



The impact of angry rumination on anger-primed cognitive control



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ABSTRACT

Background and Objectives: Recent research suggests that angry rumination augments aggressive behavior by depleting self-control resources. Yet, few studies have been conducted to empirically support this proposal. In the present study, we therefore sought to investigate the effects of angry rumination, relative to distraction, on self-reported anger and a behavioral indicator of self-control.

Methods: Seventy-two participants recalled and imagined an anger-inducing autobiographical memory and were instructed to engage in either angry rumination ($n = 37$) or distraction ($n = 35$). Following these emotion regulation instructions, participants performed an affective Go/NoGo task in order to assess behavioral self-control along with several questionnaires to assess anger related constructs.

Results: As expected, results revealed that angry rumination augmented anger, whereas anger decreased in the distraction condition. Contrary to predictions, we found no differences between both groups in performance on the affective Go/NoGo task.

Limitations: A potential limitation is we instructed our participants on how to regulate their emotions rather than letting angry rumination occur spontaneously.

Conclusions: The findings indicate that whereas angry rumination results in heightened anger, it does not seem to result in lower self-control as measured with a behavioral task that requires cognitive control. More research is needed to test the boundary conditions regarding the role of self-control in understanding rumination-induced aggression.

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1. Introduction

People differ in how they deal with provoking situations. These differences can to a certain degree be explained by individual differences in cognitive processes. For instance, whereas some individuals easily distract themselves from a provoking event and move on, others keep dwelling and mentally rehearsing upon the provocation and fantasize on how to get back. This dwelling and revenge planning process is known as angry rumination (Sukhodolsky, Golub, & Cromwell, 2001). More narrowly defined, angry rumination refers to “perseverative thinking about a personally meaningful anger-inducing event” (Denson, 2013, p. 1). Angry rumination is typically initiated when there is a discrepancy between one's desired goal and one's actual state (Martin & Tesser,

1996), especially when there is a lack of perceived control over the discrepancy (Wänke & Schid, 1996). Angry rumination is often considered to be a key factor in explaining trait anger and aggression and can easily be incorporated in the main theories explaining dispositional anger and aggressive behavior (Denson, 2013; Denson, DeWall, & Finkel, 2012; Wilkowski, Robinson, & Troop-Gordon, 2010). Numerous studies have shown that people who ruminate on anger maintain or intensify their angry feelings (Bushman, 2002; Denson, Moulds, & Grisham, 2012; Ray, Wilhelm, & Gross, 2008; Rusting & Nolen-Hoeksema, 1998). Moreover, ample research has shown that both state and trait angry rumination facilitate aggressive behavior (Anestis, Anestis, Selby, & Joiner, 2009; Bushman, 2002; Collins & Bell, 1997; Denson, Pedersen, Friese, Hahm, & Roberts, 2011; Pedersen et al., 2011), including displaced aggression towards innocent victims after a seemingly minor anger-provoking event (Bushman, Bonacci, Pedersen, Vasquez, & Miller, 2005; Denson et al., 2011). Conversely, distracting oneself from ruminating (Konecni, 1974) or distancing

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oneself during ruminating (Mischkowski, Kross, & Bushman, 2012) decreases anger, aggressive thoughts, and aggressive behavior.

Another cognitive factor that takes a central role in main theories on trait anger and reactive aggression is self-control (Denson, DeWall et al., 2012; Denson, 2013; Wilkowski et al., 2010). Self-control refers to “the capacity for altering one’s own responses, especially to bring them into line with standards such as ideals, values, morals, and social expectations, and to support the pursuit of long-term goals” (Baumeister, Vohs, & Tice, 2007, p. 1). A concept closely related to self-control is cognitive control, given that exerting self-control requires cognitive control. Cognitive control refers to the ability to flexibly, voluntarily, and adaptively coordinate behavior in the service of goal-directed behavior, and is underlain by several distinct, but interacting, components, including working memory, attentional control, response inhibition, and error-processing (Luna, Garver, Urban, Lazar, & Sweeney, 2004). Self-control can be both regarded as a temperament based trait (i.e. the capacity to control one’s impulses across time and situations) or as a capacity-limited commodity that can become depleted after repeated use (Baumeister et al., 2007). Both state and trait self-control deficits have been repeatedly related to aggression (DeWall, Baumeister, Stillman, & Gailliot, 2007; Stucke & Baumeister, 2006; Tice & Baumeister, 1993; Wilkowski & Robinson, 2008; Wilkowski et al., 2010). Furthermore, patients with deficits in brain regions related to cognitive control, such as the inferior frontal cortex, often lack the ability to override their angry impulses and more often show aggressive behavior (Blair, 2012; Davidson, 2000; Siever, 2008). Adding further support to the causal relation between self-control and aggression, recent studies have shown that enhancing self-control reduces aggressive behavior (Denson, 2015; Wilkowski, Crowe, & Ferguson, 2015). In sum, both angry rumination and self-control deficits can be considered to be important cognitive risk-factors for anger and aggression.

