

## Experimental effects of rumination styles on salivary cortisol responses

Thomas F. Denson · Emma C. Fabiansson ·  
J. David Creswell · William C. Pedersen

Published online: 17 December 2008  
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**Abstract** Emerging research suggests that rumination increases risk for negative health outcomes. In the first experiment to investigate cortisol responses during angry rumination, participants were provoked and induced to engage in self-focused rumination, provocation-focused rumination, or distraction. Consistent with social threat theory, self-focused rumination maintained high levels of cortisol following provocation, whereas provocation-focused rumination and distraction facilitated decreases in cortisol. However, even within the provocation-focused rumination condition, adopting an emotionally reactive, self-immersed perspective was associated with higher levels of cortisol as were thoughts about the self. Individual differences in displaced aggression but not general aggression were also positively associated with cortisol levels in the provocation-focused condition. The present findings shed light on rumination styles and cortisol responses in ways that may have long-term consequences for health and well-being.

**Keywords** Cortisol · Angry rumination · Aggressive personality · Provocation · Stress · Anger · Health

Rumination is characterized by uncontrollable, repetitive thoughts about some distressing occurrence. It is a multifaceted construct and at a broad level, along with worry, can be considered a form of perseverative cognition (Borkovec et al. 1998; Brosschot et al. 2006; Fresco et al. 2002; Segerstrom et al. 2000). Although it is thought to be unproductive and possibly even harmful, rumination is an emotion regulation strategy that some individuals rely on when coping with aversive events. Rumination has been examined in the context of depression, anxiety, and anger (Nolen-Hoeksema 2000; Rusting and Nolen-Hoeksema 1998; Sukhodolsky et al. 2001). In the present research, we examined rumination following an anger-inducing interpersonal provocation.

Rumination has been linked to adverse health outcomes, yet the physiological mechanisms responsible for these relationships are not well understood (Gillespie and Nemeroff 2005; Thomsen et al. 2004a, b; Thomsen et al. 2003). Previous studies implicate the stress hormone cortisol as a potential mechanism linking rumination to negative health outcomes (Brosschot et al. 2006), although no studies have examined whether various ruminative styles elicit cortisol responses under well-controlled conditions. In the first experiment to do so, we examined the effects of two rumination styles and distraction on cortisol responses following provocation.

At least three perseverative cognitive responses to provocation are possible: distraction, self-focus, or anger-related thoughts. First, one can distract oneself by thinking about something unrelated to the provocation. This allows time for the affective, cognitive, and physiological effects of the provocation to subside. Second, one can turn inward and focus on the self. Such internalizing self-focused rumination might increase self-awareness and self-critical evaluation. According to objective self-awareness theory,

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T. F. Denson (✉) · E. C. Fabiansson  
School of Psychology, University of New South Wales,  
Sydney, NSW 2052, Australia  
e-mail: t.denson@unsw.edu.au

J. D. Creswell  
Carnegie Mellon University, Pittsburgh, PA, USA

W. C. Pedersen  
California State University, Long Beach, CA, USA

self-awareness initiates a process whereby individuals compare their current state with personal standards (Duval and Wicklund 1972). If there is a discrepancy, and the individual is not capable of reducing this discrepancy, negative affect ensues. Moreover, self-focused rumination increases negative affect to a greater extent than other forms of self-focused attention (Mor and Winquist 2002).

Similar to objective self-awareness theory, social threat theory also posits a role of critical evaluation. However, rather than being initiated by comparison to personal standards, threats to the social self occur in the presence of negative social evaluation, rejection, or potential loss of social status (Dickerson et al. 2004; Dickerson and Kemeny 2004). Relative to distraction, self-focused rumination is likely to lead to higher levels of cortisol because it focuses one's attention on threats to the social self. Indeed, meta-analytic evidence confirms that experimental stress paradigms such as the Trier Social Stress Test, which contain strong social-evaluative components, elicit a cortisol response (Dickerson and Kemeny 2004; Kirschbaum et al. 1993). Thus, we expected that self-focused rumination would be associated with higher cortisol levels than distraction.

