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ORIGINAL ARTICLE

Rumination, distraction and mindful self-focus: effects on mood, dysfunctional attitudes and cortisol stress response

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Background. Although aggravating effects of rumination on dysfunctional cognitions and endocrine stress responses have been proposed, experimental studies testing these assumptions are lacking. In parallel, mindfulness theory suggests beneficial effects of mindfulness on dysfunctional cognitions. This study aimed to investigate the effects of induced rumination, distraction and mindful self-focus on mood and dysfunctional attitudes and to assess the possible impact of induced rumination on participants' cortisol responses.

Method. Sixty university students were subjected to negative mood induction and subsequently randomly assigned to a rumination, distraction or mindful self-focus condition. The latter included statements focusing on self-acceptance and awareness of the breath. Four saliva cortisol samples were selected during the session.

Results. Compared to induced rumination, distraction showed a clear beneficial effect on the course of dysphoric mood, whereas a mindful self-focus did not. In contrast to distraction and mindful self-focus, participants induced to ruminate showed significant increases in dysfunctional attitudes from baseline to post-induction. Although rumination was not itself linked to higher cortisol responses, participants scoring high on the Beck Depression Inventory (BDI)-II who were induced to ruminate showed a smaller decrease in cortisol levels than those scoring low on the BDI-II.

Conclusions. This study indicates that rumination as a dysfunctional mode of cognitive processing is able to maintain depression-linked dysfunctional thought content. Furthermore, our study revealed preliminary indications for a link between induced rumination and the cortisol stress response in vulnerable individuals.

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Key words: Dysfunctional attitudes, mindfulness, rumination, stress response.

Introduction

The Response Styles Theory (Nolen-Hoeksema, 1991, 2004) addresses the role of two coping styles, namely perseverative self-focused rumination and distraction, for the exacerbation, maintenance and discontinuation of depressed states. Ruminative responses to depressed mood comprise passively focusing one's attention on one's dysphoric symptoms and aspects of the self and repetitively thinking about possible causes and consequences of one's symptoms and negative self aspects. Distractive coping is defined as actively turning one's attention away from one's symptoms on to pleasant or neutral thoughts and actions. The theory postulates that ruminative coping amplifies and prolongs depressed mood by increasing the likelihood of recalling negative memories, by interfering with attention and instrumental behaviour, and by impairing problem solving (cf. Nolen-Hoeksema, 1991, 2004). There is evidence from observational studies for the proposed prediction of response styles regarding onset, severity and duration of depressed moods in non-clinical (e.g. Nolen-Hoeksema *et al*. 1994, 2007; Nolen-Hoeksema, 2000; Abela *et al*. 2002; Sarin *et al*. 2005; Smith *et al*. 2006; Hong, 2007) and clinical samples (Kuehner & Weber, 1999; Raes *et al*. 2006), whereas others failed to confirm the predictive validity of response styles (Lara *et al*. 2000; Goodyear *et al*. 2003) or reported ambiguous results (Bagby *et al*. 2004).

Other studies assessed effects of experimentally induced rumination on various outcomes. Compared to induced distraction, rumination prolonged depressed moods, enhanced negatively biased memories and negative future thinking, and impaired problem solving, executive functioning, and specificity of autobiographic memory in dysphoric subjects (e.g. Watkins & Teasdale, 2001, 2004; Donaldson & Lam, 2004; Joormann & Siemer, 2004; Lavender & Watkins, 2004; Lyubomirsky & Tkach, 2004; Rimes & Watkins, 2005; Kuehner *et al*. 2007*a*). Some studies report

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enhancing effects of trait rumination on the impact of induced rumination for the course of dysphoric mood (Hertel & Gerstle, 2003; Donaldson & Lam, 2004; Kuehner *et al*. 2007*a*).

Recent research suggests that negative mood induction may activate or amplify dysfunctional attitudes (Fresco *et al*. 2006; Segal *et al*. 2006). Furthermore, cognitive reactivity to negative mood induction predicted future relapses in depressed patients (Segal *et al*. 2006). If rumination can be shown to affect the course of dysfunctional attitudes, this may explain one possible mechanism for the perpetuation of the deleterious loop between dysfunctional cognitions and negative affect (cf. Ingram *et al*. 1998; Spasojevic & Alloy, 2001; Monroe *et al*. 2007). However, respective experimental studies are lacking.