Several lines of research provide indirect evidence that angry rumination and self-control may be related. Using self-report White and Turner (2014) showed that effortful control, a concept closely related to cognitive control, mediated the association between angry rumination and reactive aggression. Moreover, a recent study that used both self-report and behavioral tasks found that a disposition towards angry rumination was associated with deficient inhibition of related but at that time irrelevant information in long term memory (Whitmer & Banich, 2010). Another study conducted by Whitmer and Banich (2007) failed to find an association between a tendency towards rumination on anger and deficient inhibition in working memory, but did find angry rumination to be associated with difficulties switching to a new task set. Finally, evidence from neuroimaging research shows that higher levels of self-reported angry rumination were associated with heightened activity in regions related to cognitive control, including the (ventro) lateral prefrontal cortex, the dorsal medial prefrontal cortex, and the dorsal anterior cingulate cortex (Denson, Pedersen, Ronquillo, & Nandy, 2009; Ray et al., 2005).

Aside from these empirical studies suggesting that angry rumination and self-control may be related, several researchers have theorized that high self-control mitigates angry rumination (Denson, 2013; Finkel, 2007; Wilkowski & Robinson, 2008, 2010). Interestingly, Denson further proposes that angry rumination may lead to the loss of self-control and subsequent aggression by depleting self-control resources (also see Denson, DeWall et al., 2012; Denson, 2009; DeWall et al., 2007). More specifically, he posits that stopping angry rumination is challenging and depletes self-control resources as it requires individuals to down-regulate the intensity of their anger, to inhibit their angry thoughts, and to inhibit aggressive urges (Denson, 2013; Denson et al., 2011).

Note that this account is based on ego depletion models of self-regulation (Baumeister et al., 2007), in which angry rumination is proposed to consume self-regulatory resources subsequently contributing to self-control failures, such as aggression “in the same manner as refraining from eating a tempting donut” (Denson, 2009; p. 236). In order to answer this “causal question”, experimental studies are needed. To our knowledge, the only direct investigation of the impact of angry rumination on self-control is a series of studies by Denson, Pedersen, Friese, Hahm, and Roberts (2011). In one study, these researchers showed that inducing angry rumination following provocation resulted in higher aggression and lower self-control (as measured via self-report) compared to distraction (2011; study 2), and that the reduction in self-control mediated the association between angry rumination and aggressive behavior. Moreover, another study (2011; study 4) found indirect support by demonstrating that glucose, which supposedly replenishes the ability to exercise self-control (Gailliot et al., 2007), improved performance on a Stroop task relative to placebo following angry rumination but not following distraction.

Our main goal was to extend knowledge on the impact of angry rumination on self-control. In order to do so, we sought to investigate the effects of angry rumination on anger and using a behavioral indicator of a cognitive aspect of self-control. More specifically, we investigated whether angry rumination influenced experienced anger and performance on an anger-primed Go/NoGo task. An affective Go/NoGo task has been repeatedly used as a measure of response inhibition (e.g., Lujten, Littel, & Franken, 2011; Maurer et al., 2015; Munro et al., 2007), which is considered to be an important aspect of both cognitive control (e.g., Luna et al., 2004) and self-control (Muraven & Baumeister, 2000). Based on the work of Denson et al. (2011), we expected lower inhibitory control following angry rumination relative to distraction as evidenced by more commission errors on the Go/NoGo task.¹

2. Materials and methods

2.1. Participants

Seventy-three undergraduate psychology students took part in our study in return for course credits or a financial compensation of 10 euros. We randomly assigned the participants to one of two experimental conditions (angry rumination vs distraction), such that approximately equal numbers of men and women were assigned to each condition. One participant was not able to come up with an autobiographical event in which he became very angry and was therefore excluded from our data analyses, leaving a total of 72 participants. Thirty-seven participants (28 women [75.7%]; M age = 19.97, SD = 1.95) were in the angry rumination condition, and 35 participants (26 women [74.3%]; M age = 20.46, SD = 2.20) were in the distraction condition. The study was conducted according to the rules of the helsinki declaration on informed consent and confidentiality (World Medical Association, 2001) and all procedures were carried out with adequate understanding and written informed consent of the participants.

