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Cognitive Impairments in Unipolar Depression: The Impact of Rumination

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Keywords
Rumination · Major depression · Cognitive impairments · Cognitive dysfunctions · Processing speed · Attention · Memory · Executive functions

Abstract
Background: Major depressive disorder (MDD) is associated with impairments in several cognitive domains. People with depression also tend to focus on and think about their problems ("ruminate") more than people without depression. Recent studies indicate that depressive rumination is connected to cognitive impairments in MDD. However, there is little scientific understanding of the role of rumination in these deficits. ***Sampling and Methods:*** The current study examined the performance of 62 outpatients suffering from unipolar major depression with a low tendency to ruminate versus outpatients with a high tendency to ruminate using a neuropsychological battery covering the 5 cognitive domains: attention, memory, working memory, executive functions and processing speed. ***Results:*** The results indicated that high ruminators show a lower performance than low ruminators with regard to processing speed and executive function tasks with low effect sizes. However, these findings were not significant after Bonferroni correction. Hierarchical linear regression revealed that the effect on processing speed could be partially attributed to rumination, but an effect on executive functions was not established. ***Conclusions:*** The current study is the first to systematically investigate the impact of rumination on cognitive impairments in MDD, exploring a broad range of cognitive domains. The results partially support the hypothesis that rumination has an impact on single cognitive domains and highlight the necessity for further investigations in order to generalize these findings.

Introduction

Major depressive disorder (MDD) is associated with a wide range of affective and somatic symptoms as well as cognitive impairments in the acute state [1–4] and may be long lasting despite symptom reduction and recovery [5, 6]. Rumination is often discussed as an important potential underlying cognitive mechanisms in the context of cognitive impairments in MDD. Rumination is a style of thinking characterized by repetitive, recurrent, intrusive, and uncontrollable thoughts [7]. These persistent negative thoughts are a hallmark feature of MDD. People who ruminate repetitively contemplate reasons for and consequences of their sadness [8]. Although ruminators believe

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that rumination can help to understand themselves better, research has shown that rumination aggravates negative mood. Moreover, rumination has been identified as a core risk factor for depression with serious clinical implications due to more depressed mood, longer depressive episodes and the occurrence of future depressive episodes [7–10]. Recent studies indicate that depressive rumination is connected to cognitive impairments in MDD. It is discussed as an important underlying cognitive mechanism. However, there is little understanding of the extent to which rumination influences cognitive performance, especially in single domains.

Rumination and Cognitive Impairments

Resource allocation theory posits that rumination absorbs cognitive capacities which can thus not be directed towards task-relevant processes [11–13]. According to this theory, valuable cognitive resources are allocated to irrelevant depressive and ruminative thought processes. Indeed, there are many findings that support the link between reduced cognitive performance and rumination as put forward in the dual-process model of cognitive vulnerability in depressed persons. According to this model, the ability of depressed individuals to implement corrective reflective processing in order to overcome automatic negative biases is impaired, because this processing requires effort and cognitive resources that are not available [14]. Thus, rumination might reduce *cognitive flexibility* and raise interference levels above a critical threshold. In line with these results, Davis and Nolen-Hoeksema [15] showed that participants who scored high on a self-report measure of ruminative style made more perseverative errors than nonruminators in the Wisconsin card sorting test, a widely used measure of *executive control* and *cognitive flexibility*.

In addition, the dual-process model posits that the cognitive resources of depressed individuals might already be strained by competing mood-congruent and ruminative thought processes [14]. In particular the brooding, maladaptive component of rumination has been found to be associated with higher negative *attentional biases* [16], suggesting that depressed individuals with high levels of brooding have tightly connected negative schemata from which they have difficulty in breaking away. Some scholars, on the other hand, have related rumination to major deficits in *cognitive control*, regardless of the valence of the processed material. Specifically, ruminators are thought to exhibit an impaired ability to flexibly shift *attention* or *inhibit* irrelevant information [e.g. 15, 17].

Previous research has also reported that rumination is related to *memory deficits* and *memory biases* [18, 19]. For example, when people are asked to recall memories of specific autobiographical events, depressed patients are more likely to retrieve overgeneral, categorical memories that are summaries of repeated occasions than controls [for a review, see 20]. Watkins et al. [21] found that the distraction induction (as a composite of rumination induction) significantly reduced overgeneral memory at preinduction levels.

Rumination has also been associated with *working memory* deficits. Joormann and Gotlib [22] proved a link between rumination, impaired *working memory*, and depression. They found that the interference of negative irrelevant words was correlated with self-reported rumination. This relation with rumination was limited to the MDD group and remained significant even after partialing out the level of depressive symptomatology: the higher the participants' scored for the self-reported measure of rumination, the greater their difficulty in removing task-irrelevant negative content from their working memory. The connection between rumination and impaired working memory was also reported by other authors [23, 24].