Initial experimental studies investigated effects of a mindful self-focus as a different way of focusing one's attention in response to dysphoric mood. The construct of mindfulness, originally based on Buddhist philosophy, describes a non-evaluative and sustained moment-to-moment awareness of mental states and processes. A central aim includes the development of an attitude of acceptance towards unpleasant perceptions and thoughts (cf. Grossman *et al*. 2007). Mindfulness-based interventions, usually conducted over a few weeks, provide intensive training in various mindfulness practices, such as mindful meditation. Variations of these interventions have been shown to reduce anxiety, depression, stress symptoms and ruminative thoughts (Ramel *et al*. 2004; Jain *et al*. 2007; Kenny & Williams, 2007; Kingston *et al*. 2007; Shapiro *et al*. 2007) and to prevent relapses in depressed patients with at least three previous episodes (Teasdale *et al*. 2000; Ma & Teasdale, 2004).

Two studies so far have compared the effects of experimentally induced mindfulness conditions with those of rumination and distraction after negative mood induction (Broderick, 2005; Singer & Dobson, 2007). In contrast to the above-mentioned intervention studies, the latter included only short induction periods (8–10 min) of mindful elements that focused on self-acceptance and awareness of the breath. Both studies identified mood improvements after the induced mindful self-focus that were comparable (Singer & Dobson, 2007) or even higher (Broderick, 2005) than for induced distraction.

To date, few studies have looked at associations between rumination and biological parameters. Functional magnetic resonance imaging (fMRI) studies suggest a link between deficient corticolimbic processing of negative affective materials and habitual rumination (Ray *et al*. 2005; Siegle *et al*. 2006). To our knowledge, relationships between rumination and hypothalamic–pituitary–adrenal (HPA) axis activity have been investigated by only three studies. Young & Nolen-Hoeksema (2001) found no associations between trait rumination and the cortisol response to a psychosocial stressor, but their stress test also failed to cause a significant increase in rumination. McCullough *et al*. (2007) showed that rumination about a recent painful interpersonal transgression was linked to elevated saliva cortisol levels. In a non-clinical sample, Kuehner *et al*. (2007*a*) identified substantial associations between self-focused trait rumination and a blunted cortisol awakening response (CAR). In parallel, subjects with a blunted CAR experienced less mood improvement after induced distraction. By contrast, studies investigating direct effects of induced rumination on cortisol responses in dysphoric subjects are lacking, although theoretical considerations suggest a respective link (Brosschot *et al*. 2006).

The aims of the present study were (*a*) to assess the effects of induced rumination, distraction and mindful self-focus on the course of mood and levels of dysfunctional attitudes in a non-clinical sample of young adults subjected to negative mood induction, and (*b*) to assess the effect of induced rumination on participants' cortisol responses. We expected that, compared to distraction and mindful self-focus, induced rumination would have adverse effects on both mood and dysfunctional attitudes. Furthermore, we expected that induced rumination would elicit higher cortisol responses than the other conditions. As cortisol responses appear to vary with the severity of depressive symptoms (Burke *et al*. 2005), we also tested for a possible interaction of induction condition by depression levels on the cortisol response.

Method

Participants

Our sample included 60 undergraduate students (30 men, 30 women) from different faculties at the University of Mannheim, Germany. The mean age of the participants was 22.3 years (S.D. = 3.0, range 19–34 years). The study was conducted in accordance with the Declaration of Helsinki and had been approved by the local ethics committee of the University of Heidelberg. All participants provided written informed consent.

Questionnaires

Beck Depression Inventory (*BDI-II, German version; Hautzinger et al. 2006*)

The BDI-II is a 21-item self-report instrument intended to assess the severity of depressive symptoms according to DSM-IV (APA, 1994). The German

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version of the BDI-II (Hautzinger *et al*. 2006) has demonstrated good internal consistency and retest reliability as well as convergent and discriminant validity (Kuehner *et al*. 2007*b*).

