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BRIEF REPORT

Trait rumination and inhibitory deficits in long-term memory

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Prior research has shown that individuals who tend to ruminate about dysphoric moods have difficulties with inhibitory processes in working memory (Joormann, 2006; Whitmer & Banich, 2007). The goals of the current study were to determine if these inhibitory deficits (1) also affect processes in long-term memory (LTM) and (2), if so, whether they are associated specifically with depressive rumination or also with other forms of rumination. To examine inhibitory processes in LTM, we used a retrieval-induced forgetting paradigm. In this paradigm, the practised retrieval of certain memories causes the inhibition of related but unpractised memories. In our non-clinical population, reduced inhibition was associated not only with the tendency to depressively ruminate but also with tendencies to angrily ruminate and to ruminate more generally. These findings suggesting that ruminators' inhibitory deficits affect retrieval of information from LTM and that such deficits are not specific to depressive rumination.

Keywords: Rumination; Inhibition; Depression; Memory; Retrieval-induced forgetting.

Rumination can be generally defined as a series of prolonged and recurrent thoughts united by a common theme. Although rumination can be about a variety of topics from anger to philosophical issues, researchers have primarily focused on depressive rumination. Depressive rumination is defined as prolonged and repetitive thinking focused on the causes, symptoms and implications of one's sad mood, dysphoria or depression (Nolen-Hoeksema & Morrow, 1991) and is associated with longer lasting, more severe, and more numerous bouts of depression (e.g., Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008)

Recent research has begun to delineate the cognitive mechanisms underlying the tendency to engage in depressive rumination. This research suggests that a tendency to depressively ruminate may be driven by attentional inflexibility. For example, one study found that in a sample of normal college undergraduates, individuals with high tendencies to depressively ruminate had more difficulties than non-ruminators using feedback to

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flexibly switch between card sorting rules in the Wisconsin Card Sorting Task (WCST; Davis & Nolen-Hoeksema, 2000). If ruminators are attentionally inflexible, it may explain why they continue fixating their attention on negative information even though such focus has serious harmful consequences.

Recent research has attempted to determine the cognitive mechanism(s) that may underlie such attentional inflexibility in ruminators. For example, ruminators may have trouble changing between sorting rules in the WCST because they cannot effectively inhibit the previously correct sorting rule and, as a result, mental representations of that sorting rule continue to guide their actions. On the other hand, ruminators may have difficulty changing between sorting rules because they have difficulties switching their attention to a new focus (e.g., the next sorting rule). To dissociate between these two potential explanations, we assessed ruminators' performance (Whitmer & Banich, 2007) on a backward inhibition paradigm (Mayr & Keele, 2000). In this paradigm, one switches between different tasks across trials. Previous work has shown that one automatically inhibits representations of previous task demands (e.g., pick the oddly shaped item) from working memory (WM) when one switches to a new task (e.g., pick the moving item; Mayr & Keele, 2000). Therefore, responses will be slower if one has to return immediately back to a previous task as compared to a new task because of the extra time needed to overcome the inhibition of the prior task. Interestingly, in a sample of normal college undergraduates, an increased tendency to depressively ruminate was associated with a smaller time cost suggesting ruminators cannot effectively inhibit the representation of the prior task. On the other hand, individuals high in depressive ruminative tendencies showed roughly the same increase in response time as those low in rumination when they had to switch between two tasks as compared to repeating the same task twice in a row. This finding suggests that tendencies to depressively ruminate do not impair switching abilities. Therefore, depressive ruminators appear to be attentionally inflexible specifically because they have difficulties inhibiting previously relevant information from WM, not because they have difficulty switching between different task sets.

Another study used a variant of the negative priming paradigm (Joormann, 2004) to show that inhibitory deficits also make it more difficult for depressive ruminators to keep information from entering WM (Joormann, 2006). In this paradigm, participants must ignore the emotional valence of an irrelevant stimulus on one trial but then respond to a stimulus of that same valence on the following trial. It is thought that because the emotional valence is irrelevant, it is inhibited on the first trial to keep it from entering WM and interfering with task-relevant processing (e.g., Tipper, 2001). Hence, it takes longer to respond to a stimulus of that valence on the following trial than if the stimulus is of a different valence because of the time needed to overcome inhibition. In a sample of normal college undergraduates, an increased tendency to depressively ruminate was not associated with such a time cost (regardless of emotional valence) suggesting that ruminators do not effectively inhibit irrelevant information from entering WM. Therefore, ruminators may continue to ruminate because faulty inhibition allows ruminative thoughts to enter WM even when such thoughts are not currently relevant.