2.2. Materials and procedure

All participants were tested individually. Upon arrival at the laboratory, participants received general instructions regarding the experiment. Participants were then seated behind the computer

¹ Although hypotheses were derived from the study of Denson et al. (2011), the current study was not intended as a conceptual replication.

screen to start with the baseline mood measure using qualtrics survey software (Qualtrics Labs, Provo, Utah).

2.2.1. Baseline mood

To measure baseline mood, participants were asked to rate their current emotional state on a visual analogue scale (VAS; from 0 = “a little bit/not at all” on the left end to 100 = “very much” on the right end) for 21 emotions. Eighteen emotions were used from the positive and negative affect scale (PANAS; Watson, Clark, & Tellegen, 1988) and three emotions (angry, afraid, and happy) were added by the first author. The items “angry”, “hostile”, “irritated” were averaged to obtain a single measure of anger-hostility ($\alpha = 0.81$). The remaining items were used as filler items to help disguise the experiment’s focus on anger.

2.2.2. Anger induction: recalling an anger-inducing memory

Next, participants were given 5 min to write down in detail on a piece of paper three events in which they became very angry at another person. Moreover, they were instructed to indicate how angry they were at the time they experienced the anger-inducing event (from 1 “not at all angry” to 10 “extremely angry”) and to what extent each situation had been solved (from 1 “completely unsolved” to 10 “completely solved”). From these three reported events, the experimenter chose the least solved ($M = 6.51$, $SD = 2.84$), most anger inducing event ($M = 8.46$, $SD = 0.887$) to discuss in more detail with the participant during an anger-inducing semi-structured interview. The interview took approximately 5 min. Participants received the following instructions: “*In a moment we shall discuss one of the events you have written down, in which you were really angry, during an interview. During this interview you should try to relive the memory as vividly as possible. It is important for this interview that you picture the surroundings and the situation you were in as clearly as you can. Picture the people and the objects again, hear the sounds, and let yourself relive the experience as it was. Discuss during this interview as best as you can the thoughts and feelings that you actually felt and experienced. Everything you say will stay between us, so try to answer the interview as honestly as you can*”. The semi-structured nature allowed the interviewer to activate and encourage the subject to go into more detail about the anger-inducing event to evoke strong feelings of anger. This method has been shown to effectively induce anger (Lobbestael, Arntz, & Wiers, 2008). Directly after the anger-induction, participants rated their current emotional state for the second time using the VAS scales.

2.2.3. Emotion regulation manipulation: angry rumination versus distraction

Following the anger induction, participants were assigned to one of the two experimental conditions: Angry rumination versus distraction. Specifically, both groups received a set of instructions presented on their computer screen for 45 s followed by six statements that were presented for 30 s each. Participants in the angry rumination condition were instructed to think back about the anger inducing memory and to focus on the emotional aspects. The specific instructions were taken from Fabiansson, Denson, Moulds, Grisham, and Schira (2012). Participants in the distraction condition were instructed to think about what the campus looks like (see Appendix A for materials).

2.2.4. Mood measure and emotion regulation manipulation check

After the experimental manipulation, participants were once more instructed to rate their current emotional state using the VAS scales. In addition, participants filled in some emotion regulation manipulation checks (e.g., Please indicate on a scale from 1 to 100 what percentage of the time during the past 5 min you thought

about the angry memory you have discussed”; see Appendix B).

2.2.5. Anger-related Go/NoGo task

After filling in the questionnaires, participants performed a shortened version of an anger-related Go/NoGo Task (Lievaart et al., 2015).² In this particular task, participants viewed a series of pictures with an anger-related or neutral content. Each picture was displayed for 200 ms and had a blue or yellow frame. The frame color indicated whether a stimulus was a Go or a NoGo trial. Response assignments were randomized across participants. Each stimulus was followed by a black screen for a randomly varying duration between 1020 ms and 1220 ms. Participants were explicitly instructed to respond as fast and as accurate as possible to the pictures in Go trials by pressing a button with the right index finger, and to withhold their response for the NoGo trials. The task consisted of 56 different anger-related pictures and 56 neutral pictures selected from the international affective picture system (IAPS; Lang, Bradley, & Cuthbert, 2008) and google images, that were matched for color, gender and number of people displayed on the pictures. Anger-Related pictures displayed scenes of angry and/or fighting people, whereas neutral pictures showed similar scenes of people engaged in non-angry behavior. Each picture was presented four times, resulting in a total of 448 trials, of which 25% were NoGo and 75% were Go trials. The amount of NoGo trials were equally divided over picture categories (i.e., 56 NoGo trials and 168 Go trials). We used a blocked design with two blocks consisting of 224 trials each. The first block consisted of neutral pictures and the last block consisted of anger-related pictures. This fixed order was chosen to prevent priming and carry-over effects of the anger-related pictures onto the neutral pictures. After the first block, participants were given the opportunity to take a short break. The order of Go and NoGo trials was quasi randomized such that at most two NoGo trials were presented consecutively. Before starting the actual task participants performed 23 practice trials involving additional neutral pictures. Total task duration was about 15 min. The accuracy rates for NoGo trials was used as performance measure for the Go/NoGo task. One participant was excluded from the Go/NoGo task analyses as this participant failed to comprehend the instructions. This participant was included in all remaining data analyses.