A third ruminative strategy could involve replaying the anger-provoking incident in one's mind while focusing on angry feelings and thoughts of revenge. This has been termed provocation-focused rumination (Bushman et al. 2005; Denson et al. 2006; Denson et al. in press b). Thus, in the present research we directly manipulated distraction, self-focused rumination, and provocation-focused rumination. By contrast with self-focused rumination, recent research suggests that provocation-focused rumination does not uniformly exert detrimental effects on mental and physical health-relevant outcomes (Ayduk and Kross 2008; Kross et al. 2005; Wimalaweera and Moulds 2008).

One critical variable that moderates the effects of provocation-focused rumination on negative affect and cardiovascular reactivity is the perspective that one adopts during rumination. Participants who were asked to recall anger-laden memories from an emotionally immersed perspective endorsed higher levels of negative affect and cardiovascular reactivity relative to those who were asked to recall an angry memory from an emotionally detached, distanced perspective (Ayduk and Kross 2008; Kross et al. 2005). Our manipulation of provocation-focused rumination was subtle enough to allow for a post hoc examination as to whether the type of provocation-focused processing style adopted by participants differentially affected cortisol levels. We suspected that relative to distraction, only the emotionally immersed processing style would be associated with higher levels of cortisol.

In the present experiment, participants were provoked by a rude confederate and randomly assigned to a 20-min

period of self-focused rumination, provocation-focused rumination, or distraction. This research is novel because in addition to the experimental manipulation of two types of rumination, we included a distraction condition that allowed us to determine whether the effects of each type of rumination were more similar to each other or distraction in terms of cortisol responses. Moreover, all participants were exposed to the same provocation. Prior work has focused on anger-laden autobiographical memories and has therefore not controlled for individual differences in recalled content. Finally, we examined the effects of two aggressive personality dimensions—general aggression and displaced aggression—on cortisol (Bettencourt et al. 2006; Buss and Perry 1992; Denson et al. 2006, in press a, b; Denson 2008). Individual differences in general aggression are characterized by brief, strong feelings of anger and immediate retaliation. By contrast, some people do not respond immediately to provocations. Rather, they tend to engage in rumination over time. Such individuals are high in displaced aggression. Individual differences in displaced aggression are characterized by extended provocation-focused rumination and eventually “taking out” these angry feelings on undeserving others. Because individuals high in displaced aggression engage in emotionally reactive rumination (Denson et al. 2006), we expected this disposition, but not general aggression, to be associated with higher levels of cortisol.

## Method

### Participants

Forty-eight introductory psychology students ( $M_{\text{age}} = 20$  years,  $SD_{\text{age}} = 3.25$ ; 30 women) from the University of New South Wales were randomly assigned to self-focused rumination, provocation-focused rumination, or distraction). To control for diurnal variation in cortisol, participants were tested between 2 p.m. and 6 p.m. They were also asked to abstain from caffeine, alcohol, and exercise 24 h prior to the experiment. There were no gender differences in cortisol levels.

### Materials and procedure

The experiment was introduced by an experimenter as a study on the effects of performing academic tasks on physiological responses. Participants were advised that although the session would be run by a female research assistant (RA), the experimenter, who was blind to condition, would be checking in during the session. Participants rested quietly for 15 min prior to beginning. They also completed the 29-item Aggression Questionnaire, which

assesses general aggression (AQ; Buss and Perry 1992;  $\alpha = .85$ , e.g., “If somebody hits me, I hit back”), and the 31-item Displaced Aggression Questionnaire (DAQ; Denson et al. 2006;  $\alpha = .90$ ; e.g., “I take my anger out on innocent others” and “When angry, I tend to focus on my thoughts and feelings for a long period of time”; 1 = *extremely uncharacteristic of me*, 7 = *extremely characteristic of me*). Afterwards, a baseline saliva sample was collected with a Salivette (Sarstedt, Rommelsdorf, Germany).

#### Provocation procedure

Participants were given 4 min to complete an anagram task consisting of 11 difficult anagrams (e.g., ‘dmpaiunneo’ = ‘pandemonium’) and 4 easy anagrams (e.g., ‘miet’ = ‘time’). As expected, participants performed poorly on the anagram task ( $M = 4.88$  correct,  $SD = 1.54$ ), which was ostensibly submitted to the experimenter for scoring. After a delay, the experimenter entered the room and insulted the participant by stating that their performance was so poor that their data could not be used. Furthermore, the experimenter explained that the participant should really repeat the experiment, but that would be a waste of time. This provocation has been previously validated (Denson et al. 2006, 2008; Vasquez et al. 2005).