Dysfunctional Attitudes Scale (*DAS, German version; Hautzinger et al. 2005*)

The DAS is a 40-item self-report scale designed to assess the presence of excessive and rigid depression-related dysfunctional beliefs. Dysfunctional attitudes are hypothesized to constitute important aspects of cognitive vulnerability to depression and are assumed to be more enduring than typical negative automatic thoughts activated during an acute episode of depression (Segal *et al*. 2006). The German version of the DAS has adequate psychometric properties and shows good sensitivity to change (Hautzinger *et al*. 2005). In the present study, the internal consistency of the scale was Cronbach's $\alpha = 0.90$ (baseline) and 0.93 (after response induction, see below).

Positive and Negative Affect Schedule (*PANAS; Watson et al. 1988*)

The PANAS consists of two 10-item scales for positive affect (PA, examples: 'active', 'alert', 'interested') and negative affect (NA, examples: 'distressed', 'nervous', 'guilty'). The instrument has proven a reliable and valid measure of the constructs of positive and negative affect for different time-frames (Krohne *et al*. 1996; Crawford & Henry, 2004). In the present study, the PANAS served as a state measure of mood at different time-points during the study.

Mood induction

To induce a sad mood, we used a combination of mood-suggestive music (extract from the Adagio in G minor by Tomaso Albinoni, arranged for strings and organ by Remo Giazotto) and negative autobiographic recall. The mood-inducing efficacy of this procedure has been demonstrated previously (Martin, 1990; Westermann *et al*. 1996; Singer & Dobson, 2007). For the recall task, participants were asked to remember three specific events in their lives that had caused them to feel lonely, sad, rejected or hurt. These events were listed in ascending order with respect to subjective sadness as perceived by the participants. For the subsequent mood-induction phase (lasting 6 min), the participants were instructed to successively remember these events as vividly as possible, each for 2 min, while listening to the music alone.

Response induction

The rumination and distraction induction task followed the protocol by Lyubomirsky *et al*. (2003). The paradigm requires participants to focus their attention and think about a series of items presented on cards (28 cards per condition). In the rumination condition, participants are asked to focus on symptom-focused and self-focused thoughts (e.g. 'think about … your current level of energy, … the physical sensations in your body, … what your feelings might mean'). Participants in the distraction condition are asked to concentrate their attention on externally focused thoughts ('think about … a boat slowly crossing the Atlantic, … the expression on the face of the Mona Lisa', etc.). While participants have to spend exactly 8 min focusing on the cards, they are free to decide how long they focus on individual cards during the allotted time.

For the purpose of this study, we expanded this task by a mindfulness condition using the same methodology. Following Segal *et al*. (2002), Heidenreich & Michalak (2003) and Singer & Dobson (2007), we constructed 28 statements presented on cards reflecting prompts to a mindful, accepting approach. Items focused on non-judgemental acceptance (e.g. 'realize that all feelings, including negative feelings, are part of human experience', 'take note of your thoughts and feelings without judging them') and on moment-to-moment awareness ('consciously attend to your breath for a few seconds', repeated on every seventh card). The content validity of these statements was determined by expert ratings. As in the rumination and distraction induction, participants were asked to focus on the cards for 8 min.

Saliva cortisol

Salivette sampling devices (Sarstedt, Rommeldsdorf, Germany) were used for saliva collection. Four samples were collected during the session (see below). The saliva samples were stored at $-20\,^{\circ}C$ at the Central Institute of Mental Health until biochemical analysis. Free saliva cortisol levels were assessed using a commercially available chemiluminescence assay at the laboratory of C. Kirschbaum (University of Dresden). Inter- and intra-assay variations were $<8\%$. Two subjects were excluded from cortisol analyses because of missing saliva data. Neither sex nor age of the probands, being a smoker or, in women, use of oral contraceptives or phase of menstrual cycle was significantly related to the course of cortisol levels during the session (all p values >0.05).

