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Looking on the Dark Side: Rumination and Cognitive-Bias Modification

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Abstract

To understand cognitive bases of self-reported ruminative tendencies, we examined interpretations and subsequent memories of ambiguous situations depicting opportunities for rumination. In Experiment 1, we recruited students, randomly assigned them to a distracting or ruminative concentration task, and then measured their latencies to complete fragments that resolved situational ambiguity in either a ruminative or a benign direction. Students in the ruminative task condition who previously self-identified as brooders were quicker to complete ruminative fragments. In Experiment 2, we simulated this bias to investigate its possible contribution to rumination; nonbrooding students were trained to make ruminative or benign resolutions of ambiguous situations. Ruminative training led to more negative continuations of new, potentially ruminative situations in a subsequent transfer task. Next, ruminative training also caused more negatively valenced errors in recalling the ambiguous transfer situations. Finally, after reflection about a personal experience, state-rumination scores were higher in the ruminative condition. These results establish the causal role of interpretation biases in ruminative patterns of thought.

To some extent, people interpret emotionally ambiguous situations in benign or negative directions instead of maintaining their inherent ambiguity. The extent to which the interpretation is negative instead of benign has been associated primarily with measures of anxiety (e.g., Eysenck, Mogg, May, Richards, & Mathews, 1991; Hirsch & Mathews, 2000) but occasionally with dysphoria or depression (Hertel & El-Messidi, 2006; Lawson, MacLeod, & Hammond, 2002). More recently, by using procedures called cognitive-bias modification (CBM), investigators have gone beyond these bias demonstrations to establish causal connections from the bias to features of emotional disorders (see the review by Hertel & Mathews, 2011). In our view, interpretation bias should be instrumental in the development and maintenance of one feature of depression in particular: the tendency to ruminate or to think repetitively about one's problems and oneself in relation to those problems.

Rumination is a maladaptive and prevalent traitlike feature of depressive disorders (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Ruminators tend to perceive their problems as debilitating and focus on themselves to the detriment of solution-focused behavior. Recent frameworks for understanding rumination have suggested that trait rumination is maintained by cognitive biases that make negative content more accessible and create a vicious cycle of ruminative thinking and negative affect (Nolen-Hoeksema et al., 2008). Rumination-related cognitive biases—revealed through correlations—have been found mostly in attention and memory tasks. For example, ruminators have trouble controlling attention away from irrelevant self-related or emotional content (e.g., Daches, Mor, Winquist, & Gilboa-Schechtman, 2010; Joormann & Gotlib, 2008). Similarly, depressive rumination has been linked to enhanced retrieval of negative memories (Lyubomirsky, Caldwell, & Nolen-Hoeksema,

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1998) and negative self-related material (Moulds, Kandris, & Williams, 2007) and to overgeneral autobiographical memories (Debeer, Hermans, & Raes, 2009; Watkins & Teasdale, 2004).

Two subtypes of rumination have been identified: reflection and brooding (Treynor, Gonzales, & Nolen-Hoeksema, 2003). Reflection involves purposefully turning inward to engage in problem solving and alleviate depressive symptoms. Brooding, in contrast, involves self-critical and evaluative thinking about the self. Brooding, but not reflection, has been associated with a variety of negative outcomes, such as increased depression over time (Treynor et al., 2003) and maladaptive coping strategies (Burwell & Shirk, 2007). Cognitive biases, such as the ones reported earlier, are often specific to brooding (Bernblum & Mor, 2010; De Lissnyder, Koster, Derakshan, & De Raedt, 2010).

To date, only a few studies have focused on interpretive biases associated with rumination. In a very recent study (Mor, Hertel, Ngo, Shachar, & Redak, 2014), brooding and nonbrooding students performed a lexical decision task similar to the one first used by Richards and French (1992) to show interpretation biases in anxiety. Students judged the lexical status of targets that were each related to either the ruminative or the benign meaning of the preceding homographic prime. In this type of lexical decision task, decision times are faster when the initial interpretation of the homograph is consistent with the upcoming target (e.g., *bitter/angry* vs. *bitter/lemon*). Accordingly, students who reported a higher degree of habitual rumination produced faster decision times for the ruminative targets but not for other targets with negative and threatening meanings. These data were informative but incapable of addressing the possible causal directions involved.