There have also been several experimental research studies on the effect of induced rumination on *executive functions* [e.g. 25–27]. In the study by Watkins and Brown [13], for example, the performance of depressed patients and nondepressed controls was compared for 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 (reflecting a failure of inhibitory executive control) in depressed patients but not in controls. However, after distraction, no difference was found between the 2 groups. The authors concluded that the rumination induction may interfere with concurrent executive processing.

In sum, findings from the studies reviewed above tentatively support a connection between rumination and deficits in cognitive performance. However, previous research on the impact of rumination on cognitive impairments in MDD has a number of shortcomings and has left open questions of which 3 seem especially important:

Previous studies reported the influence of ruminative thinking on memory, attention, or executive functions. However, most studies have assessed only 1 or very few aspects of the specific domains such as attentional inflexibility, cognitive control, cognitive inflexibility, or task switching. So far there have been no studies that system-

atically examine all cognitive domains. Therefore, general knowledge on the impact of rumination on different cognitive domains in MDD is still very limited.

Furthermore, many studies on rumination and cognitive dysfunctions have not controlled for the influence of other factors such as the severity of depression, the amount of depressive episodes in the past, medication or duration of the current episode. Previous research has shown that these factors can strongly influence the extent of cognitive deficits in MDD [28]. Moreover, it seems essential to control for general factors such as age, patients' intelligence, or level of education [29]. However, these factors have not been taken into consideration so far.

Previous investigations have also failed to explore the relationship between rumination in everyday life and cognitive performance. Most studies have assessed the influence of rumination in an experimental design, which required participants to complete several cognitive tasks after introducing rumination. Therefore, it stands to reason that rumination induced shortly before examination has an impact on the ability to solve cognitive tasks. However, it is unclear as to whether depressive patients who ruminate a lot about themselves and their diseases in everyday life also exhibit higher cognitive impairments than depressive patients whose tendency to ruminate in everyday life is not as pronounced.

The current study aims at answering the above-mentioned questions, thus closing a gap in research by systematically analyzing the relationship between assessed everyday-life rumination and different cognitive functions in MDD by controlling for as many influencing factors as possible. Based on previous research, we hypothesize that the severity of cognitive deficits in MDD is related to ruminative thinking.

Methods

Participants

The sample consisted of 62 outpatients (age 18–66 years, mean = 43.32, SD = 12.93, 46 female) currently diagnosed with MDD. All participants fully met the criteria for a current unipolar MDD episode of the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev., DSM-IV-TR [30]) on the basis of the Structured Clinical Interview for the DSM-IV (SCID-I [31]). They were recruited for the study from a university teaching outpatient clinic. Thirteen participants were diagnosed with comorbidity in addition to MDD: dysthymia (10 participants), bulimia nervosa (2 participants), and undifferentiated somatoform disorder (1 participant). Participants with comorbid anxiety disorder, posttraumatic stress disorder, substance dependence, a history of head injury, neurological disease, opioid or antipsychotic medication were excluded. The clinical sample was divided into 2 groups: low ruminators and high ruminators based on their scores on the Response Style Questionnaire, German version (RSQ-D) [32], with a sum score of 40 and above indicating high rumination. Thirty-six participants (22% of low ruminators and 38% of high ruminators) were taking antidepressants. Twenty-two participants were taking selective serotonin reuptake inhibitors, 5 selective norepinephrine reuptake inhibitors, 11 noradrenergic and specific serotonergic antidepressants, 5 tricyclic antidepressants, and 1 was taking monoamine oxidase inhibitors.

Measures

Hamilton Depression Rating Scale

The 17-item version of the Hamilton Depression Rating Scale (HAMD) [33] was used. The HAMD is the most commonly used clinical scale to assess the severity of depression in clinical practice and research [34].

Response Styles Questionnaire, German Version

The RSQ [32] is a self-report instrument that assesses the tendency to respond to negative emotions with ruminative thoughts. Participants respond to items on a 4-point scale anchored by "almost never" and "almost always." The authors report high test-retest reliability and internal consistency for the RSQ-D.

Neuropsychological Assessment

The neuropsychological tests were taken from the COGBAT test battery of the Vienna test system [35]. The test set measures subdimensions in the areas of attention, memory, verbal working memory, executive functions, and processing speed and has been validated across neurological and psychiatric populations.

