Cogn Ther Res (2012) 36:714–721
DOI 10.1007/s10608-011-9409-4

ORIGINAL ARTICLE

# Repetitive Thought and Reversal Learning Deficits

**Anson J. Whitmer · Marie T. Banich**

Published online: 8 November 2011


**Abstract** A tendency to ruminate or repetitively think about depressed mood is associated with increased perseveration in the Wisconsin Card Sorting Task (Davis and Nolen-Hoeksema in Cogn Ther Res 24:699–711, 2000). In the current study, we used a reversal learning task to determine if trait ruminators' perseveration could be driven, at least in part, by a cognitive process called reversal learning, that is, the ability to learn from feedback of the need to reverse stimulus-reward associations. We also examined whether reversal learning would be generally associated with repetitive thought regardless of whether it is maladaptive (depressive brooding, anger rumination, and worry) or adaptive (intellectual selfreflection, and depressive reflection). The results suggest that a tendency to engage in repetitive thought, regardless of its adaptiveness, is related to difficulties reversing stimulus-reward associations but not to the ability to initially learn reward associations.

**Keywords** Repetitive thought · Rumination · Depression · Reversal-learning · Attention

## Introduction

Repetitive thought is a series of prolonged and recurrent thoughts united by a common theme. Investigators typically focus on particular subtypes of repetitive thought such as depressive rumination, which is defined as repetitive thought about the causes, feelings and implications of a sad or depressed mood. Individuals who tend to ruminate when sad, that is, trait ruminators, are more likely to experience longer, more severe and more numerous bouts of clinical depression than are nonruminators (for a review see Nolen-Hoeksema et al. 2008).

To understand why some individuals tend to engage in rumination despite its maladaptive consequences, researchers have started to examine the cognitive characteristics of trait ruminators. Davis and Nolen-Hoeksema (2000) used a Wisconsin Card Sorting Task (WCST) to assess whether trait ruminators, as assessed with the Ruminative Response Styles (RRS) scale (Nolen-Hoeksema and Morrow 1991), were more likely to perseverate than are nonruminators. They found that compared to nonruminators, trait ruminators more likely to continue sorting cards by no-longer-correct rules despite the presence of negative feedback and even after controlling for group differences in depressive symptoms, verbal intelligence, working memory capacity and switching ability. Davis and Nolen-Hoeksema concluded that trait ruminators are more likely to perseverate in the WCST task than are nonruminators because they are attentionally inflexible. This inflexibility could potentially lead to an increased susceptibility to rumination or to difficulties engaging in adaptive behaviors, which could thereby perpetuate negative mood.

More recent studies have attempted to identify the exact cognitive processes underlying trait ruminators' perseveration. For example, Whitmer and Banich (2007) used a backward inhibition task to examine whether trait ruminators' perseveration is related to difficulties inhibiting mental representations of previous task demands or to

A. J. Whitmer (✉)
Department of Psychology, Stanford University, 450 Serra Mall, Stanford, CA, USA
e-mail: whitmera@stanford.edu

M. T. Banich
Department of Psychology, University of Colorado at Boulder, Boulder, CO, USA

difficulties switching thoughts to new task demands. Whitmer and Banich reported that trait rumination is related to inhibitory but not switching deficits, suggesting that trait ruminators' perseveration is driven, at least in part, by difficulties inhibiting mental representations of previously relevant task demands.

In the current study, we use a reversal-learning task to examine whether trait ruminators' perseveration could be also driven by another cognitive process called reversal learning, that is, the ability to learn from feedback of the need to reverse stimulus-reward associations. Previous investigators have suggested that reversal learning is one of multiple cognitive processes underlying perseveration in the WCST (e.g., Dias et al. 1996; Downes et al. 1989); and, therefore, it may be deficient in trait ruminators. To obtain a measure of reversal learning, participants must first learn from reward and punishment feedback to select a stimulus usually associated with reward and to not select a second stimulus that is usually associated with punishment. After a preset number of trials, feedback is reversed so that the previously rewarded stimulus is punished and the previously punished stimulus is rewarded. Individuals who are good at reversing stimulus-reward associations quickly learn that they should select the previously punished stimulus instead of the previously rewarded one.