2.2.6. Personality questionnaires

Lastly, participants filled in some personality questionnaires to ascertain that there were no important trait differences between the groups that could affect the results. *The Dutch version of the state trait anger expression inventory-2* (STAXI-2; Hovens, Lievaart, & Rodenburg, 2014; Spielberger, 1999) was used to measure the tendency to experience, express, and control anger. *The Dutch version of the aggression questionnaire* (AVL; Buss & Perry, 1992; Meesters, Muris, Bosma, Schouten, & Beuving, 1996) was used to measure trait aggressiveness. Finally, *The Dutch version of the barratt impulsiveness scale 11* (BIS-11; Lijffijt & Barratt, 2005; Patton, Stanford, & Barratt, 1995) was used to measure trait impulsivity. All the above mentioned questionnaires show good psychometric properties.

² After completing the Go/NoGo task, participants also performed an emotional Stroop task and an ambiguous hostile stories task in the above mentioned order. The results of the latter tasks are beyond the scope of this paper as there is no consensus in the literature whether these tasks tap into inhibitory control and because of the time delay between the experimental manipulation and performing these tasks.

3. Results

3.1. Preliminary analyses

3.1.1. Personality questionnaires and baseline assessments

One-way ANOVAs with group (angry rumination, distraction) as the independent variable revealed that the groups did not differ regarding their anger at baseline, $F(1,70) < 1, p = 0.578$, nor were there group differences in how angry participants reported to feel during the recalled event, $F(1, 70) = 1.11, p = 0.296$, and the extent to which the recalled event had been solved, $F(1,70) < 1, p = 0.621$. Lastly, there were no group differences in trait aggressiveness, $F(1, 70) = 2.14, p = 0.148$, trait impulsivity, $F(1,70) < 1, p = 0.787$, and their disposition to experience, express, and control anger, all $ps > 0.124$. Together, these data suggest that random assignment was successful.

3.1.2. Effectiveness of the anger induction

To examine the effectiveness of the anger induction on experienced anger, we conducted a 2×2 mixed ANOVA with group (angry rumination, distraction) as between-subjects variable and time (baseline, after the anger induction) as within-subjects variable. This analysis, yielded a main effect of time, $F(1, 70) = 133.48, p < 0.001, \eta_p^2 = 0.66$, indicating that participants felt more angry after the anger induction ($M = 35.81, SD = 21.12$) than they did at baseline ($M = 7.81, SD = 10.21$; see Fig. 1). Importantly, there were no differences in experienced anger across the two conditions ($F(1,70) < 1, p = 0.827$, nor was the time x Group interaction significant ($F(1,70) < 1, p = 0.474$). These data imply that the anger induction was successful and had the same effect on both groups.

3.1.3. Effects of the emotion regulation manipulation onto rumination and anger

To assess whether the participants from the Angry Rumination Condition ruminated more than participants in the Distraction condition, we performed one-way ANOVAs with Group as the independent variable and the emotion regulation manipulation checks as the dependent variables. As can be seen from Table 1, participants that were instructed to ruminate reported (a) to be more focused on their angry thoughts, their anger towards others, and their emotional response to the event, (b) to think about the angry memory more often and intensively, and (c) to have more difficulties to stop thinking about the angry memory than participants in the Distraction Condition.

To examine whether the groups differed in their anger experience after receiving the emotion regulation instructions, we conducted a 2×2 mixed ANOVA with Group (Angry Rumination, Distraction) as between-subjects variable and time (after the anger induction, after the emotion regulation manipulations) as within-subjects variable. The analysis yielded a main effect of time, $F(1, 70) = 23.22, p < 0.001, \eta_p^2 = 0.25$, and Group, $F(1, 70) = 12.09, p = 0.001, \eta_p^2 = 0.15$, that was qualified by a significant time x Group interaction, $F(1, 70) = 73.20, p < 0.001, \eta_p^2 = 0.51$. As can be seen in Fig. 1, this indicates that rumination and distraction had different effects on experienced anger. Follow-up paired t-tests within each condition, showed that rumination increased participants' anger, $t(36) = 2.72, p = 0.010, d = 0.91$, whereas distraction decreased participants' anger, $t(34) = 9.20, p < 0.001, d = 3.15$.