Procedure

All participants were recruited from the outpatient psychotherapy clinic of the University of Landau, Germany, where they asked for psychotherapy. As it is usual routine of the outpatient clinic, potential patients were invited for a first screening interview. If depressive symptoms were identified and were of major concern to the patients, they were informed of the study. If they agreed to participate, informed consent was obtained.

The assessment was divided into two 1-h sessions. In the first session, trained interviewers administered the structured clinical Interview for the DSM-IV [36] to participants to ensure that they fully met the criteria for a current unipolar MDD episode. Afterwards participants were interviewed regarding further criteria for being included in or excluded from the study and were rated on the HAMD [33]. In a next step, they completed the RSQ-D [32]. A few days after the first session, participants came to our laboratory to complete the cognitive tasks with the neuropsychological test battery COGBAT. All participants were tested individually after having completed the informed consent form. The research was approved by the Local Research Ethics Committees.

Statistical Analysis

All statistical comparisons were performed using the Statistical Package for the Social Sciences (SPSS for Windows, version 21). The neuropsychological test scores were transformed into standardized (z) scores and polarized in 1 direction (with higher scores indicating a better performance). Performance was calculated separately for the 5 cognitive domains of information-processing speed, attention, verbal working memory, memory, and executive

Table 1. Overview of the neuropsychological test battery

Neuropsychological function Test (main variables)	Shortcut
Information-processing speed	
Trail-Making Test A (processing time)	TMTA[a]
Attention	
Alertness (mean reaction time)	WAFA[a]
Divided attention (mean reaction time, amount of errors)	WAFG[a]
Working memory	
Nback verbal (correct choices)	NBV[a]
Figural memory	
Figuraler Gedächtnis-Test (sum of learned figures, delayed reproduction)	FGT[a]
Executive functioning	
Cognitive flexibility – Trail-Making Test B (processing time)	TMTB[a]
Inhibition – Go-Nogo (mean reaction time)	INHIB[a]
Capability to plan – Tower of London (solved items in specified moves)	TOL[a]

[a] Subtests taken from the test battery COGBAT of the Vienna Test System (Wiener Test-System, 2012, Mödling, Schuhfried GmbH) [35].

Table 2. Demographics and clinical characteristics of subjects, separated by level of rumination (low vs. high)

Variable	Low (n = 41, 28 female)	High (n = 21, 18 female)
Age, years	44.24±12.24	41.52±14.32
Years of education	12.17±1.83	11.95±1.56
Amount of past episodes, n	1.24±1.36	1.38±1.40
Duration of current episode, days	68.59±81.14	81.40±102.34
HAMD-17 score	17.88±5.14	19.29±5.40
RSQ-D total score**	31.59±4.57	67.00±48.49

n = 62; asterisked variables differed between groups: ** $p < 0.01$, two-tailed.

function by combining the test scores, shown in Table 1, in accordance with the published recommendations (Wiener Test-System, 2012, Mödling, Schuhfried GmbH). These scores demonstrated an acceptable internal consistency ranging from α = 0.63 (attention) to α = 0.95 (memory).

In the preliminary analyses t tests were conducted to compare the group of depressive patients (n = 62) with the normative data of COGBAT (n = 62) matched on gender, age, and education level on cognitive performance. Further t tests were conducted to compare the differences between low- and high-rumination groups on the same cognitive domains. The relation between rumination and distinct domains of cognitive performance was examined through a series of hierarchical regression analyses. In each analysis the general factors age, years of education and gender were entered into the model in step 1. In step 2, depression-related variables – number of depressive episodes in the past, severity of depression (score on the HAMD), intake of medication and duration of the current episode – were included into the model. Finally, in step 3, the rumination score was added to the model.

Results

The descriptive statistics for the main study variables, separated according to the level of rumination (low vs. high) are presented in Table 2. There were no significant differences in age, years of education, amount of past depressive episodes, and duration of current depressive episode as well as HAMD score between the groups. The 2 groups only differed significantly on the RSQ-D score.

The results of the t tests comparing the differences between depressive patients and normative data indicate a worse performance of the patients in processing speed tasks ($t(60) = 2.59$; $p < 0.05$; Cohen's $d = 0.47$), attention tasks ($t(60) = 4.69$; $p < 0.001$; Cohen's $d = 0.84$), memory tasks ($t(59) = 3.84$; $p < 0.001$; Cohen's $d = 0.69$), verbal working memory tasks ($t(60) = 1.61$; ns; Cohen's $d = 0.29$), and executive function tasks ($t(60) = 2.64$; $p < 0.01$; Cohen's $d = 0.47$). The results of the t tests relating to the different rumination groups are presented in Table 3. The findings indicate that high ruminators perform worse than low ruminators in processing speed tasks ($t(59) = 1.70$; $p < 0.05$; Cohen's $d = 0.41$) and executive function tasks ($t(60) = 1.82$; $p < 0.05$; Cohen's $d = 0.48$) with low effect sizes. However, the results become nonsignificant after Bonferroni-Holm α-level adjustment ($\alpha_{fam} = 0.05$, $s = 5$ comparisons).