If trait ruminators exhibit reversal-learning deficits, then this study will identify another cognitive process that could be targeted by future therapies aimed specially at rumination. In addition, unlike shifting in the WCST, reversal learning is associated with specific neural correlates (e.g., see Clark et al. 2004). Thus, if trait rumination is associated with deficits on this task, it could identify potential brain regions that underlie trait ruminators' perseveration.

Although investigators examining the cognitive mechanisms of trait rumination have primarily focused on the tendency to depressively ruminate, some investigators have emphasized that depressive rumination is only a subtype of repetitive thought (e.g., Watkins 2008). It is therefore likely that some of the mechanisms that underlie depressive rumination, such as perseveration, may also underlie other forms of repetitive thought, such as worry, anger rumination, and intellectual self-reflection. Consistent with this idea, Whitmer and Banich (2010) demonstrated that difficulties inhibiting no-longer-relevant memories in a retrieval-induced forgetting paradigm were related to multiple types of rumination such as depressive rumination, anger rumination, and a more general form of rumination that is independent of specific emotional states (e.g., angry mood). Thus, in the current study, we shall examine whether perseveration is related to the more general construct of repetitive thought, instead of examining depressive rumination per se.

Although Whitmer and Banich's (2010) work suggests that perseveration is related to the more general construct of repetitive thought, it is not clear if perseveration will be related to both adaptive and maladaptive forms of repetitive thought. Indeed, Davis and Nolen-Hoeksema (2000) argued that trait ruminators' perseveration should lead primarily to maladaptive consequences such as worse problem solving and worse mood. Thus, perseveration may not be related to more adaptive forms of repetitive thought. We examined this hypothesis in the current study by obtaining measures of both adaptive and maladaptive forms of repetitive thought, and combining the measures to create a single measure of adaptive repetitive thought and a single measure of maladaptive repetitive thought.

Maladaptive repetitive thought was measured with scales that assess the tendency to engage in depressive brooding, anger rumination, and worry. Depressive brooding is a subtype of depressive rumination and it is characterized as moody pondering about a sad or depressed mood (Treynor et al. 2003). Anger rumination is repetitive thinking about experiences that make an individual angry (Sukhodolsky et al. 2001), and worry is anxious repetitive thinking about anticipated threats (Meyer et al. 1990; Fresco et al. 2002). All of these types of repetitive thought have been related to maladaptive consequences (e.g., see Nolen-Hoeksema et al. 2008).

In contrast, adaptive repetitive thought was measured with scales that assess the tendency to engage in intellectual self-reflection and depressive reflection. Intellectual self-reflection is the tendency to think philosophically or intellectually about one's problems (Trapnell and Campbell 1999), while depressive reflection is a subtype of depressive rumination that is considered to be purposeful thinking about one's problems while sad (Treynor et al. 2003). Intellectual self-reflection is associated with openness to experience, decreased depressive symptoms, and protection from depressed mood after a goal failure (e.g., Jones et al. 2009; Takano and Tanno 2009; Trapnell and Campbell 1999). Depressive reflection is associated with long-term adaptive consequences such as decreased depressive symptoms over time (Treynor et al. 2003; although see Nolen-Hoeksema et al. 2008 for an argument suggesting that depressive reflection can be associated with more distress in the short-term).

In sum, we predicted that reversal-learning deficits would be associated with multiple types of repetitive thought. We examined whether such reversal-learning deficits are specific to more maladaptive forms of repetitive thought or if they are instead related to repetitive thought regardless of the consequences of such thinking. We also controlled for individual differences in mood and depressive symptomology. These variables are related to repetitive thought, and we wanted to ensure that they do not underlie any associations found in the study.

## Methods

### Participants

A total of 118 (86 females; 32 males) undergraduates from an introduction to psychology course participated in this study for course credit.

### Reversal Learning Task

#### *Stimuli*

On each trial, two abstract patterns composed of white lines (see Downes et al. 1989) were presented inside two quadrants of the screen. Participants use the numbers 1, 2, 4, and 5 to select the quadrant with the white line of their choice.