#### Rumination manipulation

The experimenter instructed participants that they would be completing a writing task on the computer for 20 min. Those assigned to the self-focused rumination condition wrote short-answer responses about what sort of person they are, how they are treated by others, and reflections on their relationships with other people. Participants in the provocation-focused rumination condition were asked to write an essay on their experience as a research participant. This included describing their feelings, thoughts and what had happened during the experiment. Participants in the distraction condition wrote about several neutral topics such as the layout of the local post office, the shape of a large black umbrella, and two birds sitting in a tree. The self-focused rumination and distraction conditions were taken from Rusting and Nolen-Hoeksema (1998). The rumination manipulations have been shown to increase anger and aggression in prior research (Bushman et al. 2005; Denson et al. 2006; Rusting and Nolen-Hoeksema 1998). Fifteen minutes into the writing task, the experimenter took the 2nd saliva sample.

Once the 20 min writing task was completed, the RA entered and announced in a bored tone that the data had been lost and that the participant would be required to repeat the task. The 3rd saliva sample was taken and the

writing task was re-started. After 5 min, the experimenter re-entered the room and remarked that after consulting with another experimenter, the data should be able to be recovered as it was automatically saved on the network drive. Thus, the experimenter appeared somewhat incompetent, thereby providing a source of continued rumination (e.g., Pedersen et al. 2000).

To determine the level of self-focused rumination and provocation-focused rumination, participants rated how often and how strongly they thought about themselves ( $\alpha = .92$ ) and about the anagram task ( $\alpha = .93$ ) during the writing task (1 = *not at all*, 7 = *very strongly/often*). At the study conclusion, the final saliva sample was collected and participants were debriefed. All saliva samples were stored at  $-20^{\circ}\text{C}$  and assayed for cortisol by a professional reference laboratory using a time-resolved immunoassay with fluorometric end-point detection (Dressendorfer et al. 1992).

## Results

### Manipulation checks

There were significant effects of the rumination manipulations on the extent to which participants thought about themselves,  $F(2,45) = 9.33$ ,  $p < .001$ , and the provocation,  $F(2,45) = 3.24$ ,  $p < .05$ . As predicted, participants in the self-focused rumination condition reported ruminating about themselves more than participants in the distraction condition ( $M_{\text{self-focused}} = 5.94$ ,  $SD = 0.95$ ;  $M_{\text{distraction}} = 3.91$ ,  $SD = 1.71$ ;  $p = .01$ ,  $d = 1.47$ ), but not more about the anagram task than participants in the distraction condition ( $M_{\text{self-focused}} = 3.59$ ,  $SD = 2.11$ ;  $M_{\text{distraction}} = 2.76$ ,  $SD = 1.81$ ;  $p = .23$ ,  $d = .42$ ). Participants in the provocation-focused rumination condition reported ruminating about the anagram task more than participants in the distraction condition ( $M_{\text{provocation-focused}} = 4.57$ ,  $SD = 1.97$ ;  $M_{\text{distraction}} = 2.76$ ,  $SD = 1.81$ ;  $p = .01$ ,  $d = .96$ ), and more about themselves than participants in the distraction condition ( $M_{\text{provocation-focused}} = 5.21$ ,  $SD = 1.40$ ;  $M_{\text{distraction}} = 3.91$ ,  $SD = 1.71$ ;  $p = .03$ ,  $d = .83$ ). This latter finding is expected as the self is the victim of the provocation, which was the focus of this condition. Overall, these data suggest that the rumination manipulation was successful in producing the intended ruminative states.