Additional evidence for the association between inhibitory deficits in WM and ruminative tendencies comes from a recent study that employed a modified Sternberg task with individuals who were clinically depressed (Joormann & Gotlib, 2008). In this study, participants first learned two short lists of emotional words at the start of each trial. A cue then indicated that only one of the two lists would be relevant. The authors suggested that inhibitory processes were used to remove the no-longer-relevant words from WM so that they do not interfere with future processing demands. Participants were then immediately given a probe word and asked if it was from the relevant list. Faulty inhibition would result in longer reaction times to no-longer-relevant words as compared to new words (that did not appear in either list).

Consistent with predictions, a tendency to depressively ruminate was associated with greater inhibitory difficulties (i.e., longer reaction times to words from the irrelevant list), although such deficits only occurred when the no-longer-relevant list was composed of negative words but not when composed of positive words. The researchers concluded that difficulties inhibiting emotionally negative information were driving increased rumination in clinically depressed individuals.

In sum, evidence from a variety of paradigms—backward inhibition, negative priming and a Sternberg-like paradigm—suggest that ruminators have difficulties with inhibitory processes related to WM. Deficiencies in this type of inhibition may make it easier for information to gain access to WM and more difficult for it to then be eliminated.

The current study was designed to determine whether ruminators' inhibitory deficits can also be seen in long-term memory (LTM). To investigate this possibility, we used the retrieval-induced forgetting (RIF) paradigm (Anderson, Bjork & Bjork, 1994) as a measure of inhibitory function in LTM. In this paradigm, participants first learn category–exemplar pairs (e.g., fruit–orange; fruit–strawberry) from different categories (e.g., fruit, weapons, etc.). Next, participants practice retrieving some category–exemplar pairs (e.g., fruit–orange) but not others (e.g., fruit–strawberry). Lastly, participants are asked to recall all exemplars from each of the different categories. Practised exemplars (e.g., fruit–orange) are the most likely to be recalled. However, exemplars that were not practised but were from categories that were practised (e.g., strawberry) are actually less likely to be recalled than exemplars from categories that were not practised at all (e.g., metals–bronze). It has been suggested that when a subset of exemplars are retrieved during practice, memory representations of related but unwanted exemplars (i.e., unpractised exemplars from practised categories) are automatically inhibited to allow interference-free retrieval of the desired exemplar. In turn, this inhibition will make it harder to later recall those previously unwanted exemplars (e.g., Anderson et al., 1994; Saunders & MacLeod, 2006). If inhibitory deficits in ruminators also affect these representations and/or access to them then individuals with higher as compared to lower tendencies to depressively ruminate should exhibit less inhibition, which would result in better recall of unpractised exemplars from practised categories.

A secondary goal of the current study was to determine if these inhibitory deficits in LTM are associated with other types of rumination besides depressive rumination such as angry rumination. If inhibitory deficits are observed across different types of ruminative tendency, it would suggest that inhibitory deficits in LTM underlie repetitive thought in general. To investigate this issue, we included three additional measures of ruminative tendencies: anger rumination, intellectual self-reflection, and a more general form of rumination, that assessed how often an individual engages in repetitive thought about past events and memories *without* determining if that repetitive thought occurs in a particular context (e.g., when feeling sad) or on a certain topic (e.g., a sad memory or an angry experience). Examining whether inhibitory deficits in LTM are related to rumination regardless of the nature of ruminative tendencies is also of interest because our previous work using the backward inhibition paradigm found that tendencies to angrily ruminate and intellectually self-reflect were not associated with inhibitory difficulties in WM (Whitmer & Banich, 2007). Therefore, it is currently uncertain whether inhibitory deficits are particular to depressive rumination or if they underlie rumination in general.

METHODS

Participants

Sixty-seven undergraduates (38 females, 29 males) from an introductory psychology class participated in this study for course credit.