#### *Initial Discrimination Learning*

Participants are presented with two stimuli and are forced to select one of the two. They are given feedback telling them that their selection was either "correct" (reward) or "wrong" (punishment) depending on which stimulus they selected. They must learn from the feedback to select the rewarded stimulus and to not select the punished stimulus. This task was made more difficult by giving participants probabilistic feedback, in that, on 80% of trials participants were told "correct" if they selected the rewarded stimulus, but were falsely told that they were "wrong" on the other 20% of trials. The other stimulus was rewarded 20% of the time and punished 80% of the time. Participants were instructed to consistently select the stimulus that is most associated with reward, but to be aware that the reward-contingencies of the stimuli could change. The criterion for achieving initial discrimination learning is the number of trials it takes participants to select the rewarded stimulus eight times in a row (e.g., Blair et al. 2001).

#### *Reversal Learning*

After 40 trials, the stimulus-reward associations reversed so that the previously incorrect stimulus became correct and the previously correct stimulus became incorrect. Participants must learn from the change in feedback that they should reverse their selection and start choosing the previously-incorrect-but-now-correct stimulus on every trial. Participants were considered to have demonstrated awareness of the reversal if they stopped selecting the previously rewarded stimulus and instead selected the previously punished stimulus for at least two trials in a row (as one successful reversal might occur because of an accidental button press). This phase lasted for a maximum of 40 trials. After the reversal learning stage, participants completed another seven stages of simple reward learning tasks (hence, participants went through a total of nine stages) that are not the focus of the present paper.

### Questionnaires

#### *Rumination Questionnaires*

Participants completed multiple measures designed to assess the tendency to experience different forms of repetitive thought. See Table 1 for descriptive statistics and a correlation matrix of these scales.

1. Depressive rumination was measured with the Ruminative Response Styles (RRS; Nolen-Hoeksema and Morrow 1991). The RRS has been used to show that rumination is a stable, individual characteristic (e.g., Roberts et al. 1998). Participants were given a 10-item short version of the RRS that provides separate 5-item measures of depressive reflection (RRS-reflect) and depressive brooding (RRS-brood; Treynor et al. 2003). An example of reflection item is, "Go someplace alone to think about your feelings," and an example of a brooding item is, "Think what am I doing to deserve this?"
2. Anger rumination was measured with the 19-item Anger Rumination Scale (ARS; Sukhodolsky et al. 2001). An example of an item is, "I keep thinking about events that angered me for a long time."
3. Intellectual self-reflection was measured with the 12-item reflection component of the Rumination-Reflection Questionnaire (RRQ-reflect; Trapnell and Campbell 1999). An example of an item is, "I love exploring my "inner" self."
4. Worry was measured with the 16-item Penn State Worry Questionnaire (PSWQ; Meyer et al. 1990). An example of an item is, "my worries overwhelm me."

#### *Scale Combination*

Examination of the correlation matrix suggests that the maladaptive scales measure one construct, while the adaptive scales measure a second one. Therefore, we created a combined maladaptive repetitive thought scale and a combined adaptive repetitive thought scale.

1. Combined Maladaptive Repetitive thought (RT-mal). We created a maladaptive repetitive thought scale by averaging the z scores from the ARS, PSWQ, and the brooding subscale of the RRS.