3.1.4. Associations between rumination and experienced anger

Interestingly, increased anger from time 2 (after the anger induction) to time 3 (after the emotion regulation manipulations) was associated with increased focus on the angry thoughts ($r = 0.533, p < 0.001$), anger towards others ($r = 0.386, p = 0.001$), and the emotional response to the event ($r = 0.446, p < 0.001$).

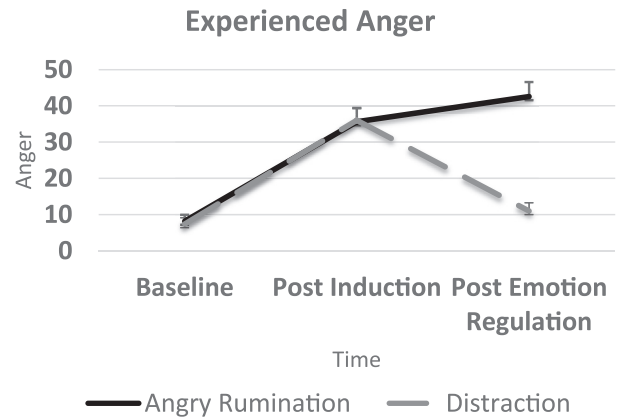


Fig. 1. Experienced anger during the experiment per condition.

Moreover, increased anger was associated with an increased tendency to think about the angry memory more frequently ($r = 0.628, p < 0.001$) and intensively ($r = 0.495, p < 0.001$), and with having difficulties to stop thinking about the angry memory ($r = 0.395, p = 0.001$). Finally, increased anger was not associated with questions related to re-appraisal, nor were angry rumination checks associated with anger reported at time 1 and time 2 (all $ps > 0.115$).

3.1.5. General performance on the anger-related Go/NoGo task

A 2 (Inhibition; NoGo versus Go) \times 2 (picture content; anger-related versus neutral) repeated measures ANOVA was conducted to assess whether the Go/NoGo task worked as supposed to by means of lower accuracy for NoGo Trials than for Go trials. As expected, there was a main effect of Inhibition, meaning that accuracy was lower for NoGo trials (79%) than for Go trials (98%), $F(1, 70) = 212.02, p < 0.001, \eta_p^2 = 0.75$. There was also a main effect of Picture Content, $F(1, 70) = 34.30, p < 0.001, \eta_p^2 = 0.33$, meaning that accuracy was lower for anger-related pictures than for neutral pictures. These effects were qualified by a significant Inhibition \times Picture Content interaction, $F(1, 70) = 20.14, p < 0.001, \eta_p^2 = 0.22$, meaning that accuracy was lowest for anger-related No-Go trials. In short, the typical Go/NoGo effect was demonstrated, indicating the task worked as intended.

3.2. Main analyses

3.2.1. Effects of rumination and distraction on response inhibition

To determine whether rumination resulted in lower accuracy on NoGo trials on the affective Go/NoGo task compared to distraction, and whether this effect was more pronounced for anger-related pictures compared to neutral pictures, a 2×2 mixed ANOVA was conducted with group as between-subjects variable and picture content (anger-related, neutral) as within-subjects variable for the NoGo trials. The analysis yielded a main effect of Picture Content, $F(1, 69) = 27.88, p < 0.001, \eta_p^2 = 0.29$, meaning that accuracy on NoGo trials was lower for anger-related pictures (77%) than for neutral pictures (82%). However, contrary to expectation, the analysis yielded no main effect of Group, $F(1, 69) = 1.89, p = 0.173, \eta_p^2 = 0.03$, nor a Picture Content \times Group interaction, $F(1,69) < 1, p = 0.499$, indicating that inhibitory performance was not differentially affected by rumination and distraction instructions (see Table 2). This was also true for the first 122 neutral trials, $t(69) = 1.22, p = 0.226$, indicating that shortly after the induction similar results were obtained with regard to inhibitory performance (suggesting that the duration of the task or the opportunity

Table 1
Means (and standard deviations) of the emotion manipulation check questions per condition.