Materials

Task stimuli

Participants were presented with eight categories (e.g., metals, fruits) each containing six exemplars (e.g., iron, banana) for a total of 48 category–exemplar pairs (12 filler and 36 experimental). The stimuli used were taken from Anderson et al. (1994) and were emotionally neutral. All stimuli were presented and all responses were made on a PC computer.

Questionnaires measuring tendencies to experience rumination

Participants completed four measures designed to assess the tendency to experience different forms of rumination.

1. The Ruminative Response Styles Questionnaire (RRS; Nolen-Hoeksema & Morrow, 1991). This measures an individual's tendency to engage in "depressive rumination" or rumination about one's mood, recent events and one's self when feeling sad, dysphoric or clinically depressed. The RRS has been used to show that depressive rumination is a stable, individual characteristic (e.g., Roberts, Gilboa, & Gotlib, 1998). Participants were given a 10-item short version of the RRS as compared to the full 22-item version. The advantage of the short version for present purposes is that its items are not confounded with depression, yet it is still a reliable measure of depressive rumination (Treynor, Gonzalez, & Nolen-Hoeksema, 2003). Additionally, this short version makes a distinction between two 5-item subscales: reflection and brooding. Brooding has been characterised as moody pondering (e.g., thinking "What am I doing to deserve this?") and reflection as repetitive thinking that deals with one's problems (e.g., "Analyse recent events to try to understand why you are depressed"). One study found that brooding but not reflection is predictive of future levels of depression suggesting that only brooding is maladaptive (Treynor et al., 2003; however see Miranda & Nolen-Hoeksema, 2007). Previous research has found the alpha coefficient of reflection to be .72 and brooding to be .77 (Treynor et al., 2003).

2. The Anger Rumination Scale (ARS; Sukhodolsky, Golub, & Cromwell, 2001). This measures the tendency to experience repetitive thoughts about one's angry experiences. Participants rate how often they experience such statements as: "After an argument is over, I keep fighting with this person in my imagination". This scale was found to have alpha coefficient of .93 (Sukhodolsky et al., 2001).

3. The reflection component of the Rumination-Reflection Questionnaire (RRQ-reflect; Trapnell & Campbell, 1999). This measures the tendency to engage in philosophical reflection on one's self and one's thoughts. Participants rate how much they agree with statements such as: "I love to meditate on the nature and meaning of things". This scale was found to have alpha coefficient of .91 (Trapnell & Campbell, 1999).

4. The rumination component of the Rumination-Reflection Questionnaire (RRQ-rumin; Trapnell & Campbell, 1999). This measures a more general form of rumination—measuring repetitive and excessive thinking about events, states and/or memories that may be negative in nature but are not necessarily so. Participants rate how much they agree with statements such as: "I often find myself re-evaluating something that I've done". This scale was found to have alpha coefficient of .90 (Trapnell & Campbell, 1999).

Control questionnaires

Two additional questionnaires were also used to determine whether any observed association between rumination and RIF is independent of other characteristics that may be associated with ruminative tendencies.

5. The Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). This assesses how many symptoms of depression an

individual is currently feeling. Previous research has suggested that people suffering from depression may have reduced inhibition (e.g., Joormann, 2004) and therefore we wanted to determine whether any relationship between increased rumination and decreased inhibition is independent of symptoms of depression. It should be noted, however, that we were not testing whether clinically diagnosed depression was related to inhibition in this study. We merely included the BDI to control for any possible influence of depressive symptoms or increased levels of dysphoria.

6. Positive And Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). The PANAS measures an individual's current mood and provides separate measures of positive affect and negative affect. Considering the close relationship between a tendency to ruminate and depressive symptoms, this study included the PANAS to control for differences in mood that might not have been picked up by the BDI.

Procedure

The RIF task (see Anderson et al., 1994, for more detail) is composed of four main stages.

Stage one: Learning of category–exemplar pairs. Category–exemplar pairs (e.g., "Fruit–orange") are presented for five seconds each and participants are instructed to memorise each pair with an emphasis on understanding the exemplars' relationships to the cues.