**Table 1** Descriptive statistics and correlation matrix

| | Mean | SD | Range | Skew | Kurtosis | Coefficient Alpha | RRS Reflect | RRS Brood | ARS | PSWQ | RT-mal | Reversal (log) | Initial (log) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Intellectual self-reflection | 3.1 | .62 | 1–3.7 | .41 | .25 | .74 | .39* | .012 | .07 | −.16 | | .18† | −.03 |
| RRS-reflect | 2.0 | .72 | 1–4 | .49 | −.55 | .81 | | .58* | .35* | .15 | | .19† | .02 |
| RRS-Brood | 2.0 | .60 | 1–3.8 | .80 | .42 | .71 | | | .60* | .38* | | .23* | .06 |
| ARS | 1.9 | .74 | 1.3–5 | .97 | .44 | .91 | | | | .32* | | .30* | .10 |
| PSWQ | 2.9 | .88 | 1.2–5 | .46 | −.54 | .68 | | | | | | .16 | −.09 |
| RT-adapt | – | .77 | −1.9–2.4 | .59 | .76 | – | | | | | .36* | .22* | −.01 |
| RT-mal | – | .89 | −1.4–3.0 | .99 | .31 | – | | | | | | .29* | .09 |
| Reversal (log) | .84 | .30 | 0–1.5 | −.55 | 1.6 | – | | | | | | | −.05 |
| Initial (log) | .37 | .50 | 0–1.6 | .85 | −.88 | – | | | | | | | |
| Reversal (not transformed) | 8.4 | 5.7 | 1–31 | 1.8 | 3.3 | – | | | | | | | |
| Initial (not transformed) | 3.4 | 5.7 | 0–24 | 1.7 | 2.1 | – | | | | | | | |

Analyses were performed on the questionnaire scores of the 93 participants retained in all analyses

*RRS-Reflect* reflection subscale of the Ruminative Response Styles (RRS) scale, *RRS-Brood* brooding subscale of the RRS, *ARS* Anger Rumination Scale; *PSWQ* Penn State Worry Questionnaire, *SD* standard deviation, *RT-adapt* the combined repetitive thought scale, *RT-mal* the combined maladaptive repetitive thought scale, *Reversal (log)* number of trials until reversal (log transformed), *Initial* number of trials until initial discrimination criterion was achieved (log transformed), *Reversal (not transformed)* raw reversal scores before log transformation, *Initial (not transformed)* raw initial learning scores before log transformation

* Significant correlation ($P < .05$)

† Marginally significant correlation ($P < .10$)

2. Combined Adaptive Repetitive thought (RT-adapt). We created an adaptive repetitive thought scale by averaging the z scores from the RRQ-reflect and the reflection subscale of the RRS.

These two scales were positively and significantly correlated, $r = .36$, $P < .001$, suggesting that although we examined them separately in the current study, they do share a substantial amount of variance.

*Control Questionnaires*

1. The Beck Depression Inventory (BDI; Beck et al. 1961) is a 21-item scale that assesses the number of depressive symptoms exhibited by participants. It is important to control for depressive symptoms, because it is strongly associated with a tendency to ruminate (e.g., Nolen-Hoeksema 2000).
2. Positive And Negative Affect Schedule (PANAS; Watson et al. 1988). The PANAS is a 16-item scale that measures an individual's current mood and provides separate measures of positive affect and negative affect. This scale controls for differences in mood that may not have been assessed with the BDI.

Procedure

Participants completed the reversal-learning task and then the questionnaires.

## Results

Sixteen participants were eliminated from all analyses for failing to reach criterion on a majority of the nine stages. Failure to obtain the learning criterion for such a large number of relatively simple stages suggests that these participants did not fully understand the directions before beginning the task. If participants did not fully understand the directions, then they would not be aware that the reward contingencies of the stimuli could suddenly change. Indeed, this lack of knowledge about task demands may explain why the 16 excluded participants took twice as many trials on average to reverse (average of 16.1 trials) as the nonexcluded participants did (average of 8.4 trials). We therefore removed these participants because their slower reversals are likely to be due to a misunderstanding of task demands and not to an inability to reverse stimulus-reward associations. An independent samples *t* tests indicated that the RT-mal and RT-adapt scores for these participants did not significantly different from participants whose data were not eliminated, $t(116) < 1$.