Causal connections among rumination and cognitive phenomena were perhaps first explored by experimentally manipulating state rumination and observing the cognitive and emotional consequences (for a review, see Nolen-Hoeksema et al., 2008). For example, we know that dysphoric students who underwent a rumination induction recalled more homographs that they had interpreted personally—*bitter, strain, vent*—than did participants in other conditions (Hertel & El-Messidi, 2006). Such experiments reveal consequences of rumination but tell us nothing about why people think in ruminative patterns in the first place. When investigators approached a similar issue regarding possible cognitive contributions to anxiety, they developed CBM procedures to simulate or modify interpretation biases to provide evidence that interpretation biases influence features of the disorder (for a review, see Hertel & Mathews, 2011).

We therefore revised the typical CBM procedure used to modify interpretation bias in anxiety to suit our goal of investigating the mechanisms of ruminative habits. Several investigators have reported modifications of interpretation biases that are potentially applicable to depression (Blackwell & Holmes, 2010; Holmes, Lang, & Shah, 2009; Watkins, Baeyens, & Read, 2009). Reports of appraisal modifications are also relevant (e.g., Miller, Rude, & Haner, 2013; Schartau, Dalgleish, & Dunn, 2009), and one such study (although not applying CBM) showed direct effects of "big-picture" appraisal on ruminative thought (Rude, Mazzetti, Pal, & Stauble, 2011). None that we are aware of, however, has targeted negative interpretations of ambiguity as a potential cause of rumination. After developing a set of ambiguous scenarios with the potential for ruminative resolutions, we conducted two experiments: a first experiment to document bias in scenario interpretation as a characteristic of individuals who ruminate and a second experiment to simulate the bias to produce rumination-related consequences. Specifically, in the second experiment, we used CBM to establish a rumination-related interpretation bias and then examined the contribution of those effects to subsequent memory bias and state rumination.

Experiment 1

Building on our previous findings (Mor et al., 2014), in Experiment 1 in the current report, we examined the rumination-related bias in latencies to complete the fragmented final word of ambiguous scenarios. The final word disambiguated the meaning of the scenario much like targets used by Mor et al. (2014) disambiguated the priming homographs. Scenarios, however, are more ecologically valid materials for expressing the ambiguity found in real-world settings. Moreover, the scenarios were modeled after those used by Mathews and Mackintosh (2000) in one of the first successful CBM simulations of interpretation bias in anxiety. Because we found their approach useful in considering the design of our upcoming simulation experiment, we wished to document biases by using the same task in Experiment 1. In constructing materials related to a ruminative mental set, we focused primarily on situations conducive to thinking about oneself in a negative way but that permit other viewpoints (e.g., "You have a reunion with your high school friends. Everyone is talking about their lives after graduation. When you reflect on your own experiences in relation to everyone else's, your difficulties seem [unusual/typical]."). We also tried to capture the backward glance that is so intuitively a feature of ruminative episodes. In Experiment 1, half of the scenarios ended in a fragment that established a ruminative meaning for the scenario, and half ended in a way that established a nonruminative or benign meaning. We predicted that the alacrity in resolving each type would indicate the ruminative status of the participant.