Procedure

All participants were examined individually. To control for the diurnal variation of cortisol secretion, each experimental session started after noon. After giving consent, participants provided demographic

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information and completed the BDI-II, the DAS and the PANAS (T1). Subsequently, all participants underwent negative mood induction before completing the PANAS a second time (T2). The sample was then randomly assigned to one of the three induction groups (rumination, distraction, mindful self-focus). To control for possible gender effects, randomization was stratified by sex (10 men and 10 women per condition). Following the response induction, participants completed the PANAS and the DAS again (T3). The four probes of saliva cortisol were sampled as follows: baseline assessment 15 min before response induction (immediately prior to the instruction for the mood induction, and again 15, 30 and 45 min after starting the response induction.

Analyses

To test for possible pretest differences between induction groups, analyses of variance (ANOVAs) were used for continuous and χ^2 tests for categorical variables. The effects of mood induction on positive and negative PANAS scores (T2) were investigated by repeated measurement (RM) ANOVAs. To assess effects of response induction on PANAS scores (T3), analyses of covariance (ANCOVAs) were conducted with task condition (rumination, distraction, mindful self-focus) as between-subject factor and PANAS scores T2 as covariate. *Post-hoc* pairwise analyses were performed to compare the effects of individual conditions. Similarly, ANCOVAs assessed the effects of response induction on DAS scores T3, with task condition as between-subject factor, and DAS scores T1 and the T2–T3 PANAS change scores for positive and negative affect as covariates. RM ANOVAs assessed the direction of change in DAS scores for each group.

Saliva cortisol analyses were performed using a formula by Pruessner *et al*. (2003) to calculate the time-dependent change in the area under the curve with respect to increase (AUC_I).

$$\begin{aligned} AUC_I = {} & [(CORT2 + CORT1)/2] \times 30 \\ & + [(CORT3 + CORT2)/2] \times 15 \\ & + [(CORT4 + CORT3)/2] \times 15 \\ & - [CORT1(30 + 15 + 15)]. \end{aligned}$$

AUC_I is calculated with reference to the baseline measurement and explicitly emphasizes changes over time, and ignores the distance of measurements from the ground. This parameter may achieve positive and negative values. Importantly, subjects with similar patterns over time do not necessarily have the same AUC_I values, because AUC_I takes into account the vertical distances of each measurement from the baseline reference (Fekedulegn *et al*. 2007). To assess the effect of induced rumination on the participants' cortisol responses, we collapsed the distraction and mindful self-focus groups. We performed a multiple linear regression of AUC_I scores on task condition, BDI-II scores, and the interaction term of BDI-II scores by task condition to assess if high *versus* low depression levels would moderate the effect of induced rumination on the cortisol response. In this analysis, we included baseline cortisol levels and exact time of baseline assessment as covariates, thus controlling for a potential impact of these variables. Analyses were performed using SPSS version 15 (SPSS Inc., Chicago, IL, USA).

Table 1. *Relevant baseline characteristics in the three induction groups*

	Induction group		
	Rumination ($n=20$)	Distraction ($n=20$)	Mindful self-focus ($n=20$)
Age (years)	21.15 (1.46)	23.30 (3.78)	22.45 (3.12)
Female (%)	50	50	50
BDI-II	7.60 (5.81)	7.35 (7.25)	7.95 (7.20)
PANAS-PA T1	27.35 (4.77)	26.55 (4.83)	29.20 (5.71)
PANAS-NA T1	12.50 (1.93)	11.15 (1.95)	13.75 (6.26)
DAS T1	113.00 (16.78)	110.30 (17.74)	114.55 (31.99)
CORT1	5.31 (2.38)	5.72 (2.12)	5.12 (2.17)

BDI-II, Beck Depression Inventory-II; PANAS, Positive and Negative Affect Schedule; PA T1, positive affect at T1 (before mood induction); NA T1, negative affect at T1 (before mood induction); DAS T1, Dysfunctional Attitudes Scale at T1 (before mood induction); CORT1, baseline cortisol sample (before mood induction).

Values are given as mean (standard deviation).

Results

Comparison of experimental groups at baseline

Table 1 provides baseline characteristics of the three induction groups prior to randomization. Subjects randomly assigned to the rumination, distraction and mindful self-focus induction at T2 did not differ regarding demographic variables, mood-related variables, dysfunctional attitudes, and cortisol levels at baseline (T1, all p values >0.05).