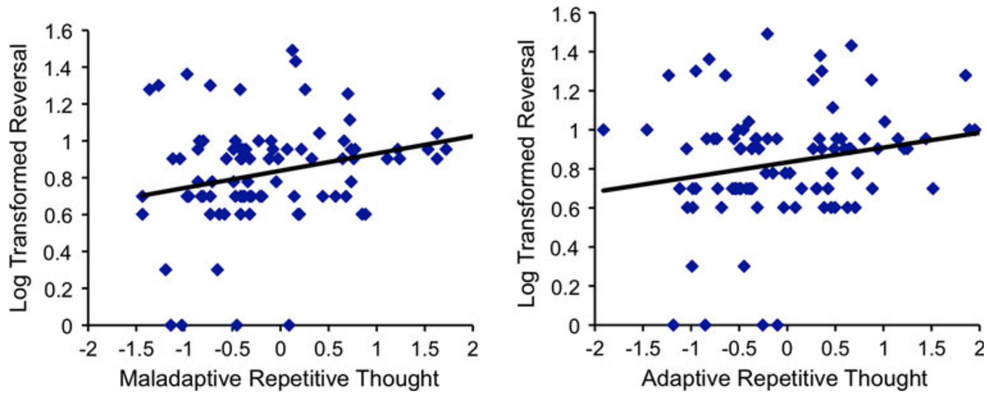


**Fig. 1** A tendency to engage in maladaptive and adaptive repetitive thought (averaged z scores from the individual measures of RT) increases from *left* to *right* on the X-axes. The log transformed number of trials until successful reversal learning (2 trials in a row) is on Y-axis. A larger number means slower reversal learning

Scores from the initial discrimination and reversal learning stages of the task were log transformed before data analysis so as to increase the normality of the data distribution. See Table 1 for skew and kurtosis values.

Reversal Learning

We removed an additional nine participants from analysis because they failed to achieve the criterion for initial discrimination learning. If participants did not learn the initial stimulus reward associations, then it is not possible to examine their ability to reverse those associations. Thus, reversal-learning analyses were performed on a total of 93 participants.[1]

Adaptive and Maladaptive Repetitive Thought

A simple regression found that RT-mal was associated with significantly slower reversal learning, $t(91) = 2.83$, $r = .29$, $P < .01$ (see Fig. 1). This association was marginally significant when the regression model also included the control measures (BDI, positive affect and negative affect), $t(84) = 1.97$, $\beta = .25$, $P = .05$. In contrast, BDI, positive affect, and negative affect were not related to reversal learning in this regression model, all $t(84)$'s $< 1$. Another simple regression model found that RT-adapt is also significantly related to slower reversal learning, $t(91) = 2.16$, $r = .22$, $P < .05$ (see Fig. 1). This association was also marginally significant when the regression model included BDI, positive affect and negative affect, $t(84) = 1.84$, $\beta = .20$, $P = .07$. Again, none of the control measures in this model were significantly related to reversal learning, all $t(84)$'s $< 1.3$.

Two tests were performed to determine whether slower reversal learning was more strongly related to RT-mal than RT-adapt. First, a Fisher's $z$ test performed on the beta weights taken from the models with multiple regressors (i.e., the relation with reversal learning after controlling for mood and depressive symptoms) did not find RT-mal to be more strongly related to reversal learning than RT-adapt, $t(90) = .11$, $P > .1$. When both RT-mal and RT-adapt were entered into same regression model, along with BDI and mood, neither adaptive or maladaptive repetitive thought were related to reversal learning (both $t(83)$'s $< 1.6$). Thus, the variance unique to each form of repetitive thought is not related to reversal learning, suggesting that it is primarily the variance that is common to both forms of repetitive thought that is related to worse reversal learning.

Initial Discrimination Learning

We also examined the relation between repetitive thought and initial discrimination scores to determine if repetitive thought is related to general deficits in learning or if it is related only to reversal learning difficulties. We first examined initial discrimination scores when retaining the nine participants who did not obtain the learning criterion, finding no significant relation between initial discrimination scores and RT-mal, $t(101) = -1.10$, $r = -.11$, $P = .28$, or between initial discrimination scores and RT-adapt, $t(101) = .94$, $r = .09$, $P = .35$. We also tested whether we would find a relation between repetitive thought and initial discrimination scores when excluding the nine participants who did not reach criterion (i.e., the same sample analyzed in the reversal-learning section), but, again, we did not find a relation between initial discrimination scores and RT-mal, $t(92) = .96$, $r = .10$, $P = .34$, or between initial discrimination scores and RT-adapt, $t(92) = -.02$, $r < -.01$, $P = .98$.