In documenting the bias, we reasoned that ruminative reactions do not dominate every situation that a person encounters (Takano, Sakamoto, & Tanno, 2013). Participation in a psychology lab to fulfill class requirements might well sidestep opportunities for rumination. Three specific features of our design therefore were chosen for the purpose of varying ruminative engagement of the maladaptive sort. First, we began each session with a frequently used concentration task to temporarily induce self- or other-focused thinking (e.g., Hertel & El-Messidi, 2006; Nolen-Hoeksema & Morrow, 1993). This self-focused task has been used for a variety of experimental purposes (e.g., to induce a negative mood in dysphoric individuals and negative bias in autobiographical remembering; Lyubomirsky et al., 1998). Again, the purpose of this manipulation in our experiment was to potentiate a ruminative state for those individuals who have the habit of ruminating. Second, we directed participants to imagine themselves in scenarios that were written to potentiate maladaptive resolutions. Engagement through imagery instructions is a typical feature of bias experiments (e.g., Holmes et al., 2009). Third, we recruited participants who scored in the extreme quartiles of the Brooding subscale of the Ruminative Response Scale (RRS; Nolen-Hoeksema & Morrow, 1991) because brooding represented the more maladaptive form of rumination (Nolen-Hoeksema et al., 2008). We predicted that students with high brooding scores would be quick to resolve scenarios negatively if they came to the task from a particularly self-focused perspective.

Method

Participants and design. Undergraduate students were asked to complete the RRS during their introductory psychology class. Students whose scores on the Brooding subscale fell into the 1st quartile (8 and below) were recruited as nonbrooders, whereas those who scored within the 4th quartile (13 and above) were recruited as brooders. Brooding scores can range from 5 to 20, and these cutoffs are similar to those reported in prior research (e.g., Bernblum & Mor, 2010; Daches et al., 2010). Forty students in each brooding category initially were selected and randomly assigned to a combination of conditions for thought induction (self-focus or distraction) and counterbalancing materials (rotating negative and benign endings between scenarios), with the constraint of equal cell sizes. Balancing the mean brooding scores across conditions served as an additional constraint for assignment of the last several participants. After the data from 4 participants were set aside as outliers (2.5 *SD* from the overall mean latency for either negative or benign fragments), 4 additional students were recruited and randomly assigned as replacements. The final sample contained 6 females and 4 males in each combination of brooding category, thought induction, and condition for counterbalancing materials.[1]

Materials. The concentration task required two booklets to make the task seem separate from the main computer task. One booklet contained 50 self-focusing phrases (e.g., "think about: who you are as an individual") and the other contained 50 distracting phrases (e.g., "think about: the typical layout of a classroom"); each phrase was presented separately on a new page. The booklets were used by Hertel and El-Messidi (2006) and were modifications of Nolen-Hoeksema and Morrow's (1993) materials, which were designed to induce a state of rumination in the self-focused condition compared with the distraction condition.

A total of 40 scenarios were compiled for the main task. Eight were filler scenarios that described nonambiguous, nonemotional situations, and 8 were ambiguous scenarios capable of being resolved in a socially anxious direction (Hertel, Brozovich, Joormann, & Gotlib, 2008; Mathews & Mackintosh, 2000); the latter were included as a control for a nonspecific negative bias, and the control scenarios were used to make our purpose a little less obvious. The remaining 24 ambiguous scenarios were constructed to invite ruminative thinking; each ended in a word that signified either a ruminative resolution or its absence. Table 1 contains examples of each type. Each potential social-anxiety and ruminative scenario was paired with two possible ending words (negative and benign), and all words were turned into fragments by omitting one to three letters, depending on word length, but never the first letter. Each scenario was also associated with a yes/no question designed to encourage participants to read the scenarios before completing the fragment. The scenarios were organized into four blocks, each of which contained 6 ruminative scenarios (3 ending in negative fragments and 3 ending in benign fragments), 2 social-anxiety scenarios (1 ending each way), and 2 filler scenarios. The scenarios assigned to each type of ending were fully counterbalanced within each cell of the design, and the order of presentation within blocks was randomized anew for each participant.