### Cortisol

At baseline, a one-way between groups ANOVA demonstrated no significant differences in cortisol between the rumination conditions,  $F(2,45) = .09$ , *ns*. Importantly, a 3 (time)  $\times$  3 (rumination condition) mixed ANCOVA with

rumination condition specified as the between-participants factor and baseline cortisol levels as the covariate revealed a time  $\times$  rumination condition interaction,  $F(3,56) = 2.67$ ,  $p = .06$ ,  $\eta^2 = .11$ . Follow-up repeated measures tests compared cortisol levels at Time 1 (baseline) to Time 4 (conclusion of the experiment) within each rumination condition. Cortisol levels in the provocation-focused rumination condition showed a significant decrease ( $M_{T1} = 8.98$ ,  $SD_{T1} = 4.67$ ;  $M_{T4} = 6.31$ ,  $SD_{T4} = 3.45$ ),  $t(13) = 2.69$ ,  $p < .05$ ,  $d = -.65$ , as did cortisol levels in the distraction condition ( $M_{T1} = 7.98$ ,  $SD_{T1} = 2.79$ ;  $M_{T4} = 6.28$ ,  $SD_{T4} = 2.81$ ),  $t(15) = 3.23$ ,  $p < .05$ ,  $d = -.72$ . By contrast, in the self-focused rumination condition, there was no change in cortisol during the experiment ( $M_{T1} = 9.48$ ,  $SD_{T1} = 7.39$ ;  $M_{T4} = 7.79$ ,  $SD_{T4} = 4.68$ ),  $t(14) = 1.16$ ,  $p > .05$ ,  $d = -.27$ . Cortisol levels typically decrease during the late afternoon. Indeed, in our sample, participants who started the experimental sessions at 2 or 3 p.m. demonstrated higher cortisol levels at baseline than did those who began the experiment at 3:30 or 4 p.m.,  $t(46) = 3.13$ ,  $p = .003$ ,  $d = .94$ . Thus, self-focused rumination delayed this normal decline, whereas provocation-focused rumination and distraction did not (see Kim 2008 and Nes et al. 2005 for similar cortisol responses; Fig. 1).

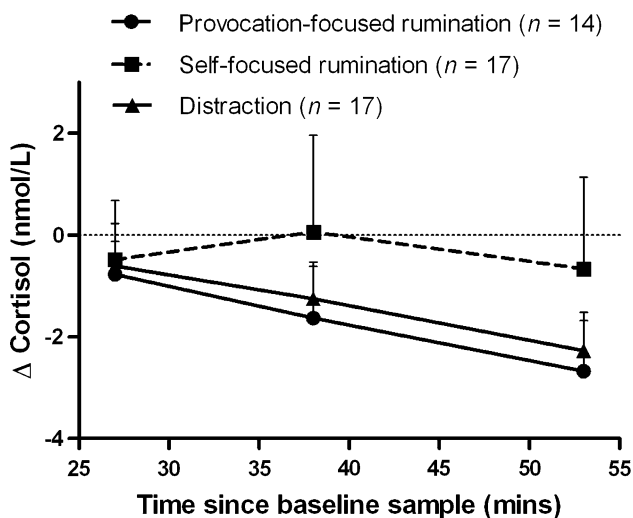
#### *Distanced versus emotionally immersed provocation-focused rumination*

In order to determine whether the type of processing that participants adopted in response to the provocation differentially influenced cortisol reactivity, we created two groups of participants within the provocation-focused

condition by coding their written comments. Two blind coders were instructed to group participants into an emotionally distanced perspective (e.g., "...the next task began with a set of 15 anagrams. This anagrams had to be sorted in 4 min i.e. is 15 s for each anagram. Completing 7 of those anagrams in 4 min."); or to an emotionally immersed perspective (e.g., "I was already aware of my poor performance and my displeasure with my score was not aided by the fact that the marker was blunt and to a degree, rude, about this result. To an extent he was degrading, saying bluntly that it was a poor score and a waste of time"). Coders were highly reliable in determining individuals who wrote in an objective emotionally distanced perspective ( $n = 6$ ) and those who wrote in an immersed, emotionally expressive manner ( $n = 8$ ; 93% agreement,  $\kappa = .87$ ).<sup>1</sup> There were no differences in baseline cortisol levels between these groups,  $t(12) = 0.65$ ,  $p = .53$ .