## Discussion

The results suggest that a tendency to engage in both adaptive and maladaptive repetitive thought is related to

[1] We would like to note that we did not find a relation between gender and reversal learning scores or initial discrimination scores, all $P$'s $> .1$. Gender also did not modify any of the relationships found between repetitive thought and the task measures, all $P$'s $> .1$.

difficulties with reversal learning but not with initial discrimination learning. This finding suggests that individuals who engage in repetitive thought are capable of learning reward and punishment values of information, but that they will have difficulties altering these values once they have been learned. Thus, compared to individuals who do not repetitively think, repetitive thinkers may be more likely to continue thinking about information that has stopped being relevant because they are slower to notice that such information is no longer rewarding.

A novel finding of this study was that perseveration, or the inability to modify behavior based upon negative feedback, was related to multiple types of repetitive thought, regardless if the repetitive thought is associated with adaptive (intellectual self-reflection and depressive reflection) or maladaptive (depressive brooding, anger rumination, and worry) consequences. The finding that perseveration is related to relatively adaptive forms of repetitive thought is not consistent with the formulation that perseveration leads primarily to poor problem solving and worse mood. This finding is instead more consistent with the findings of Altamirano et al. (2010), which suggest that the perseverative tendencies of ruminators can also be adaptive. For example, Altamirano et al. found that ruminators' perseverative tendencies are associated with the stable maintenance of adaptive information like a task goal. Thus, perseveration may be related to the likelihood that thoughts will become "stuck" in mind (i.e., how repetitive thoughts are) but not to the adaptiveness of the thoughts that are stuck in mind.

We think that it is possible that other mechanisms, unique to particular subtypes of repetitive thought, will drive the adaptiveness of repetitive thinking. For example, Watkins (2008) proposed that the valence of one's thoughts might influence the adaptiveness of those thoughts; in that, repetitive thoughts that are negative are more likely to be maladaptive than are positive repetitive thoughts. In this context, cognitive mechanisms that affect the valence of thoughts should affect the adaptiveness of repetitive thinking. Interestingly, Joormann et al. (2006) demonstrated that in a depressed sample, a tendency to depressively brood, a maladaptive form of rumination, was associated with an increased attentional bias towards negative information in a dot-probe task, but a tendency to depressively reflect, a potentially adaptive form of rumination, was not. Thus, certain cognitive mechanisms, like those involved in attentional biases, may underlie the adaptiveness of repetitive thoughts, and other cognitive mechanisms, like those involved in perseveration, may underlie the repetitiveness of thoughts.

In this context, we would like to note that if we are to gain a complete understanding of the cognitive causes and consequences of repetitive thought, investigators need to continue distinguishing between mechanisms that are more broadly related to repetitive thought (i.e., the shared variance) and mechanisms that are specific to different subtypes of repetitive thought (i.e., the unique variance). Past research has suggested that some mechanisms, such as inhibition during task switching, may be specific to depressive rumination, while other mechanisms, such as non-inhibitory switching processes, may be specific to other forms of rumination, such as anger rumination (e.g., Whitmer and Banich 2007). The present results suggest that reversal-learning deficits are related to the variance that is shared between multiple forms of repetitive thought.

One question that arises from the current study is if reversal-learning deficits found in the present study may be caused by inhibitory deficits, given that ruminators have exhibited inhibitory deficits in other studies (e.g., Joormann 2006; Whitmer and Banich 2007). Indeed, investigators have suggested that inhibition may be needed to override the prepotent response to the previously rewarded stimulus once a participant has become consciously aware of a change in reward contingencies (e.g., Clark et al. 2004). Such deficits, however, seem unlikely in the current study, because we examined reversal learning in a group of healthy, college undergraduates and despite a tendency to repetitively think, it seems unlikely that that any of our participants had inhibitory deficits severe enough that they could be aware of a change in reward contingencies but still be unable to alter their response over multiple trials. Indeed, past research has found that ruminators' inhibitory deficits only slightly affect their responses to task stimuli (e.g., changing response rates on the order of milliseconds; e.g., Whitmer and Banich 2007).

