed only in dysphoric participants in the rumination condition.

2. Methods

Female university students from the campus of Louvain-la-Neuve, Belgium, were approached in student residences and lecture halls, and were proposed to volunteer in a psychology experiment. After having been fully informed of the procedure and deontological rules, and after having given consent to participate, they were proposed to fill in the Beck Depression Inventory (BDI II, Beck & Steer, 1987) in order to check for inclusion characteristics. Participants were selected if they scored on the BDI II either at 10 or below (control group, $n = 50$) or at 18 or above (dysphoric group, $n = 44$).

They were then invited to the experimental session that took place in the following days in an experimental room of the psychology department or in a quite room of a students' residence. After being reminded of the procedure, they were proposed modules of a semi-structured interview diagnosing specific DSM-IV (American Psychiatric Association, 1994) axis I disorders (MINI, Lecrubier, Weiller, Bonora, Amorin, & Lépine, 1994; Sheehan et al., 1998). The modules diagnosing major depressive episode, dysthymia, (hypo-)manic episode, and suicidal risk were administered. They were also proposed a questionnaire assessing demographic variables and psychotropic drug consumption. On the basis of the MINI interview and of the questionnaire, five participants had to be excluded: one participant of the control group fulfilled the criteria for hypomaniac episode, while in the dysphoric group, three participants were taking antidepressive drug and one L-thyroxine. Participants' characteristics in each experimental condition are displayed in Table 1. In the final sample, no control participants fulfilled the criteria for one of the four DSM IV category assessed, but in the dysphoric sample, 16 participants fulfilled the criteria for present major depressive episode, 7 for suicidal risk, and 6 for dysthymia.

Table 1
Participants' mean characteristics according to experimental condition (standard deviation in parentheses)

	Control group		Dysphoric group		
	Rumination ($n = 24$)	Distraction ($n = 25$)	Rumination ($n = 20$)	Distraction ($n = 20$)	
Age	19.9 (2.1)	20.2 (2.0)	20.1 (2.0)	20.5 (2.1)	$F(3.85) = .31$, n.s.
BDI II[a]	6.2a (2.7)	5.5a (2.8)	23.1b (7.0)	22.2b (3.9)	$F(3.85) = 110.8$, $p < .001$
Years of university education	3.0 (1.6)	2.9 (1.6)	2.4 (1.2)	3.2 (1.7)	$F(3,85) = .98$, n.s.

[a]BDI II is Beck Depression Inventory.

After the diagnostic interview, the experimental manipulation took place. In both the control and the dysphoric groups, participants were randomly allocated to a rumination or to a distraction condition. The manipulation followed exactly the procedure developed by Watkins and Teasdale (2001). In both conditions, participants were presented with a written list of 10 items. They were asked to center their attention on each item at a time and to imagine them vividly. In the rumination condition, they were additionally asked to reflect upon the causes, meanings, and consequences of each item. Each item started with "reflect upon the causes, meanings, and consequences of …" and was then completed with a potential symptom of depression (e.g., "your present level of motivation", or "the body sensations you are experiencing now"). In the distraction condition, participants were asked to "think about …" a series of highly imaginable neutral items (e.g., "clouds forming in the sky" or "a boat slowly crossing the Atlantic"). This induction procedure lasted about 12 min.

Immediately after the manipulation, participants completed a modified version of the Stroop color word test (1995). This test consists of four sheets assessing denomination, reading, interference, and flexibility. Performance was recorded with a stopwatch. On the first sheet (denomination), rectangles of red, green, and blue colors are presented in a matrix of 10. Participants have to tell as quickly as possible the color of the rectangles. On the second sheet (reading), the names of the colors (red, green, and blue) are presented on a matrix of 10 and participants have to read them as quickly as possible. In the third sheet (interference), the names of the colors written in another color are presented on a matrix of 10, e.g., "red" would be written in blue. Participants have to tell the color in which the word is written. The number of interferences (number of errors, corrected or not) is noted and an interference index is computed as the percentage of the increased time for completing the interference sheet as compared to the denomination sheet (sheet 2). In the fourth sheet (flexibility), the colors names written in another color are also presented in a matrix of 10 but some words are framed. The participants are asked to tell the ink color of unframed words and to read the framed word. The number of flexibility errors is noted and a flexibility index is computed as the percentage of the increased time for completing the flexibility sheet as compared to the interference sheet (sheet 3). As Miyake et al. (2000) emphasizes, the Stroop task is a prototypical inhibition task, as it requires to inhibit or override the tendency to produce a more dominant or automatic response (i.e., name the color word). Among the studies that investigated depressed subjects on executive tests,

several successfully used the paper version of the Stroop's test (e.g., Austin, Mitchell, & Wilhelm, 1999; Crews, Harrison, & Rhodes, 1999; DegI'Innocenti, Agren, & Backman, 1998; Harvey et al., 2004; Lampe, Sitskoorn, & Heeren, 2004; Ravnkilde et al., 2002). The adapted version of the Stroop test (1995) is particularly interesting in the present context as it allows, by the adding of a fourth sheet, to assess inhibition and flexibility, the two main executive deficits observed in depression.

After the Stroop task, dysphoric participants in the rumination condition were administrated a shorter version of the distraction condition, in order to alleviate any remaining (and potentially depressogenic) ruminative process. Participants were then fully debriefed and thanked for their participation.