Mood induction

The negative mood induction revealed highly significant changes in positive and negative affect (PANAS). Positive affect decreased from 27.7 (S.D. = 5.2) to 22.2 (S.D. = 5.8) [$F(1,59) = 99.43$, $p < 0.001$] from T1 (before) to T2 (after mood induction). In parallel, negative affect increased from 12.5 (S.D. = 4.0) to 16.1 (S.D. = 5.8)

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Table 2. *Means and standard deviations for positive and negative affect and dysfunctional attitudes*

	Induction group		
	Rumination ($n=20$)	Distraction ($n=20$)	Mindful self-focus ($n=20$)
PANAS-PA T2	21.10 (5.16)	20.95 (5.08)	24.55 (7.36)
PANAS-PA T3	22.30 (6.04)	26.20 (6.68)	26.70 (7.29)
PANAS-NA T2	15.80 (4.72)	15.85 (5.05)	16.50 (7.61)
PANAS-NA T3	14.25 (4.14)	11.15 (1.39)	12.95 (5.80)
DAS T3	122.05 (17.18)	105.25 (20.19)	110.50 (36.46)

PANAS, Positive and Negative Affect Schedule; PA, positive affect; NA, negative affect; DAS, Dysfunctional Attitudes Scale; T2, after negative mood induction; T3, after response induction (rumination, distraction, mindful self-focus).

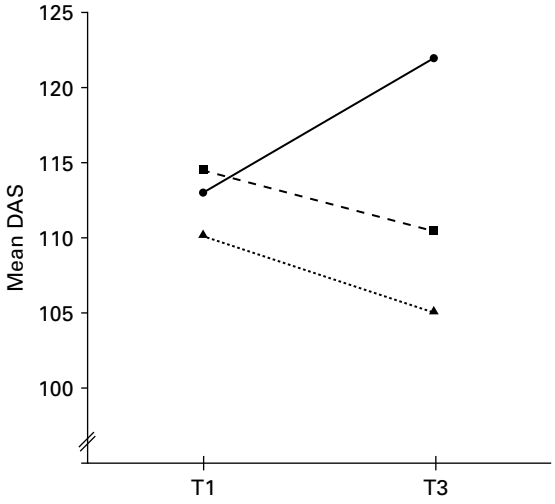

Fig. 1. Course of dysfunctional attitudes in the three induction groups from T1 to T3. DAS, Dysfunctional Attitudes Scale; T1, before mood induction; T3, after response induction. —●—, Rumination; ····▲····, distraction; - -■- -, mindful self-focus.

[$F(1,59)=48.22$, $p<0.001$]. The three induction groups did not differ with regard to change in positive [$F(2,57)=0.70$, N.S.] or in negative affect [$F(2,57)=1.28$, N.S.] from T1 to T2.

Response induction: effects on mood and dysfunctional attitudes

Means and standard deviations for PANAS scores at T2 and T3 and for dysfunctional attitudes at T3 of the three induction groups are listed in Table 2. The ANCOVAs identified a highly significant effect of group status on the change in negative affect from T2 (before) to T3 (after response induction) [$F(2,56)=5.47$, $p<0.007$] and a marginally significant effect for change in positive affect [$F(2,56)=2.87$, $p<0.065$]. Pairwise *post-hoc* analyses revealed significant differences between the rumination and distraction group regarding change in positive [$F(1,37)=5.64$, $p=0.023$] and negative affect [$F(1,37)=24.84$, $p<0.001$]. By contrast, the course of positive and negative affect in the mindful self-focus group was not significantly different compared to the rumination group [positive affect: $F(1,37)=1.43$, $p=0.239$, negative affect: $F(1,37)=2.88$, $p=0.098$]. Finally, the distraction and mindful self-focus groups did not differ regarding change in positive [$F(1,37)=1.24$, $p=0.273$] and negative affect [$F(1,37)=2.32$, $p=0.136$].