Procedure. The concentration task in Phase 1 was described as a pilot study to determine how well people can concentrate, and participants were told that questions would follow the task. They were instructed to read the phrase on each page and to concentrate on it by using their imagination to visualize the idea represented by the phrase. After 10 s, a beep signaled the participants to turn to the next page. Afterward, in a task to complete the cover story, we had participants rate their perceived ability to form images corresponding to the phrases and

Table 1. Scenario Examples

Scenario	Benign ending	Negative ending	Question	Benign answer
[Filler/control—Experiments 1 and 2] You begin reading a book that you recently found around your house. One afternoon you are reading it while sitting in the recliner. The doorbell rings so you put the book down. You think it could be your . . .	ne-ghb-r [neighbor]	—	Were you watching a movie when the doorbell rang?	No
[Socially anxious—Experiment 1] You arrange to meet a friend in town. Last time you met, you had a quarrel. Just before you leave, she phones to say that she can't make it. You think that this is because she is feeling . . .	unwe-l [unwell]	an—y [angry]	Did your friend forgive you?	Yes
[Ruminative—Experiments 1 and 2] While doing your calculus homework, you encountered a problem that you couldn't solve. The next day, you go to class and turn it in. Later, you keep thinking about it and realize that, during class, everyone seemed so . . .	in-ec-re [insecure]	co–fid-nt [confident]	Did the other students encounter problems with the homework?	Yes

to concentrate on the ideas during the allotted time periods. Finally, as part of the same cover story, they were asked to recall five phrases.

The main task in Phase 2 (programmed in Superlab Pro 4.07, Cedrus Corporation, San Pedro, CA) was described as unrelated to the Phase 1 task. Details of this procedure were arranged to be as similar as possible to those used by other researchers to measure or manipulate interpretation bias; for example, self-involving imagery instructions were used (e.g., Mathews & Mackintosh, 2000). We asked participants to read each scenario, visualize themselves in the situation, and contemplate their reaction before pressing the space bar. The bar press revealed the word fragment, and participants were instructed to type the completing word in a text box that appeared below the fragment. We recorded latencies from the onset of the fragment to the first letter press. By clicking "next," participants saw the question and typed "yes" or "no" in the answer box. Two practice examples were completed in the presence of the experimenter. The Beck Depression Inventory–II (BDI-II; Beck, Steer, & Brown, 1996) was administered after completion of Phase 2. We used a version that omitted the "suicide" item. We included this self-report of depressed state to examine whether there would be reason to suspect that depression would predict interpretation bias relevant to our scenarios as well as or better than would rumination measures.

Results and discussion

Mean latencies to respond to the 12 negative and 12 benign scenarios were calculated by omitting error trials

($M = 4.2\%$). Then latencies beyond 2.5 *SD* of each individual's mean for the relevant fragment type were removed. The adjusted mean latencies were submitted to an analysis of variance with a within-subjects factor for fragment type (negative and benign) and between-subjects factors for brooding group (low or high) and concentration task (self-focus or distraction). In an attempt to reduce error variance, an additional factor was included to represent the counterbalancing condition; significant effects associated with that factor are not reported.

The only significant effect in the main design was the three-way interaction of fragment type, brooding group, and task, $F(1, 72) = 4.26$, $MSE = 148,761$, $p = .04$, $\eta_p^2 = .06$. Means and standard deviations are reported in Table 2. The interaction was partitioned into simple interactions of fragment type and brooding group within each concentration condition. In the distraction condition, no differences were found (all *F*s < 1.0). In the self-focus condition, the simple interaction was significant, $F(1, 36) = 5.07$, $MSE = 123,142$, $p = .03$, $\eta_p^2 = .12$. Brooders responded more quickly to negative fragments than to benign fragments, $F(1, 18) = 4.34$, $MSE = 142,388$, $p = .052$, $\eta_p^2 = .19$. The difference in the nonbrooding group was nonsignificant ($p > .31$). These data therefore reveal an interpretation bias experienced by individuals who report brooding but only after an induction of self-focus.