Stage two: Retrieval practise. Participants are then cued with the category name and the two first letters of the exemplar (e.g., "Fruit–or_____) to retrieve and type out the appropriate exemplar (e.g., "orange"). Only a subset of category–exemplar pairs are practised creating three distinct types of exemplars:

1. *Rp+*. Exemplars that are practised and are from practised categories (e.g., "orange").
2. *Rp−*. Exemplars that are not practised but are from practised categories (e.g., "strawberry").
3. *Nrp*. Exemplars that are not practised and are from unpractised categories (e.g., "Bronze").

Retrieval of *Rp+* exemplars during this phase should cause automatic inhibition of *Rp−* exemplars because they are related to the category but are not retrieved. *Nrp* trials serve as a baseline to determine whether *Rp−* items are indeed inhibited.

As in Anderson et al. (1994), all *Rp+* exemplars are practised three times in an expanding sequence; on average, there are three intervening trials between the first and second practice and an average of 6.8 items between the second and third practice. Categories were never presented twice in a row. Two additional categories were also used as filler categories. These categories were used to enable the preceding constraints. Additionally, exemplars from the filler categories were the first three and last three to be practised.

To minimise effects of counterbalancing on individual differences in inhibitory abilities, we did not counterbalance categories in regards to whether they were in the practised or unpractised condition (see also Miyake et al., 2000).

Stage three: Distraction. Participants were given a 15-minute task-switching paradigm as a distraction task in order to ensure that final recall of exemplars was from long-term memory.

Stage four: Exemplar recall. Lastly, participants were given the name of each category and 30 seconds to type all the exemplars that they could recall.

The main dependent measure obtained in this paradigm indexes inhibition by comparing how much poorer accuracy is for recall of unpractised exemplars (*Rp−*), that are thought to be inhibited when *Rp+* items are retrieved during practice as compared to unpractised exemplars (*Nrp*) that are not inhibited. If ruminators have deficits in inhibition, then an increased tendency

to ruminate should be associated with more accurate recall of *Rp−* exemplars. We also examined whether there were differences as a function of ruminative tendencies in memory recall for practised (*Rp+*) exemplars as compared to non-practised (*Nrp*) exemplars, a difference we refer to as the practice effect. *Rp+* exemplars should be recalled significantly better than *Nrp* exemplars because they have been practised. Because the putative role of inhibition is to make retrieval of desired exemplars easier (Anderson et al., 1994), it is possible that because ruminators have deficient inhibition, they will exhibit a smaller practice effect. However, other factors besides inhibition may contribute to retrieval and practice success and these factors may obfuscate any effect of inhibition on practice. Therefore, we expect rumination to be either related to a smaller practice effect or not related to the practice effect.

After completing the RIF task, participants filled out the questionnaires.

RESULTS

Overall results

A repeated measures analysis of variance (ANOVA) was used to assess differences in final recall accuracy of the three different exemplar types (*Rp+*, *Nrp*, and *Rp−*). There was a main effect of Exemplar Type, $F(1, 66) = 1061.5$, $p < .0001$, $\eta^2 = .816$. Bonferroni post hoc tests indicated that final recall accuracy for *Rp+* exemplars (86.2%) was significantly greater than final recall accuracy of *Nrp* exemplars (52.9%), $t = 16.65$, $p < .0001$, indicating that as expected, retrieval practise in stage two significantly improved memory during final recall. Final recall accuracy for *Rp−* exemplars (46.2%) was significantly worse than recall accuracy of *Nrp* exemplars (52.9%), $t = -3.67$, $p = .002$, indicating that as expected, retrieval practise of *Rp+* exemplars during stage two caused inhibition of *Rp−* exemplars below baseline (*Nrp*). In sum, the paradigm elicited a pattern of results as seen previously (e.g., Anderson et al., 1994).

Association of self-report measures with overall performance and practice effect

To test the association of the self-report measures with overall performance and the practice effect we performed a series of regression analyses. Each regression model had only one independent variable (IV) and one dependent variable (DV). The IV was either one of the measures of trait rumination, the BDI, the PANAS (positive affect) or the PANAS (negative affect). The DV was either one of the measures of overall performance (% recall of *Rpt+*, % recall of *Nrp*, % average recall) or the practice effect (% *Rp+* minus % *Nrp*). Regression analyses tested all possible combinations of IVs and DVs. Separate regression analyses showed that none of the IVs predicted overall accuracy of recall of exemplars (ps $> .20$), recall accuracy of *Rp+* exemplars (ps $> .20$), recall accuracy of *Nrp* exemplars (ps $> .20$) or size of the practice effect (ps $> .20$). Thus, self-report measures were not associated with general memory ability.