Significant group differences emerged for the course of dysfunctional attitudes from T1 (before mood induction) to T3 (after response induction, see Fig. 1). While DAS scores at baseline did not differ between groups [$F(2,57)=0.171$, N.S., see Table 1], the ANCOVA with task condition as a fixed factor and DAS scores T1 and PANAS change scores T2–T3 as covariates revealed a highly significant effect of task condition on DAS scores T3 [$F(2,54)=6.72$, $p=0.002$]. *Post-hoc* tests identified significant differences in DAS scores T3 between rumination and distraction [$F(1,35)=6.40$, $p=0.016$] and between rumination and mindful self-focus [$F(1,35)=16.69$, $p<0.001$] whereas distraction and mindful self-focus did not differ [$F(1,35)=0.74$, $p=0.787$]. Separate RM ANOVAs identified a significant increase in dysfunctional attitudes from T1 to T3 in the rumination group [cf. Fig. 1; $F(1,19)=14.69$, $p<0.001$] whereas distraction and mindful self-focus were linked to statistically non-significant decreases in dysfunctional attitudes [cf. Fig. 1; distraction: $F(1,19)=2.84$, $p=0.108$, mindful self-focus: $F(1,17)=3.93$, $p=0.062$].

Response induction: effect on cortisol responses

In the total sample, the mean AUC_I was in the negative range (mean −47.55, S.D. = 61.45, range −207.00 to 161.93), suggesting a decrease in cortisol levels over the experiment. The linear regression analysis with AUC_I as the dependent variable revealed no significant effect of task condition ($B=38.03$, S.E. = 0.5, $t=1.69$, $p=0.097$) and a significant effect of BDI-II score ($B=5.18$, S.E. = 2.04, $t=2.53$, $p=0.014$) that was qualified, however, by a significant interaction of task condition by BDI-II score ($B=-6.42$, S.E. = 2.32, $t=-2.77$, $p=0.008$). The interaction effect is demonstrated graphically in Fig. 2. The AUC_I scores per condition (rumination *versus* other conditions), as predicted by the regression model, are shown at one standard deviation below the mean of BDI-II scores and one standard deviation above the mean. Figure 2

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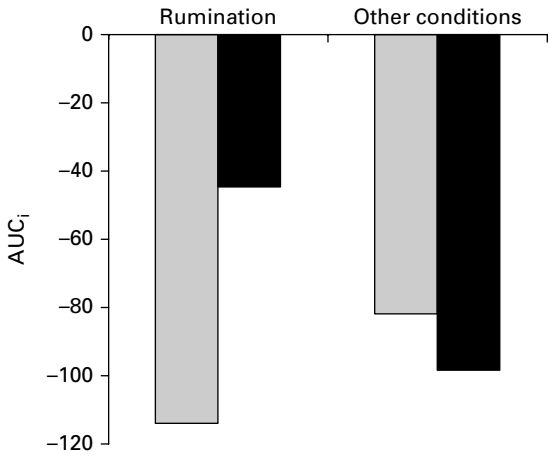

Fig. 2. Area under the curve increase (AUC_I) levels of cortisol in the rumination and non-rumination conditions for participants scoring high (■; +1 S.D.) and low (; −1 S.D.) on the Beck Depression Inventory II (BDI-II).

shows that, in the rumination condition, participants with high BDI-II scores (+1 S.D.) displayed a markedly lower AUC_I decrease over the experiment as compared to participants with low BDI-II scores (−1 S.D.), a pattern not seen in the non-rumination group.

Discussion

In the present study, we sought to determine effects of induced rumination, distraction and mindful self-focus on mood and dysfunctional attitudes after negative mood induction in a non-clinical sample of young adults. Furthermore, we examined whether induced rumination would elicit a larger cortisol stress response during the laboratory session than the other conditions and whether baseline levels of depressive symptoms would moderate this possible connection.

To induce a sad mood, we used a combination of mood-suggestive music and negative autobiographical recall. This procedure resulted in highly significant changes regarding positive and negative affect, confirming previous findings on its efficacy for mood induction (cf. Martin, 1990; Westermann *et al*. 1996; Singer & Dobson, 2007).