The same analysis was performed on the latencies to complete fragments after the social-anxiety scenarios. These scenarios have been used to show interpretation biases related to trait and social anxiety (e.g., Mathews & Mackintosh, 2000). In the current experiment, however, no systematic differences or effects associated with

Table 2. Results From Experiment 1

Measure	Distraction/low brooding	Distraction/high brooding	Self-focus/low brooding	Self-focus/high brooding
Ruminative Response Scale	37.6 (8.4)	59.7 (10.1)	33.8 (6.9)	61.8 (9.2)
Brooding scale	7.0 (1.0)	15.4 (1.6)	7.2 (0.9)	15.3 (1.7)
Reflective pondering	9.0 (3.9)	12.9 (3.0)	7.6 (2.5)	13.5 (3.4)
Mean RT: Ruminative				
Negative fragment	1,708 (669)	1,806 (585)	1,826 (688)	1,586 (395)
Benign fragment	1,726 (552)	1,674 (406)	1,721 (473)	1,834 (627)
Mean RT: Social anxiety				
Negative fragment	2,029 (873)	1,916 (752)	2,344 (1,320)	1,934 (981)
Benign fragment	1,857 (626)	2,115 (1,222)	2,105 (1,186)	1,893 (1,054)
Beck Depression Inventory–II	8.2 (5.5)	15.2 (9.0)	8.8 (5.7)	16.1 (8.8)

Note: n = 20. The table presents means for each measure. Standard deviations are shown in parentheses. Reaction times (RTs) were measured in milliseconds. All group differences in questionnaire measures were significant ($p < .001$), but other effects were not ($p > .13$). The Beck Depression Inventory–II did not include the "suicide" item.

brooding and state rumination were found (all ps > .27). Thus, the interpretive bias revealed by the ruminative scenarios that we created can be viewed as specifically ruminative and not generally negative or benign, although this specificity should be replicated because few social-anxiety trials were included in this design.[2]

An analysis of variance was conducted on the BDI-II scores and revealed a significant main effect of brooding group, $F(1, 76) = 18.45$, $MSE = 55.42$, $p < .001$, $\eta_p^2 = .20$. The means reported in Table 2 suggest an effect of self-focus on the scores in the brooding group, but the main effect of concentration task and the interaction were both nonsignificant, $F < 1.0$, as one would expect from a more stable measure of dysphoria. Finally and more relevant, we examined the correlation between the BDI-II score and the valence effect in latencies (benign reaction time minus negative reaction time) across all 80 participants and within each condition of the concentration task. All three correlations were positive, but none was significant ($p > .20$).

Experiment 2

Having produced evidence for rumination-related bias in the interpretation of ambiguity, we turned our efforts toward its simulation. CBM-interpretation paradigms consist of a training phase in which scores of such scenarios are resolved consistently in either the benign or the negative direction. Then transfer of training is typically evaluated via a measure of the interpretation of new, open-ended scenarios. In Experiment 2, we randomly assigned 20 participants to each of three training conditions (ruminative, benign, and control) and presented 70 training scenarios before asking the participants to write continuation sentences for 9 new ambiguous scenarios, to be judged as expressing negative or benign

interpretations. Thus, one measure of the success of bias simulation is whether participants reveal that bias in similar but unconstrained situations. Writing a continuation for a scenario is less constrained than is filling in letters of a predetermined word that functions to resolve ambiguity.

Ruminative thought feeds on memories for past events. The review by Nolen-Hoeksema et al. (2008) documented evidence of negative bias in autobiographical memory among ruminators or those induced to ruminate. Another possible measure of the success of bias training, therefore, is the extent to which participants reconstruct aspects of past ambiguous events from a negative perspective. Emotionally ambiguous events can be remembered negatively through reconstructions mediated by interpretation (Bartlett, 1932). A similar phenomenon occurs in social anxiety, in which case the memory bias clearly results from interpretations made on initial exposure to the events to be remembered (Hertel et al., 2008). This sort of reliance of one type of bias on another type was first addressed in the combined cognitive-bias hypothesis of Hirsch, Clark, and Mathews (2006) and applied to cognition in depression (Everaert, Koster, & Derakshan, 2012). In fact, evidence of memory bias that results from CBM interpretation training has already been found (e.g., Tran, Hertel, & Joormann, 2011). We therefore predicted that a request to recall the transfer scenarios in the current experiment would reveal evidence for training-congruent biases of the sort that fuel ruminative thought. In practice, we examined the number of intrusions in the recall of the ambiguous scenarios that were judged emotionally benign or ruminatively negative. (Our use of the term *intrusion* refers to the inclusion of nonpresented material or confabulations during recall; in this regard, it differs from the term *intrusion* used in the context of intrusive memories that arise in

consciousness in uninvited ways; e.g., Lang, Moulds, & Holmes, 2009.)