Association of depressive rumination with inhibition

In all the following regression analyses, the DV is inhibition and the IVs are one or more of the self-report measures. Regression analyses indicated that an increased tendency to depressively ruminate as measured by RRS score was associated with less inhibition (recall accuracy of *Nrp* exemplars minus accuracy of *Rp−* exemplars) both when RRS score was the model's sole predictor, $r = -.299$, $t(65) = -3.481$, $p = .014$ (see Figure 1), and when the BDI and PANAS were included in the model as covariates, $\beta = .306$, $t(62) = -3.120$, $p = .003$ (see Table 1). Thus, higher tendencies to depressively ruminate were associated with a decreased likelihood that retrieving information from LTM will automatically inhibit related but unretrieved information. Since this association is based on a difference score, we wanted to be sure that it was specifically driven by an inability to inhibit *Rp−* exemplars. Confirming that this is the case, higher scores on

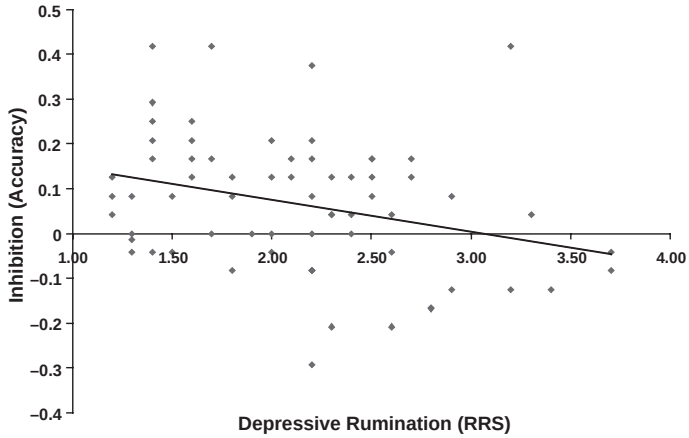

Figure 1. *Increased depressive rumination (RRS-avg) is associated with decreased inhibition of related but unwanted memories. X-axis: Higher RRS scores indicate an increased tendency towards depressive rumination. Y-axis: Inhibition is measured by subtracting accuracy of final recall of* Rp– *exemplars (unpractised exemplars from practised categories) from accuracy of final recall of* Nrp *exemplars (unpractised exemplars from unpractised categories). Positive difference scores indicate greater inhibition.*

the RRS were specifically related to better recall of *Rp*– exemplars with RRS as the model's sole IV, $r = .287$, $t(65) = 2.415$, $p = .019$, and with BDI and PANAS also in the model as covariates, $\beta = .344$, $t(62) = 2.248$, $p = .028$. Also, as stated before, RRS was unrelated to recall accuracy of *Nrp* exemplars, indicating that recall of *Nrp* exemplars is not driving the observed pattern of effects. Thus, depressive ruminators were only more likely than non-ruminators to recall words that should have been inhibited (see Figure 2).

Moreover, separate regression analyses showed that decreases in inhibition were associated with increases in scores on both the brooding, $r = -.278$, $t(65) = -2.332$, $p = .023$, and reflection, $r = -.274$, $t(65) = -2.295$, $p = .025$, subscales of the RRS suggesting that this inhibitory deficit is not particular to one subscale versus another.