For the subsequent response induction, we expanded a paradigm originally developed by Lyubomirsky *et al*. (2003) for the induction of a mindful self-focus, with items focusing on non-judgemental acceptance and moment-to-moment awareness. Regarding these contents, our mindful condition was very similar to that of Broderick (2005) and Singer & Dobson (2007), although the latter group placed particular emphasis on acceptance. Compared to rumination, induced distraction showed a distinct beneficial effect on the course of mood in our dysphoric subjects, consistent with prior studies (e.g. Donaldson & Lam, 2004; Joormann & Siemer, 2004; Lavender & Watkins, 2004; Lyubomirsky & Tkach, 2004; Kuehner *et al*. 2007*a*). By contrast, the induced mindful self-focus failed to show such a clear advantage over rumination. Finally, induced mindful self-focus and distraction did not differ in their effects on mood change. In quantitative terms, the magnitude of mood change after induced mindful self-focus was located between the effects achieved through induced rumination and distraction. These findings offer only partial confirmation of the prior studies (Broderick, 2005; Singer & Dobson, 2007). However, these studies differ in some methodological aspects, thus restricting comparability. Broderick (2005), for example, induced rumination and distraction according to Lyubomirsky *et al*.'s (2003) protocol, whereas the mindfulness condition was induced by audiotaped meditation and acoustic prompts to guide participants' attention to their breathing. These procedural differences may have affected the results insofar as the way in which the mindful self-focus was induced may *per se* have involved more attention drawing and absorbing. Singer & Dobson (2007) also reported more pronounced mood differences between the mindfulness condition and rumination, although, similar to our study, no difference emerged between mindful self-focus and distraction. However, whereas we studied university students, Singer & Dobson (2007) examined remitted depressed patients across a broad age range. Two hypotheses worth testing in this context would be that rumination has a more deleterious effect and/or that a mindful self-focus has a more beneficial effect on the course of negative mood in remitted patients than in non-clinical samples. It must also be considered, however, that according to mindfulness theory, marked short-term effects of mindfulness on temporary dysphoric mood should not necessarily be expected, but rather increased tolerance towards respective states (cf. Segal *et al*. 2002).

To our knowledge, our study is the first to assess the impact of response induction on dysfunctional cognitions as derived from Beck *et al*.'s (1979) cognitive model. While all groups showed very similar levels of dysfunctional attitudes at baseline, we identified highly significant differences in DAS change scores between rumination and both distraction and mindful self-focusing. In the induced rumination group, DAS scores increased significantly from baseline to post-response induction whereas distraction and mindful self-focus were linked to non-significant decreases in dysfunctional attitudes. There is evidence that negative mood induction increases dysfunctional attitudes in persons vulnerable to depression (Miranda *et al*. 1998; Segal *et al*. 1999, 2006; Gemar *et al*. 2001) as well as in healthy probands (Fresco *et al*. 2006). As we did

not assess the DAS directly after mood induction, we can only speculate that induced rumination, compared to distraction and mindful self-focus, has entailed a perpetuation of dysfunctional attitudes originally activated by negative mood induction. This hypothesis should be investigated in more depth in future research.

In this context, a study by Ramel *et al*. (2004) demonstrated positive effects of mindfulness training on habitual rumination and dysfunctional attitudes in individuals with lifetime mood disorders. The most reliable improvement occurred for rumination, with changes in ruminative thinking accounting for reductions in dysfunctional attitudes but not vice versa. Based on our findings and those by Ramel *et al*. (2004), it is conceivable that the manipulation of a dysfunctional mode of cognitive processing (rumination), whether by experimental induction or by clinical intervention, appears to alter depression-linked thought content and levels of negative thinking (cf. Segal *et al*. 2002; Ramel *et al*. 2004; Kenny & Williams, 2007). Importantly, the observed increase in dysfunctional attitudes in the rumination group was not attributable to parallel mood change in the present study.

The induction of rumination was not *per se* linked to a higher cortisol stress response during the experiment. The overall time-dependent change in the AUC was negative, indicating decreases in cortisol levels over time with no significant difference between the rumination and non-rumination groups. The observed decreasing cortisol levels appeared to reflect primarily the circadian course of cortisol secretion, peaking in the morning with a steady decline into the evening (Kudielka *et al*. 2004). It may therefore be concluded that the induction of rumination was not stressful enough to activate a distinct cortisol response. However, a significant interaction between task condition and depression levels indicated that the effect of induced rumination on the cortisol response varied across groups with high and low depression scores. Participants scoring high on the BDI-II who were induced to ruminate showed a smaller decrease in cortisol levels than participants with lower BDI-II scores, suggesting that, particularly in this vulnerable subsample, active rumination has modified the course of cortisol levels during the task.