Table 3. Cognitive performances of MDD patients, separated by level of rumination (low vs. high)

Variable	RSQ low (n = 41)		RSQ high (n = 21)		Average comparisons		Effect d'
	mean	SD	mean	SD	t (df)	p	
Processing speed	0.156	0.644	–0.300	1.432	1.70 (59)	0.047	0.41
Attention	0.014	0.547	–0.026	0.914	0.21 (60)	0.415	0.05
Figural memory	0.031	0.830	–0.055	1.063	0.35 (59)	0.364	0.09
Working memory	11.756	2.644	11.762	2.528	–0.01 (60)	0.496	0.00
Executive function	0.154	1.036	–0.301	0.871	1.82 (60)	0.045	0.48

n = 62; one-tailed; after the Bonferroni-Holm correction α_{fam} = 0.05; s = 5 comparisons; d' by Cohen.

Table 4. Hierarchical regression of predicting factors and rumination on cognitive performances

Predictors	Dependent variables: cognitive functions									
	processing speed		attention		figural memory		working memory		executive function	
	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2
Step 1		0.341***		0.295***		0.385***		0.060		0.044
Age	–0.609***		–0.542***		–0.639***		–0.076		–0.191	
Years of education	0.174		0.314**		0.172		0.239		0.116	
Gender	0.077		–0.066		0.010		–0.146		–0.130	
Step 2		0.038		0.118		0.072		0.074		0.039
HAMD score	–0.127		–0.120		–0.251*		0.128		–0.138	
Medication	–0.035		–0.187		–0.015		–0.117		–0.152	
Duration of current episode	–0.016		–0.302*		0.108		–0.152		–0.011	
Amount of past episodes	–0.138		0.109		0.024		0.158		0.042	
Step 3		0.044*		0.000		0.007		0.000		0.024
Rumination	–0.220*		–0.019		–0.091		–0.005		–0.165	

* p < 0.05, ** p < 0.01, *** p < 0.001.

The results of hierarchical regression analyzing the relation between rumination and distinct domains of cognitive performance are shown in Table 4. The addition of the rumination score in step 3 only produced a significant increment in R^2 for the processing speed tasks (β = –0.22; ΔR^2 = 0.05; p < 0.05). For the executive function tasks, adding rumination led to a nonsignificant increment (β = –0.19; ΔR^2 = 0.03; p > 0.05). Rumination did not explain cognitive performance in attention, verbal working memory, and memory either. Moreover, age was found to be a significant predictor of worse cognitive performance on processing speed (β = –0.60; p < 0.001), attention (β = –0.53; p < 0.001), and memory (β = –0.64; p < 0.001). Attention was significantly predicted by duration of current depressive episode (poorer attention in case of prolonged episode) (β = –0.29; p < 0.05) as well as by years of education (higher attention in case of more years of education) (β = 0.30; p < 0.01). The HAMD score significantly predicted the memory (β = –0.25; p < 0.05) of MDD patients.

Discussion

The aim of the current study was to determine whether there is a connection between everyday-life rumination and cognitive impairments in attention, verbal working memory, memory, executive functions, and processing speed, respectively, in MDD patients. The results indicate that everyday rumination is associated with increased cognitive impairments with regard to information-processing speed in MDD. Moreover, high-ruminating depressive persons tend to exhibit impaired executive functions compared to low-ruminating persons. However, the impact of rumination on executive functions disappears after a hierarchical regression analysis. Beyond that, there is no association of rumination with impairments in the domains of attention, working memory as well as memory. These results imply that rumination in everyday life does not necessarily lead to problems in cognition in general. Furthermore, we identified age, the duration of the

current depressive episode, and the severity of depression as important predictors for cognitive impairments in MDD besides rumination.

Our results indicate that cognitive impairments in MDD are linked to rumination in the domain of processing speed. This was the only cognitive domain that was influenced by rumination after including other predictors in the hierarchical regression analysis. To our knowledge, there has been no previous research on the impact of rumination on processing speed. This is, however, a basic cognitive domain which affects cognitive performance in general. In line with these results, previous studies have suggested that cognitive impairments in depression may be mediated in part or wholly by more basic deficits such as processing speed [e.g. 37–39]. These studies did not, however, examine the influence of rumination in this context. It seems that rumination could be an underlying mechanism for the connection between processing speed and cognitive impairments in MDD. Further research is needed to assess this relationship and to generalize the findings if possible.