Table 1. *Correlations between rumination measures and inhibition and results of regression analyses*

	Inhibition	*Inhib. (honest)*	*Regr. model: R*	*β (rumin. measure)*	*β (BDI)*	*β (PANAS-neg)*	*β (PANAS-pos)*
RRS-avg	–.299*	–.430**	.392*	–.462**	.306	–.066	–.085
RRS-brood	–.278*	–.350*	.371	–.444**	.297	–.051	–.085
RRS-reflect	–.274*	–.448**	.341	–.354**	.219	–.105	–.081
ARS	–.236	–.300*	.313	–.348*	.241	–.077	–.072
RRQ-rumin	–.216	–.281*	.302	–.351*	.005	–.013	–.027
RRQ-reflect	–.122	–.224	.183	–.125	.105	–.117	–.058
BDI	.003	–.017					
PANAS-neg	–.109	–.065					
PANAS-pos	–.090	–.138					

Notes: *$p < .05$; **$p < .01$. Inhibition is calculated by % recall of *Nrp* exemplars minus % recall of *Rp*– exemplars. Inhib. (honest) is the same as Inhibition but excludes data from participants that reported less than honest responses on the self-report questionnaires. Results show that as rumination, except for RRQ-reflect, goes up, inhibition goes down. Table includes the results of different regressions analyses in which the dependent variable is inhibition (regardless of honesty responses) and the independent variables are each measure of rumination run in separate regression analyses, BDI, PANAS-neg, and PANAS-pos.

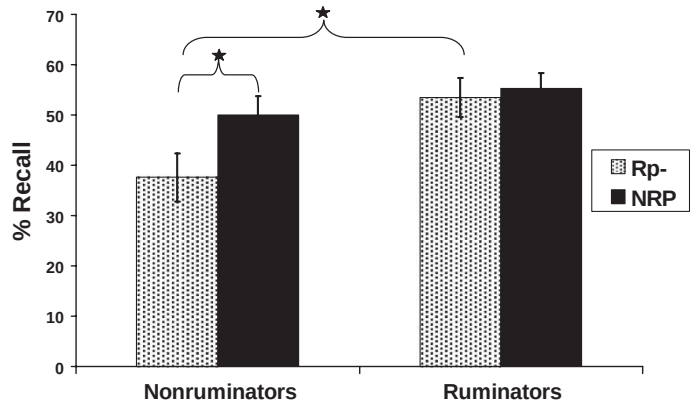

Figure 2. *p < .05. *Non-ruminators = the lowest quartile of depressive ruminators as assessed with the RRS-avg (*n = *19, RRS-avg Mean = 1.4,* SD = *0.14). Ruminators = the highest quartile of depressive ruminators (*n = *19, RRS-avg Mean = 2.9,* SD = *0.4). Only non-ruminators show significant inhibition (less recall of* Rp– *exemplars as compared to* Nrp *exemplars). The lack of inhibitory effect in ruminators is due to greater recall of exemplars that should have been inhibited (*Rp–*) and not due to greater recall of exemplars that were not inhibited (*Nrp*).*

If rumination was not included in the model, increased depression was unrelated to inhibition, $r = .003$, $t(65) = .024$, $p = .981$. However, when RRS was added to the model, increased depression was marginally related to *increased* inhibition, $\beta = .306$, $t(64) = 1.977$, $p = .052$. Thus, depressed mood appears to be acting like a classic suppressor variable. Depressed mood is highly correlated with rumination, $r = .602$, $p < .001$. Therefore, when depression is added to the model, it accounts for previously unexplained variance in the RRS and thereby enables rumination to more effectively predict decreased inhibition. This finding suggests that the aspects of the RRS that are unrelated to depressed mood are better at predicting inhibitory deficits than the aspects of the RRS that are related to depressed mood. In sum, this finding clearly shows that rumination's negative relationship with inhibition is not being driven by depressed mood.

Association of other forms of trait rumination with inhibition measure

Separate regression analyses showed that decreases in inhibition were marginally associated with increased scores on the ARS, $r = -.236$, $t(65) = -1.96$, $p = .055$, and RRQ-rumin, $r = -.216$, $t(65) = -1.78$, $p = .08$, but not to scores on the RRQ-reflection scale, $r = -.122$, $t(65) = -0.995$, $p = .323$. However, when accounting for depression's suppressor effect by adding depression into the regression models, the ARS, $\beta = -.348$, $t(64) = -2.467$, $p = .016$, and RRQ-rumin, $\beta = .351$, $t(65) = -2.301$, $p = .025$, became significantly associated with decreased inhibition. These differences remained significant when also controlling for PANAS (ps < .05). However, RRQ-reflect was still not related to inhibition even when accounting for depression's suppressor effect, $\beta = -.125$, $t = -0.898$, $p = .373$. Therefore, increased tendencies to engage in either anger rumination or a general form of rumination were related to decreased inhibition. However, inhibition was unrelated to intellectual reflection.