Although these findings should be interpreted with caution because of the small subsamples, they are in line with Brosschot *et al*.'s (2006) hypothesis suggesting a detrimental role of rumination for both affective and physiological responses. Brosschot *et al*. (2006) suggest that perseverative cognitions, such as rumination and worry, enhance stress-related physiological activity by expanding the temporal duration of stressors (in this case: negative mood and dysfunctional negative thoughts) due to their mental representation. Empirical evidence emerges from studies investigating links between perseverative cognitions and health-related outcomes including cardiovascular activity and somatic symptoms (cf. Brosschot *et al*. 2006). By contrast, we are not aware of any prior study that has actively induced rumination to investigate related effects on the endocrine stress responses. Although indirect support is provided by McCullough *et al*.'s (2007) study linking naturally occurring episodes of rumination to enhanced cortisol activity, the active induction of such a state allows firmer conclusions to be drawn regarding its possible causal effects. Taking the present results and those from prior work into account, our data suggest links between trait rumination and alterations of the basal activity of the HPA axis (Kuehner *et al*. 2007*a*) and also between induced rumination and the cortisol stress response in vulnerable individuals (present study).

Our study has several limitations. We did not screen participants with respect to their reactivity to the mood induction, which may have led to an underestimation of response induction effects. Larger sample sizes would have allowed us to exclude subjects demonstrating only minimal mood deteriorations without losing substantial statistical power.

Furthermore, it is important to note that short induction periods of mindful self-focus through prompted statements as used in the present study are not assumed to produce changes in experiential stances as achieved through repeated mindfulness practice. Nonetheless, the experimental investigation of different modes of self-focusing such as ruminative *versus* mindful self-focusing (and comparisons with a non-self-focused mode such as distraction) allowed us to identify distinct adaptive and maladaptive effects on mood and cognitive processes. In this context, further modes of self-focusing could also be of interest. For example, Watkins and colleagues (Watkins & Teasdale, 2001; Watkins & Mould, 2005) showed that induced experiential rumination ('focus your attention on your experience of …') in contrast to more abstract analytic rumination ('think about …') reduced overgeneral memory and improved problem solving in depressed patients.

It may also be regarded as a limitation that the DAS was administered only at baseline and after response induction, but not after mood induction. Therefore, we cannot totally rule out the possibility that the experimental groups may already have differed in their levels of dysfunctional attitudes after mood induction. However, this seems very unlikely because groups were allocated by randomization and we had no indication of any group differences regarding demographic or clinical variables at baseline that could have

modified the effects of mood induction. One reason for not applying the DAS after mood induction was that we expected enhanced recognition effects when presenting the instrument three times during the session. More importantly, we suspected an attenuation of the mood induction effect itself because of the time required to fill in another 40 items in addition to the PANAS. Therefore, we wanted to keep the executive load for the participants between mood and response induction to a minimum. Nonetheless, the lack of DAS assessment after mood induction is a clear shortcoming of our study. Future research may consider the application of homogeneous short versions of the DAS that could facilitate a more frequent assessment during the experiment.

Finally, our findings regarding the interaction of rumination with baseline depression levels on the cortisol response require replication in larger samples. In our study, induced rumination did not elicit a significant stress-induced rise in cortisol but instead a delayed decrease that was furthermore restricted to vulnerable individuals with elevated depression levels. Larger studies using rumination inductions with varying degrees of intensity and duration are needed to allow firmer conclusions to be made regarding possible main or interaction effects of rumination on the cortisol stress response. In addition, studies investigating endocrine reactivity to rumination in explicit high-risk and in depressed samples, as well as its predictive effect for the course of psychopathology, might help to elucidate in more detail possible pathogenic pathways between perseverative cognitions, endocrine parameters, and ill-health development and outcome.

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Declaration of Interest

None.

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