Furthermore, our findings are partially consistent with the results of Davis and Nolen-Hoeksema [15], who examined the influence of self-reported rumination on executive functions, especially on executive control and cognitive flexibility. In their study, high ruminators made more preservative errors than nonruminators. In line with this finding high-ruminating MDD patients of the current study reached a lower score in the executive domain (indicating greater deficits) than low ruminators. The decreasing influence of rumination on the executive domain score in further calculations may be due to the fact that the range between high and low rumination in the current study is smaller than between the high and nonruminators in Davis and Nolen-Hoeksema's [15] investigation.

In contrast to previous reports from experimental studies, which showed an association between rumination and attentional deficits [e.g. 16, 22], we found no significant difference between the 2 rumination groups in our analysis. Furthermore, our study does not support the existence of a link between rumination and memory deficits as well as working memory deficits found by other researchers [e.g. 23, 24]. In this context the findings of Teasdale et al. [40] and Antrobus [41] have to be taken into consideration. They observed that increasing the cognitive demands of the current external task led to a reduction in the frequency of off-task thoughts, resulting in an improvement in task performance. These results suggest that attention-demanding tasks may disrupt rumination. In the current study, we observed rumination in the everyday life of patients, with no rumination induction. For this reason, one could argue that a 1-h neuropsychological examination already constitutes an increased cognitive demand, which interrupts rumination. In this brief period of time, participants of our study may exhibit a relative improvement in their cognitive performance compared to their performance in everyday life.

Another important point should be taken into consideration when interpreting the results concerning the influence of rumination on memory. Based on evidence from "choking under pressure" [42, 43], it is plausible to assume that rumination as a predominantly verbal phenomenon mainly absorbs verbal capacities. Using a visual but not a verbal memory test may cause less interference with rumination and therefore mask possible relationships between rumination and memory. This fact may limit the interpretations to a nonsignificant relationship between rumination and visual memory, although there is a nonsignificant relationship between rumination and verbal working memory.

To our knowledge, the present investigation is the first that has attempted to systematically determine the impact of rumination on cognitive impairments in MDD in a broad range of cognitive domains. A differentiated standardization was available for each domain. Another important difference between the current study and the majority of previous studies is the absence of induced rumination. Typically, participants are induced to ruminate or distract from rumination, before being asked to complete cognitive tasks. These rumination and distraction inductions may produce stronger differences in cognitive performance in the laboratory compared to selecting participants based on their RSQ-D score.

However, there are some limitations to this study that should be addressed in future research. The first limitation is due to the outpatient MDD sample. Only 3 of 21 patients of the high-rumination group were male. Therefore, no conclusions can be drawn about the influence of gender. Furthermore, the variance of rumination scores in this sample was restricted; therefore, our results might underestimate the association between rumination and cognitive deficits. Further research should extend the sample in addition to inpatients and healthy controls. Secondly, one could argue that the lack of impact of rumination on some cognitive domains is due to the computing of the neuropsychological variables. Our cognitive performance parameters were computed by combining the test scores into a single index of specific cognitive domains. The score of the attention domain demonstrated

moderate internal consistency (α = 0.63) and was below the recommended Cronbach α of 0.70. In this respect, it is worth mentioning that the attention score was the only one with α < 0.70; all other computed domain scores showed a high internal consistency (α > 0.80). The third problem concerns the unequal distribution of participants. The group of low ruminators was almost twice as large as that of the high ruminators. This restricted only the mean value analyses on the basis of *t* tests, but not the hierarchical regression analysis. Finally, it is also important to note that the present study did not allow us to draw any causal conclusions about the relationship between rumination and cognitive impairments in MDD. Due to the limitations mentioned above, it is important to verify whether our results can be generalized.

The current findings offer new insights into the frequently observed link between rumination and cognitive impairments in MDD. We have proved that patients who tend to ruminate in everyday life only show limitations in processing speed, but not a general reduction in their cognitive performance. For a limited period of time they can exhibit the cognitive performance comparable to that of low ruminators. Inpatients and healthy controls should be included in the samples of subsequent studies to enable generalization of this study's findings. Another question unanswered by this study concerns the point in time at which attention starts to tilt and provide space for rumination under conditions of increasing cognitive demands. These prevailing ruminating thoughts can occupy cognitive resources and lead to a decreased cognitive performance, as shown in many experimental studies. This question is highly relevant in everyday life and highlights the necessity for further investigations.

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Disclosure Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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