Associations of trait rumination with inhibition when eliminating dishonest responses

Considering that individual differences data can be extremely noisy, a novel approach was taken in an attempt to weed out unreliable data. All participants were asked to rate the sincerity and honesty of their responses on the self-report

questionnaires at the end of the experiment. Participants were asked to respond "1" if they "were just randomly pressing buttons" when responding to the questionnaires, "2" if their responses to the questionnaires were only "somewhat sincere and honest", and "3" if their answers were "as sincere and honest as possible". One of the participants responded "1" and 16 of the participants responded "2" leaving 50 (75%) participants who responded "3". If the data of only those participants who indicated "3" (i.e., that their answers were as sincere or honest as possible) were used, then correlations between rumination measures and inhibition became stronger. Regression analyses showed that decreased inhibition was related to increased scores on the RRS, $r = -.430$, $t(48) = -3.296$, $p = .002$. Additionally, decreased inhibition was significantly related to scores on the ARS, $r = -.300$, $t(48) = -2.179$, $p = .034$, and RRQ-rumin, $r = -.281$, $t(48) = -2.027$, $p = .048$. If anything, all these correlations become even stronger when controlling for depressed mood. RRQ-reflect, however, was still not related to inhibition, $r = -.224$, $t = -1.593$, $p = .118$ (see Table 1). Therefore, the relationship between different measures of rumination and inhibition may be even stronger than indicated by the regression analyses performed on the complete dataset.

DISCUSSION

In the current study, we found that an increased tendency to ruminate is associated with a decrease in the automatic inhibition of related but currently irrelevant information in LTM. In addition, as far as we know, our results are the first to provide evidence that inhibitory deficits may also be associated with ruminative tendencies focused on topics other than depressed or sad mood. Whereas previous research (Whitmer & Banich, 2007) has suggested that only depressive rumination is linked to inhibitory deficits in WM, both a tendency to angrily ruminate and a tendency to engage in a more general form of rumination (repetitive focus on past events, memories and mood states) were also related to deficient inhibition in LTM in the current study. All these associations between inhibition and different aspects of ruminative tendencies (i.e., depressive, angry, general) remained or even strengthened when controlling for depressive symptomology and mood. Therefore, inhibitory deficits may underlie a tendency to ruminate in general regardless of the content of the rumination.

The one exception to this pattern was the finding that intellectual reflection, or reflection on philosophical issues, was not significantly associated with an inhibitory deficit. This finding is somewhat surprising because another form of reflection, depressive reflection or reflection on one's sadness, was significantly associated with decreased inhibition. One possibility is that this null result may merely reflects insufficient power to detect an association with inhibition that is somewhat weaker or more noisy for the intellectual reflection scale than it is for the other rumination/reflection scales. Indeed, intellectual reflection was numerically associated with decreased inhibition. On the other hand, the lack of association between intellectual reflection and inhibition may be meaningful. One major difference between the intellectual reflection scale and the other reflection/rumination scales is that the intellectual reflection scale does *not* attempt to pick up frequency or repetitiveness of thoughts while the other scales do. Thus, if this difference is meaningful, it may suggest that inhibitory deficits will only be associated with thinking styles if they are highly repetitive and frequent. Future research should develop an intellectual reflection scale that also measures the frequency and repetitiveness of such thoughts to see if such a scale would then be correlated with inhibitory deficits.

Whereas depressive rumination has been found to be associated with inhibitory deficits in both WM (Joormann & Gotlib, 2008; Whitmer & Banich, 2007) and LTM, that does not appear to be the case for anger rumination. Our prior research indicated no relationship between a tendency to angrily ruminate and ability to inhibit information in WM (Whitmer & Banich, 2007),

yet anger rumination was associated with deficits in inhibition in LTM in the current study. Future research is needed to determine if this dissociation is indeed robust, and, if so, what implications that distinction may have. In a related vein, we do not know if the inhibitory deficit observed in the current study reflects a different manifestation of the same inhibitory deficit affecting depressive ruminators' WM (Joormann, 2006; Joormann & Gotlib, 2008; Whitmer & Banich, 2007) or if it reflects a different inhibitory deficit. Our study did not attempt to address this question and future research will be needed to disentangle the possibilities.