	Rumination (<i>n</i> = 37) <i>M</i> (<i>SD</i>)	Distraction (<i>n</i> = 35) <i>M</i> (<i>SD</i>)	Main effect of condition
Focused on angry thoughts	65.54% (17.74)	28.00% (25.73)	$F(1, 70) = 52.44^{***}$
Focused on anger toward others	55.59% (25.81)	23.29% (24.77)	$F(1, 70) = 29.32^{***}$
Focused on emotional response	66.30% (18.62)	35.29% (28.44)	$F(1, 70) = 30.29^{***}$
Considered the positive aspects	16.92% (23.11)	16.00% (21.33)	$F(1, 70) < 1$
Considered how to deal with	36.81% (28.54)	22.37% (27.17)	$F(1, 70) = 4.82^*$
Reconsidered the event from another perspective	31.97% (26.08)	19.51% (21.00)	$F(1, 70) = 4.95^*$
Thought back about the angry memory	75.24% (14.70)	31.80% (26.62)	$F(1, 70) = 74.54^{***}$
How strong/intense thought back about the anger-inducing event	63.78% (18.42)	38.23% (26.06)	$F(1, 70) = 23.29^{***}$
Could not stop thinking about the angry memory ^a	4.86 (2.42)	2.94 (2.74)	$F(1, 70) = 9.98^{**}$
Considered the situation from someone else's perspective	2.59 (2.39)	2.17 (2.42)	$F(1, 70) < 1$

Note. * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

^a The last two questions were scored on a scale ranging from 1 to 10 whereas the other questions were scored on a scale ranging from 1 to 100.

Table 2
Accuracy rates (in proportions) and reaction times (in ms) per condition on the anger-related Go/NoGo task.

	Distraction (<i>N</i> = 34)		Angry rumination (<i>N</i> = 37)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Acc NoGo Agr	0.80	0.12	0.75	0.14
Acc NoGo Neutr	0.84	0.11	0.81	0.14
RT (ms) Go Agr	256	36	276	70
RT (ms) Go Neutr	262	31	276	56

for 'replenishing breaks' during the task did not alter the results).³ Finally, a 2×2 mixed ANOVA revealed the groups did not differ in reaction time on Go trials, $F(1, 69) < 1$, $p = 0.370$. In other words, both groups performed equally well on the affective Go/NoGo task.

3.3. Secondary analyses: are rumination and anger associated with performance on inhibition?

To explore if the extent to which participants ruminated and felt angry after receiving the emotion regulation manipulations, regardless of which condition participants were in, was associated with inhibition performance, we examined the correlations among the accuracy rates on the NoGo trials on the one hand, and the rumination checks as well as anger at time 3 on the other hand. In general these correlations were weak and not significant (see Table 3), indicating that the degree to which participant ruminated or felt angry after the emotion regulation manipulations was not associated with performance on the Go/NoGo task.

4. Discussion

Recent research suggests that angry rumination may lead to the loss of self-control and subsequent aggression by depleting self-control resources (Denson, DeWall et al., 2012). However, few studies have investigated whether this is indeed the case (Denson et al., 2011). The present study sought to investigate the effects of angry rumination on anger and a behavioral indicator of a cognitive aspect of self-control (i.e., Go/NoGo task). Based on previous work (Denson et al., 2011), we expected lower inhibitory control following angry rumination relative to distraction. More specifically, we expected more commission errors on the Go/NoGo task.

³ A reviewer suggested that the task is quite long and potentially depleting or distracting (with breaks), which could have weakened the effects and muddled the interpretation of the study. Interestingly, a recent meta-analysis indicates that these sort of tasks do not result in ego depletion (Carter, Kofler, Forster, & McCullough, 2015).

However, contrary to our expectation, we found no group differences in the number of commission errors on the Go/NoGo task, indicating that inhibitory performance was not differentially affected by rumination and distraction instructions. This finding suggests that there are boundary conditions regarding the role of self-control as a mediator of the effect of angry rumination on aggression (Denson, 2013). Given that the present study differed in some aspects from the work of Denson et al. (2011) the current finding could help in identifying moderators of this relationship.

First, in the current study we used a behavioral indicator of a cognitive aspect of state self-control (i.e., Go/NoGo task), whereas Denson and colleagues used a self-report measure of state self-control (i.e., the State Self-Control Capacity Scale). As such, it could be the case that whereas the phenomenological experience of self-control is influenced by angry rumination (i.e., no longer feeling able to control oneself), angry rumination does not influence self-control as measured with behavioral tasks that require inhibitory control (note that the effects of angry rumination were marginally significant, $p = 0.06$ (one-tailed) on the Stroop task in the placebo condition of study 4 of Denson et al., 2011). Perhaps someone's perception of one's ability to control oneself (self-efficacy of self-control) is more important in explaining aggression than someone's actual self-control abilities. That is, if people no longer feel able or not motivated to contain themselves they may subsequently exert less self-control than they actually could. Furthermore, it is unclear whether the State Self-Control Capacity Scale employed in Denson et al. (2011) and the anger-related Go/NoGo task used in the current study are differentially sensitive in assessing underlying self-control capacity. Perhaps the State-Self-Control Capacity Scale is better suited to detect reductions in self-control following the exertion of self-control resources. Alternatively, it may be that certain aspects of self-control are affected whereas other aspects of self-control are not, given that we specifically focused on inhibitory control in the current study as a measure of self-control. Perhaps the cognitive restraint of aggression or cognitive modulation of the emotion anger may be affected by angry rumination whereas motoric inhibition of aggression is not. Hence, future studies should disentangle what kinds of self-control processes are affected by angry rumination and what processes are not. Moreover, there is a need of studies that distinguish between the effects of angry rumination on aggression via motivational processes (i.e., shifts in motivation orientation and attentional focus undermining self-control (Inzlicht & Schmeichel, 2012)) versus ego depletion accounts (failures in self-control as a result of exerting self-control resources from a limited resource (Baumeister et al., 2007)).