Our final predictions concerned state rumination after autobiographical recall. In CBM experiments designed to simulate cognitive contributions to anxiety, investigators have been careful to argue that CBM is not merely a mood-induction procedure but instead establishes a tendency to respond anxiously to potentially stressful situations (e.g., Standage, Ashwin, & Fox, 2010; Wilson, MacLeod, Mathews, & Rutherford, 2006). Therefore, as a final "far-transfer" task, we examined ruminative reactions to remembering instead of anxious reactions to a stressful task. As is often done in assessments of state rumination (e.g., Grisham, Flower, Williams, & Moulds, 2011), we asked participants to describe an unpleasant event from their recent past and gave them time to ruminate about it afterward before we administered a measure of state rumination. We predicted training-congruent effects on that measure. To distinguish state rumination from mood, we also asked for ratings for various "states of mind" throughout the session to sample possible training effects on mood and other states.

Method

Participants and design. As in Experiment 1, we screened students in undergraduate psychology classes according to their scores on the Brooding subscale of the RRS; this time, we recruited students who scored at or below the median of 10 (to avoid exacerbating rumination and negative mood in brooding individuals). For reasons of convenience, we recruited only female students. With constraints of equal cell sizes and closely similar cell means on the Brooding scale, we randomly assigned 20 participants to a combination of training (ruminative, benign, or control) and a counterbalancing condition for rotating the valence of scenario resolution across 12 probe trials. Mean scores on the Brooding subscale were 8.2 (ruminative), 8.3 (benign), and 8.2 (control).

Materials. We developed a set of 70 training scenarios (and 70 control scenarios), 9 transfer scenarios, and 5 practice scenarios. In addition to the BDI-II, we included the Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1989) and the Momentary Ruminative Self-Focus Inventory (MRSI; Mor, Marchetti, & Koster, 2013). The MRSI is a six-item questionnaire that was recently developed to assess state rumination. Participants were asked to indicate their degree of agreement (1 = *strongly disagree*, 7 = *strongly agree*) with statements such as "right now, I wonder why I react the way I do," "right now, I am thinking about the possible meaning of the way I feel," and "right now, I am conscious of my inner feelings." The MRSI has shown good internal reliability and concurrent validity as well as sensitivity to an experimental

manipulation of ruminative self-focus (Mor et al., 2013). In the present sample, the internal consistency reliability of the MRSI was good (α = .81).

We also used a state-of-mind form (SMF) on which participants indicated responses by drawing a vertical line on 100-mm horizontal lines ranging from *not at all* (0) to *extremely* (100) to statements beginning with "I am feeling" and ending with "cheerful," "in control," "anxious," "relaxed," "worried," "sad," "resentful," and "content."

Training scenarios. Each training trial consisted of a scenario (similar or identical to the ones used in Experiment 1), a word fragment at its end, and a context question. In the ruminative and benign conditions, the same scenarios were identical and disambiguated by the word completing the fragment (see Table 1) in either a predominantly ruminative or a benign direction. They described situations related to academics, personal relations, career issues, and extracurricular activities. Completion words were balanced for word length across conditions, as were corresponding yes/no answers to the context questions. Control scenarios were nonambiguous and nonemotional, and the length of the completing words and answers to the context questions were balanced with those measures in the training sets. In both training sets and the control set, each completion word was unique. Of the 70 training scenarios, 12 were employed as probes and presented in all three conditions (including the control condition); 6 of these scenarios ended with negative completion words and 6 with benign words in a manner fully counterbalanced within conditions. Included to measure training effects as training occurred, the 12 probes were distributed evenly within the last 42 trials, and each block of 7 trials contained 1 probe with each ending. Word length and answers to the context question were each balanced across the probe categories.