Importantly, participants who wrote from a distanced perspective showed a trend toward decreasing cortisol levels, ( $M_{T1} = 9.94$ ,  $SD_{T1} = 5.51$ ;  $M_{T4} = 6.26$ ,  $SD_{T4} = 4.18$ ),  $t(5) = 2.16$ ,  $p = .08$ ,  $d = -.86$ , whereas those who wrote from an immersed, emotionally reactive perspective did so to a lesser, yet non-significant degree ( $M_{T1} = 8.27$ ,  $SD_{T1} = 4.18$ ;  $M_{T4} = 6.35$ ,  $SD_{T4} = 3.10$ ),  $t(7) = 1.59$ ,  $p = .16$ ,  $d = -.60$ . Thus, even within the provocation-focused rumination condition, individual differences in the processing style that participants spontaneously engaged in was related to cortisol reactivity. However, these results should be interpreted cautiously because of the small group sizes and because the Time 1 mean cortisol levels were directionally, yet not significantly higher in the distanced group, suggesting that these results might be an artifact of differences in baseline cortisol levels.

Furthermore, consistent with social threat theory (Dickerson et al. 2004), the degree to which participants ruminated about themselves in the provocation-focused condition was correlated with increased cortisol from baseline at Time 2, Time 3, and Time 4 (see Table 1). Subsequent analyses revealed that these correlations were driven entirely by participants in the emotionally reactive group. In that group, reported self-focus was strongly correlated with cortisol changes at Time 2,  $r = .68$ ,  $p = .07$ , Time 3,  $r = .81$ ,  $p = .02$ , and Time 4,  $r = .88$ ,  $p = .004$ . None of these correlations were significant in the distanced group or the self-focused rumination condition. However, there were marginally significant negative correlations for two of the three correlations in the distraction condition. This latter finding is consistent with the notion that self-focus is only aversive when it is negative (Duval and Wicklund 1972; Mor and Winquist 2002).



**Fig. 1** Mean level of change from baseline in salivary cortisol as a function of time since baseline assessment and rumination condition. Difference scores were calculated by subtracting the baseline sample from the subsequent cortisol samples

<sup>1</sup> Disagreement over one case was resolved via discussion.

**Table 1** Correlations between reported self-focus during the experiment and change in cortisol levels from baseline

Experimental condition	Time 2	Time 3	Time 4
Provocation-focused rumination	.60*	.65**	.58*
Self-focused rumination	.29	.17	.19
Distraction	-.25	-.47 <sup>+</sup>	-.46 <sup>+</sup>

Note: \*\*  $p < .01$ , \*  $p < .05$ , <sup>+</sup>  $p < .07$

In summary, increased self-focus, whether experimentally manipulated or within the provocation-focused rumination condition, and an emotionally reactive processing style were associated with the maintenance of high cortisol levels, whereas ruminating in an objective, distanced manner was associated with decreases in cortisol akin to that observed in the distraction condition.

#### *Individual differences in aggressive personality*

We also conducted interaction analyses (Aiken and West 1991) in order to identify the roles of individual differences in general aggression (as assessed by the AQ) and displaced aggression (as assessed by the DAQ). We regressed the 2nd, 3rd, and 4th samples on the rumination condition variables, while controlling for baseline cortisol levels. Because trait general and displaced aggression are not orthogonal dimensions,  $r = .69$ ,  $p < .001$ , we controlled for these variables simultaneously. As expected, we observed displaced aggression  $\times$  rumination interactions at Time 2,  $b = 1.30$ ,  $t(39) = 2.59$ ,  $p = .01$ , Time 3,  $b = 1.34$ ,  $t(39) = 1.81$ ,  $p = .08$ , and Time 4,  $b = 1.22$ ,  $t(39) = 1.80$ ,  $p = .08$ . Simple effects analyses revealed that displaced aggression predicted cortisol reactivity in the provocation-focused rumination condition at Time 2,  $b = 1.03$ ,  $t(39) = 2.49$ ,  $p = .02$ , and marginally at Time 3,  $b = 1.02$ ,  $t(39) = 1.68$ ,  $p = .10$ , but not at Time 4,  $b = 0.84$ ,  $t(39) = 1.50$ ,  $p = .14$ . Displaced aggression did not influence cortisol reactivity in the self-focused or distraction conditions ( $ps > .23$ ). There were no effects for general aggression in any of the conditions. Thus, displaced aggression but not general aggression was positively associated with elevated cortisol levels when ruminating about the provocation.