Second, in the current study anger was induced by means of reliving an interpersonal provocation instead of using an actual provocation. Anger inductions in which participants are directly

Table 3

Associations between accuracy rates on indices of response inhibition with anger at time 3 and rumination.

	Angry thoughts	Anger toward others	Emotional response	Thought back about the angry memory	Intensity	Could not stop thinking about the angry memory	Anger at time 3
Acc NoGo Agr	0.07	−0.08	0.01	0.09	−0.06	−0.03	0.10
Acc NoGo Neutr	−0.08	−0.26*	−0.08	−0.03	−0.13	−0.11	−0.15

Note. * $p < 0.05$.

insulted may elicit stronger inhibitory and emotion regulatory processes compared to inductions wherein anger is relived based on autobiographical memories. For instance, one could argue that because participants were instructed to think about an anger-inducing event rather than actually being provoked, participants were less inclined to adopt resource-depleting strategies (i.e., less downregulation of the anger experience, less suppression of angry thoughts, and fewer needs to control aggressive urges) making it less likely that self-control was reduced by means of resource depletion.⁴ Otherwise stated, although participants in the current study clearly engaged in angry rumination, the three processes mentioned by Denson et al. (2011; i.e., thought suppression, emotion regulation, and behavioral self-control) may have been exerted to a lesser extent, and therefore may have not affected self-control in the current study. If so, we suggest that self-control reductions can be better explained by *attempts* to stop angry rumination rather than angry rumination itself. However, note that in clinical practice angry rumination best accounts for aggressive acts that were conducted over long time periods, and are most likely initiated by reliving and thinking about an angering event (Sukhodolsky et al., 2001). As such, letting participants relive an anger-inducing event and ruminate about this in the lab has good external validity and should theoretically result in less self-control as well. For instance, given that anger is a negatively valenced affect (Fernandez, 2013), it is still very likely that participants attempted to down-regulate their anger (emotion regulation) and tried to suppress their angry thoughts (thought suppression) following our angry rumination instructions even though behavioral self-control was less likely to occur. Indeed, subjects in the rumination condition reported to have difficulties stopping to think about the angry memory to a bigger extent than participants in the distraction condition. Moreover, most studies that have found effects of angry rumination on aggressive behavior used instructions to induce angry rumination as well (Bushman, 2002; Bushman et al., 2005; Denson et al., 2009; Pedersen et al., 2011). Given that angry rumination in these studies was also not characterized by its spontaneous and uncontrollable aspects, additional studies are needed that investigate to which extent self-control is affected when these different kinds of anger inductions are used. For instance, future studies are needed in which the effects of angry rumination on past angering events are compared with the effects of angry rumination on more recent events regarding anger, aggression, and self-control.

Third, procedural differences with respect to timing may be of relevance in identifying moderators of the relation between angry rumination and self-control. For instance, the temporal gap between angry rumination manipulations and the completion of the self-control measures as well as the length of the rumination

manipulations may be potential moderators. How long does one need to engage in angry rumination in order to deplete self-control resources? And how long does it take before any potential reduction of self-control capacity caused by angry rumination may be dissipated? Future studies are needed to address these important questions. Importantly, results showed that the manipulations led to the expected outcomes. Both groups reported higher levels of anger directly after the anger-inducing interview compared to baseline, indicating that recalling an angering event is an effective way to induce anger (Lobbestael et al., 2008). Moreover, participants in the Angry Rumination condition seemed to ruminate to a bigger extent than participants in the distraction condition. Additionally, consistent with previous studies showing angry rumination amplifies angry feelings, whereas distraction decreases angry feelings (Bushman, 2002; Rusting & Nolen-Hoeksema, 1998), participants in the Angry Rumination condition reported increased levels of anger, whereas participants in the Distraction condition reported decreased levels of anger after the emotion regulation manipulation. More specifically, the angry rumination condition was a mixture of provocation-focused and experiential rumination and adds support to Denson's suggestion that provocation-focused rumination most likely heightens angry feelings (Denson, 2013). In further support of this suggestion our study showed that higher scores on the angry rumination check questions were associated with higher levels of anger reported right after the emotion regulation manipulations, indicating that the degree to which participants adopted these types of angry rumination was associated with the amount of anger felt. In sum, our angry rumination manipulation was successful, corroborating the conclusions drawn from our study.