3. Results

Each of the four scores of the Stroop test (number of interference errors, interference index, number of flexibility errors, and flexibility index) were submitted to a 2 (group: dysphoric versus control) × 2 (induced cognitive mode: rumination versus distraction) between-subject ANOVA to estimate the main effect. In addition, as the main hypothesis consisted in the prediction that executive resources should be depleted only in the dysphoric participants in the rumination condition, a priori contrasts tested the difference between that condition and the four other ones. Regarding the number of interferences, the interaction was significant, $F(1,85) = 4.17$, $p < .05$, as well as the contrast, $t(85) = 2.49$, $p < .02$. As shown in Table 2, the dysphoric participants in the rumination condition made significantly more interferences than the participants in any other condition. Regarding the interference index, a main effect of induced cognitive mode was observed, $F(1,85) = 3.99$, $p < .05$, that was tendentially modulated by an interaction with group, $F(1,85) = 2.96$, $p < .09$; the contrast also approached significance, $t(85) = 1.91$, $p < .06$. As can be seen in Table 2, the rumination induction generated a higher interference index, and this was particularly true for the dysphoric participants.

Regarding the number of flexibility errors, the main effect of group approached significance, $F(1,85) = 3.68$, $p < .06$, but the a priori contrast was significant, $t(85) = 2.13$, $p < .04$: the dysphoric participants made more errors than the controls, especially in the rumination condition (see Table 2). It is to be noted that the number of flexibility errors is significantly correlated to the score of depression, $r(83) = .32$, $p < .003$. No ANOVA effects reached significance in the analyses of the flexibility index, but the contrast tended to be significant, replicating the same pattern as the other variables, $t(85) = 1.91$, $p < .06$.

Table 2
Stroop performance as a function of experimental condition (standard deviation are given in parentheses)

	Control group		Dysphoric group	
	Rumination ($n = 24$)	Distraction ($n = 25$)	Rumination ($n = 20$)	Distraction ($n = 20$)
Number of interference	3.0 (2.8)	3.9 (3.8)	5.4 (3.5)	3.4 (2.6)
Interference index	68.3 (21.5)	67.0 (19.9)	74.7 (26.3)	57.9 (16.3)
Number of flexibility errors	2.0 (1.7)	2.3 (2.1)	3.5 (2.7)	2.6 (2.4)
Flexibility index	15.4 (14.1)	12.7 (10.2)	20.3 (11.5)	15.1 (12.4)

4. Discussion

The present results replicate and extend previous findings showing a relationship between depressive rumination and executive function impairment (Davis & Nolen-Hoeksema, 2000). Regarding interferences, that reflect inhibition deficits, both scores were affected by the rumination manipulation, but only in the dysphoric group. For those participants, induced rumination raised the number of errors and effected upon the interference index, evidencing a decrement in inhibitory capacity. This pattern had been observed by Watkins and Brown (2002), and is now replicated in a full between-subject design using the Stroop task. It should be noted, however, that even if the post hoc analyses were significant, the interaction and contrast were tendential for the interference index.

The present study also included a test of another aspect of executive functions: flexibility. On this dimension, the a priori contrasts were significant for the number of error and tendential for the index. In both cases, flexibility was specifically impaired in dysphoric participants in the rumination condition. A main effect of dysphoria was also observed for the number of errors: dysphoric individuals being less flexible than non-dysphoric ones. This observation is in line with the conclusion of the meta-analysis by Veiel (1997) and with neuropsychological evidence (e.g., Elliott, 1998).

Thus, it seems that, in dysphoric individuals, the effect of rumination on executive functioning varies according to the type of executive process considered. Regarding inhibition, our data clearly support the conclusion of Watkins and Brown (2002), that this process might not be fundamentally impaired in depressed individuals and that the rumination induction seems to interfere with concurrent inhibition. This interpretation suggests a structural interference of rumination on executive functioning: this is, rumination and inhibition processes in the Stroop task would share a common processing stage. The mobilization of this processing stage by rumination would diminish its availability for other tasks, such as the Stroop task.

In contrast, it seems that flexibility might be fundamentally impaired in depressed individuals and that rumination induction aggravate this process. Our pattern of data partly favors in this case an interpretation in terms of competing resources. An individual taxed with depression would not have the resources to efficiently apply flexible processing. The observation of the means in Table 2 suggests that this observation is not the consequence of a ceiling or floor effect. Still, replication is required before concluding to the null hypothesis. In addition, it should be stressed that the present effects (or their absence) were observed after one very short manipulation (8 min) in modest samples. Results might be more pronounced after repeated or longer manipulations in larger samples.

Watkins and Brown (2002) have proposed that controls were less affected by rumination than dysphoric participants because the former are able to ruminate and then to disengage from rumination if a task requires to do so. For dysphoric individuals, however, rumination would be the normal mode that would be counteracted by the distraction induction. Given their deficit in flexibility, dysphoric individuals would have difficulties in disengaging from the induced rumination mode, especially as this mode would be their default one. This interpretation is congruent with the pattern of results we observed for the performance in inhibition as well as in flexibility.

At the clinical level, the present observations suggest that recent clinical interventions based on rumination retraining (Watkins, 2005) might have a direct and immediate effect

on inhibitory capacities in depressed patients. This enhanced capacity might help them in inhibiting the automatic activation of depressive thinking. This is further supported by recent evidence demonstrating that such inhibitory capacities can be developed in depressed individuals (Joormann, Hertel, Brozovich, & Gotlib, 2005).

Still, the generalization of the present findings should be tempered by the facts that, although significantly depressed, the present dysphoric sample was (a) not a clinical sample of patients consulting for depression, (b) younger than the average depressed individuals, and (c) exclusively composed of women. In addition, the sample size might be modest for estimating interactions with enough power. Still, the convergence in results, at least for the inhibition scores, with Watkins and Brown (2002), who investigated mixed-gender sample of clinically depressed older adults, is remarkable.

It should also be noted that the rumination and distraction condition varied not only in terms of self-focus but also in terms of emotionality, the rumination items being self-relevant, while the distraction items were neutral. Future experiments should disentangle the effect of self-focus and emotionality and control for the mood induced by each manipulation.

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