## Discussion

This study provides the first experimental evidence of the effects of rumination styles on cortisol responses. Consistent with a recent naturalistic diary study (McCullough et al. 2007), the present experimental findings showed that self-focused and emotional rumination about interpersonal transgressions was associated with elevated

cortisol levels. Furthermore, individual differences in displaced aggression moderated these effects such that individuals high on the dimension showed higher levels of cortisol than those low on the dimension when induced to ruminate about the provocation. These data are consistent with prior research demonstrating that those high in displaced aggression differ from those in general aggression in their cognitive, behavioral, and neural reactions to interpersonal provocation (Denson et al. 2006; Denson et al. in press b).

Our findings are also consistent with social threat theory and prior work demonstrating beneficial health-related effects of distanced angry rumination (Dickerson et al. 2004; Ayduk and Kross 2008; Kross et al. 2005). However, not all studies show beneficial effects of distanced rumination about anger-inducing events, and one study has shown that this type of processing is associated with worse long-term consequences. Specifically, Wimalaweera and Moulds (2008) found that distanced processing increased negative intrusions 24 h following ruminating about an anger-inducing life episode. Thus, future research will determine whether the short-term mental and physical health benefits of distanced processing of anger-inducing events translate into long-term health benefits.

Limitations to the present research include the fact that we did not directly manipulate distanced and immersed provocation-focused rumination. Rather we relied on post hoc categorization of participants, which limits causal inference. Second, the provocation and experimental tasks failed to produce an increase in cortisol output. This is not surprising given the significant between-participant variability that is commonly observed in cortisol responses to laboratory tasks (Kirschbaum et al. 1998; and see error bars in Fig. 1), and because many laboratory stress tasks are insufficient in triggering a cortisol response (for a review, see Dickerson and Kemeny 2004). Despite these limitations, the present study observed significant and unique differences among the groups in cortisol as a result of the rumination manipulation.

The degree of variability in the self-focused rumination condition suggests the presence of additional moderators that could be explored in future research. Although in general self-focused rumination following negative events typically intensifies negative emotions (Mor and Winquist 2002; Rusting and Nolen-Hoeksema 1998), some individuals demonstrate physiological resilience to social stressors (Creswell et al. 2005; Taylor et al. 2003). For instance, when ruminating about topics such as how they get along with others and why people treat them the way they do, inducing a focus on positive aspects of individuals' social relationships and personal values rather than focusing on critical evaluation might prove beneficial. Consistent with this notion, optimistic thinking, value affirmation, and



imagined social support all buffer the physiological effects of laboratory stressors (Creswell et al. 2005; Smith et al. 2004).

Another promising avenue to examine is the relationship between the actual emotions and cognitive appraisals elicited during self-focused rumination and cortisol reactivity. In Dickerson and Kemeny's (2004) meta-analysis of 208 laboratory stress experiments, there was no relationship observed between general negative affect and cortisol effect sizes. This suggests that cortisol responses are not universally susceptible to negative affect, and might be influenced by specific appraisals and emotions instead. Within the context of our experiment, participants in the self-focused rumination condition might have focused on submissive feelings following the provocation from the relatively higher status experimenter. Sensitivity to status hierarchies and submissiveness appear to be inherited from our primate ancestors (e.g., Sapolsky 1998, 2004) and increases in cortisol are associated with avoidant and submissive behavior in social contexts (Kagan et al. 1988). Thus, increased feelings and thoughts of submissiveness in the self-focused rumination condition might account for the higher levels of cortisol observed in this condition relative to the other two conditions.

In conclusion, the present findings provide the first experimental evidence for the effects of specific ruminative styles on salivary cortisol responses following provocation. Although more studies are needed, our results provide the first evidence for links between self-focused rumination and the stress hormone cortisol in ways that may have long-term impacts on health and well-being outcomes.

**Acknowledgments** This research was supported by the Australian Research Council's *Discovery Projects* funding scheme (DP0985182). We thank Michelle Moulds for comments on an earlier draft of this article.

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