There are some methodological issues of the current study and suggestions for future research worth addressing. First, the participants in the current study were nonclinical undergraduate students who differ from clinical populations characterized by dysfunctional anger. For example, it is very likely that patients with dysfunctional anger ruminate more intensively and are more frequently characterized by a loss of self-control following angry rumination. Hence, future studies are needed that investigate the causal relation between angry rumination and self-control failure in more dysfunctional angry samples. Second, the increases in angry feelings may be partly explained by demand characteristics as we used self-report measures of anger. Note however that experimental research has suggested that effects of mood inductions using explicit instruction (i.e., not masking the true purpose) are not solely artifacts of demand characteristics and can indeed lead to changes in affect (Polivy & Doyle, 1980). Third, one could argue that the effects of the angry rumination induction were negated because participants first indicated their mood before starting the cognitive control tasks. However, we consider this explanation unlikely as participants indicated to still feel anger while filling in these questions. Moreover, previous studies have demonstrated effects of angry rumination on aggressive behavior from 8 h up to 24 h after initial provocation (Bushman et al., 2005; Bushman & Gibson, 2010). Fourth, more intense feelings of anger and rumination may have been necessary in order to elicit

⁴ For instance, one of the reviewers raised that in Denson et al. (2011, Study 2), participants may have attempted to restrain their emotions and behavior to a bigger extent compared to our rumination manipulation in order not to retaliate against the experimenter (as they would interact with him/her later on in the study).

sufficient recruitment of effortful resources. Note however, that we used validated methods to induce anger and rumination of which the effects on anger and rumination are comparable (Fabiansson et al., 2012; Lobbestael et al., 2008). Finally, we instructed our participants on how to regulate their emotions rather than letting rumination occur spontaneously. Future studies may benefit from the latter approach as spontaneous rumination may implicate different processes.

In conclusion, our study shows that whereas provocation-focused angry rumination resulted in heightened anger, it did not result in lower cognitive control as measured with an affective Go/NoGo. This finding has implications for understanding rumination-induced aggression. As previous research has shown that the phenomenological experience of self-control is influenced by angry rumination (Denson et al., 2011), it could be that someone's perceived ability to control oneself is more important than one's actual self-control abilities. Alternatively, it may be that rumination-induced aggression is more affected by certain types of anger inductions than others. Future research is needed to explore the boundary conditions of rumination-induced aggression.

Conflicts of Interest

The authors declare they have no conflict of interest.

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Appendix A. Distraction manipulation.

I want you to think about how the campus looks like in your mind and how you would describe the campus to someone who has never been on the campus before, I want you to think about how the campus looks like in your mind and how you would describe the campus to someone who has never been on the campus before. Try to focus on the details in your mind's eye.

1. Think about how the campus looks like generally.
2. Think about which building you can find at the campus.
3. Think about the campus routes you normally walk.
4. Think about the facilities you can find at the campus.
5. Think about what makes the campus unique.
6. Think about what you would tell others about the campus.

Appendix B. Emotion regulation manipulation checks:

1. Specify to what extent during the past five minutes:
 - You reconsidered the event from another perspective.
 - You focused on your angry thoughts.
 - You focused on your anger toward others.
 - You considered the positive aspects of the event.
 - You focused on your emotional response to the event.
 - You considered how to deal with anger-inducing events.

All the above questions were scored on a VAS scale with a label of 0 = "Not at all" on the left end and a label of 100 = "Extremely" on the right end, All the above questions were scored on a VAS scale with a label of 0 = "Not at all" on the left end and a label of 100 = "Extremely" on the right end.

2. Please indicate on a scale from 1 to 100 what percentage of the time during the past 5 min you thought about the angry memory that you have discussed during the interview (Percentage of time: ranging from 0 = "Not at all" to 100 = "Very often").

3. Please indicate on a scale from 1 to 100 how strong/intense you thought back about the anger inducing event (Intensity: ranging from 0 = "Not at all" to 100 = "Very intense").

4. Please indicate on a scale from 1 to 10 to what extent during the past five minutes you could not stop thinking about the angry memory (ranging from 0 = "Very easy" to 10 = "Difficult to stop").

5. Please indicate on a scale from 1 to 10 to what extent you tried to consider the situation from someone else's perspective (ranging from 0 = "Own perspective" to 10 = "Someone else's perspective").

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