Alternatively, it is also possible that inhibition may play a more subtle and automatic role in reversal learning. For example, an individual may have separate representations of a stimulus's reward and punishment values, and they may only select stimuli that are more associated with reward than punishment. Negative feedback may increase punishment values, resulting in the automatic, lateral inhibition (or deactivation) of the reward representations. If repetitive thinkers have such inhibitory deficits then it would take longer for the punishment values of a stimulus to outweigh the reward values, thereby delaying reversal. If inhibition does play such a role in this study, the present results suggest that repetitive thinkers' inhibitory deficits not only affect their mental representations of task goals, sets, or stimuli, as have been found in previous studies (e.g., Joormann 2006; Whitmer and Banich 2007), but also their mental representations of reward and punishment values. If this account of the present results is correct, then it also suggests that repetitive thinkers exhibit inhibitory deficits even in situations that do not contain explicit demands to change behavior.

It, however, is quite possible that non-inhibitory mechanisms cause all or part of the reversal learning deficits found in the current study. For example, it is possible that individuals who repetitively think are insensitive to punishment, making it harder for them to use negative feedback to make a reversal. Alternatively, and not mutually exclusive, it is possible that repetitive thinkers are hypersensitive to reward, and that positive feedback during initial learning causes them to over learn the initial reward associations, making it harder for them to override such associations during the later reversal. To examine this hypothesis, researchers should examine whether individuals who repetitively think exhibit differential sensitivities to reward and punishment in situations where no reversal is required.

We would like to note that although the reversal learning deficits elicited in the current study are similar to those found in the WCST, the advantage of the present study is that it identifies a more specific process. For example, investigators have found that the WCST task is composed of three primary processes: initial discrimination learning, ED shifting, and reversal learning (e.g., see Dias et al. 1996). Importantly, each of these processes has been associated with different psychopathologies, and with the proper functioning of different brain regions and neuromodulators (e.g., see Clark et al. 2004). Thus, we believe the additional specificity provided by the current results is important, because it connects the repetitive thought literature to the large literature on reversal learning. For example, previous reversal-learning studies have demonstrated that reversal learning relies on proper functioning of the ventral prefrontal cortex (PFC) and striatum but not the temporal lobe (see Clark et al. 2004), while initial discrimination relies on proper functioning of the temporal lobe and not the PFC or striatum (Clark et al. 2004). Therefore, the results of the present study may suggest that a tendency to engage in repetitive thought is related to abnormal function of the ventral PFC and the striatum but not to that of the temporal lobes. Future research, however, is needed to directly examine this hypothesis.

It is important to note that is not clear if reversal-learning deficits in the current study make individuals susceptible to repetitive thought or if reversal-learning deficits are instead a consequence of increased repetitive thinking in individuals who tend to repetitively think. This distinction is important because if reversal-learning deficits make an individual susceptible to repetitive thought then such deficits could be targeted with cognitive interventions *before* an individual starts to repetitively think. Previous researchers (e.g., MacLeod et al. 2002) have found that attentional biases can be trained and that such training can significantly reduce the emotional vulnerabilities of individuals. In this context, is possible that efforts to train, in the lab, a heightened sensitivity to changes in feedback and reward contingencies, may also have the effect of decreasing repetitive thought. Of course, the present findings may suggest that it is only appropriate to do so in individuals with tendencies to engage in maladaptive forms of repetitive thought.

In sum, a tendency to engage in repetitive thought is associated with reversal-learning deficits but not to initial discrimination learning.

## References

Altamirano, L., Miyake, A., & Whitmer, A. (2010). When mental inflexibility facilitates executive control: Beneficial side effects of ruminative tendencies on goal maintenance. *Psychological Science, 21*, 1377–1382.

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry, 4*, 561–571.

Blair, R. J., Colledge, E., & Mitchell, D. G. (2001). Somatic markers and response reversal: Is there orbitofrontal cortex dysfunction in boys with psychopathic tendencies? *Journal of Abnormal Child Psychology, 29*, 499–511.

Clark, L., Cools, R., & Robbins, T. W. (2004). The neuropsychology of ventral prefrontal cortex: Decision-making and reversal learning. *Brain and Cognition, 55*, 41–53.