The current results have implications for understanding how ruminative thoughts may perpetuate. The inhibitory process measured by the RIF has been conceptualised to be a mechanism that controls spreading activation among related items in LTM (Saunders & MacLeod, 2006). Therefore, when ruminators start to think about anything related to a ruminative topic, they will be more likely to automatically reactivate those ruminative thoughts and thereby begin ruminating again. In a related manner, reduced inhibition in LTM might mean that even if ruminators manage to expel ruminative thoughts from WM, they may be more likely to later retrieve those thoughts from LTM unintentionally. Thus, it is possible that even periods of complete distraction (e.g., watching an engaging movie) or a night's sleep may not be enough to keep a ruminator from starting to ruminate again.

Our finding that depressive rumination is associated with decreased inhibition of related memories may help explain some previous findings regarding depressive rumination. It may partially explain both why depressive ruminators have over-general memories and why they exhibit impaired problem solving (e.g., Raes et al., 2005). If faulty inhibition makes ruminators more likely to retrieve related but unneeded memories, it may cause them to retrieve less specific and hence more over-general memories. Because previous research has suggested that ruminators' over-general memory is the reason they show impaired problem solving (e.g., Raes et al., 2005), deficits in inhibition may therefore also underlie depressive ruminators' problem-solving deficits.

Yet our findings also raise some issues regarding depressive rumination that will require further clarification. At present, the evidence is equivocal as to whether inhibitory deficits in ruminators are general in nature or limited to negative emotional material. Our current and previous work with non-clinical samples (Whitmer & Banich, 2007) demonstrated inhibitory deficits in ruminators even though all the task stimuli were emotionally neutral. However, research with clinically depressed individuals revealed that a higher tendency to ruminate was related to difficulties inhibiting negatively valenced information but not positively valenced information. No associations were observed for a tendency to ruminate in control participants (Joormann & Gotlib, 2008). Therefore, we speculate that inhibitory deficits may be particularly strong for negative emotional material in clinically depressed participants but not specific to negative emotional information in non-clinically depressed individuals. Clearly, future research is needed to systematically address this question.

Another unresolved issue is whether the inhibitory deficits observed in ruminators are limited to memory processes or whether they generalise to other forms of inhibition, Although the current study and previous research (Joormann, 2006; Joormann & Gotlib, 2008; Whitmer & Banich, 2007) demonstrates that ruminators have poor inhibition of automatic processes in WM and LTM, other research, suggests that such inhibitory deficits may not extend to other domains. For example, at least two studies have found that ruminators do not show difficulty in inhibiting responses as measured with a stop-signal task (Lau, Christensen, Hawley, Gemar, & Segal, 2007; Whitmer, unpublished data). Future research will be needed to understand the exact scope and nature of inhibitory deficits in ruminators.

Lastly, it should be noted that due to the correlational nature of our studies, we cannot determine causality. We have suggested that faulty inhibition leads to rumination. However,

a potential alternative account is that active, ongoing ruminations impair inhibition, for example, by overloading cognitive resources (Watkins & Brown, 2002). Contrary to such an account, however, ruminators (1) exhibited no overall impairment in recall accuracy and (2) exhibited impaired inhibition by recalling *more Rp−* words. If individuals with high ruminative tendencies were ruminating during our task and therefore not paying attention, they would be expected to exhibit poorer overall recall rather than improved recall relative to individuals with lower ruminative tendencies. Therefore, it is unlikely that ongoing ruminations are causing the inhibitory impairment observed in our study.

In sum, this study extends our prior work in showing that inhibitory deficits are not limited to WM, but also extend to LTM in individuals with a tendency toward depressive rumination. Additionally, this study suggests that inhibitory impairments may generalise to other forms of rumination such as anger rumination and more general rumination. Hence, inhibitory deficits in LTM may underlie tendencies to engage in ruminative thought regardless of the content of the rumination.

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