Davis, R. N., & Nolen-Hoeksema, S. (2000). Cognitive inflexibility among ruminators and nonruminators. *Cognitive Therapy and Research, 24*, 699–711.

Dias, R., Robbins, T. W., & Roberts, A. C. (1996). Dissociation in prefrontal cortex of affective and attentional shifts. *Nature, 380*, 69–72.

Downes, J. J., Roberts, A. C., Sahakian, B. J., Evenden, J. L., Morris, R. G., & Robbins, T. W. (1989). Impaired extra-dimensional shift performance in medicated and unmedicated Parkinson's disease: Evidence for a specific attention dysfunction. *Neuropsychologia, 27*, 1329–1343.

Fresco, D. M., Frankel, A., Mennin, D. S., Turk, C. L., & Heimberg, R. G. (2002). Distinct and overlapping features of rumination and worry: The relationship of cognitive production to negative affective states. *Cognitive Therapy and Research, 26*, 179–188.

Jones, N. P., Papadakis, A. A., Hogan, C. M., & Strauman, T. J. (2009). Over and over again: Rumination, reflection, promotion goal failure, and their interactive effects on depressive symptoms. *Behavior Research and Therapy, 47*, 254–259.

Joormann, J. (2006). Differential effects of rumination and dysphoria on the inhibition of irrelevant emotional material: Evidence from a negative priming task. *Cognitive Therapy and Research, 30*, 149–160.

Joormann, J., Dkane, M., & Gotlib, I. H. (2006). Adaptive and maladaptive components of rumination? Diagnostic specificity and relation to depressive biases. *Behavior Therapy, 37*, 269–280.

MacLeod, C., Rutherford, E., Campbell, L., Ebsworthy, G., & Holker, L. (2002). Selective attention and emotional vulnerability: Assessing the causal basis of their association through the experimental manipulations of attentional bias. *Journal of Abnormal Psychology, 111*, 107–123.

Meyer, T. J., Miller, M. L., Metzger, R. L., & Borkovec, T. D. (1990). Development and validation of the Penn State Worry Questionnaire. *Behaviour Research and Therapy, 28*, 487–495.

Nolen-Hoeksema, S. (2000). The role of rumination in depressive disorders and mixed anxiety/depressive symptoms. *Journal of Abnormal Psychology, 109*, 504–511.

Nolen-Hoeksema, S., & Morrow, J. (1991). A prospective study of depression and posttraumatic stress symptoms after a natural disaster: The 1989 Loma Prieta earthquake. *Journal of Personality and Social Psychology, 61*, 115–121.

Nolen-Hoeksema, S., Wisco, B., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on Psychological Science, 3*, 400–424.

Roberts, J. E., Gilboa, E., & Gotlib, I. H. (1998). Ruminative response style and vulnerability to episodes of dysphoria: Gender, neuroticism, and episode duration. *Cognitive Therapy and Research, 22*, 401–423.

Sukhodolsky, D. G., Golub, A., & Cromwell, E. N. (2001). Development and validation of the anger rumination scale. *Personality and Individual Differences, 31*, 689–700.

Takano, K., & Tanno, Y. (2009). Self-rumination, self-reflection, and depression: Self-rumination counteracts the adaptive effect of self-reflection. *Behaviour Research and Therapy, 33*, 260–264.

Trapnell, P. D., & Campbell, J. D. (1999). Private self-consciousness and the five-factor model of personality: Distinguishing rumination from reflection. *Journal of Personality and Social Psychology, 76*, 284–304.

Treynor, W., Gonzalez, R., & Nolen-Hoeksema, S. (2003). Rumination reconsidered: A psychometric analysis. *Cognitive Therapy and Research, 27*, 247–259.

Watkins, E. (2008). Constructive and unconstructive repetitive thought. *Psychological Bulletin, 134*, 163–206.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*, 1063–1070.

Whitmer, A., & Banich, M. (2007). Inhibition versus switching deficits in different forms of rumination. *Psychological Science, 18*, 546–553.

Whitmer, A., & Banich, M. (2010). Trait rumination and inhibitory deficits in long-term memory. *Cognition and Emotion, 1*, 168–179.