Transfer scenarios. Transfer trials consisted of nine ambiguous scenarios constructed to potentiate a ruminative or benign interpretation and that ended with a complete sentence (i.e., fragments were not used). Each was presented with a title above and an answer box below, into which the participant-generated continuation could be typed. Three scenarios described academic situations, three interpersonal, two career, and one extracurricular. An example scenario follows:

The Presentation [Title]

Some important people visit the office where you work, and you present a project to them. It is imperative that you do really well. When you are done, your boss comes to talk to you. Afterwards, you reflect on the presentation.

Procedure. Before the training phase, participants completed the first SMF and placed it in an envelope to be sealed at the end of the session and never viewed by the experimenter. We then told the participants that the first task required role-playing in a variety of scenarios. They were instructed to read each scenario, imagine themselves as the main character, and think about how they would react as that character. Participants were asked to have a possible completing word in mind before hitting the space bar to continue to the word fragment and then to think of the fragment solution before typing the first missing letter followed by the complete word. The program recorded the latency to type the first letter. Next, the context question was presented, and the participant typed "y" for "yes" or "n" for "no" in the answer box below the question. The program began with 3 practice trials with the experimenter present to answer questions and then continued with the 70 training trials.

After a second administration of the SMF, we instructed participants in the transfer task by asking them to read each scenario, imagine themselves as the main character, think about how they would respond, and type at least one sentence as an ending for the scenario. They completed two practice trials, followed by the nine transfer trials, and then they responded to a third SMF. Each SMF was added to the envelope in turn. In the subsequent memory task, the title and first sentence of each practice and transfer scenario was presented. Participants were asked to first recall the remainder of the previously presented scenario and to type it in the box on the screen. After they clicked "next," participants were prompted to recall and type the ending they had previously produced. This distinction between memory for the scenario and memory for the ending was practiced with the two practice scenarios from the transfer phase. (The only purpose in asking for recall of endings was to ensure that participants understood this distinction so that memory intrusions did not merely result from carelessness regarding the source.)

After the memory task, we asked participants to recall an event or a situation that took place recently (in the past 2–4 weeks) that made them feel down, have feelings of regret, or feel bad about themselves. Then, with the event in mind, they wrote a description of what happened and what they felt or thought after the event by typing the text in a Word document. We gave them 4 min to complete this task, after having promised that the experimenter would not read the description. At the end of the allotted time, the experimenter reentered the room and asked the participant to save and close the document. Then she left to prepare some additional forms and stayed away for 2 min to provide an opportunity for rumination about the described event. When she reentered, she administered the MRSI, BDI-II, RRS, and SIAS

separately and in that order. Participants placed each of these completed forms in the envelope, in turn, and sealed the envelope. Then participants in the ruminative training condition were offered a selection of funny videos, and everyone was fully debriefed.

Results and discussion

Transfer of interpretation bias. Endings to the transfer scenarios were categorized as negative or benign interpretations by two independent raters who were blind to training conditions; kappas for each of the nine scenarios averaged to .86, and discrepancies were resolved by a third rater. Then the number of negative interpretations (with the number of benign interpretations equaling nine minus this number) was calculated for each participant and submitted to an analysis of variance with a between-subjects factor for training condition. The analysis revealed a significant effect, $F(2, 57) = 8.71$, $MSE = 2.60$, $p < .001$, $\eta_p^2 = .23$. As shown in Figure 1, the ruminative training condition produced more negative interpretations than did the control condition, $t(57) = 2.65$, $p = .010$. Although there were fewer negative interpretations in the benign training condition than in the control condition, the difference was not significant, $t(57) = 1.47$, $p = .147$.

Memory for scenarios. Recalled transfer scenarios were categorized according to whether they contained ideas that had not been part of the presented scenarios (intrusions) and, separately, according to whether those intrusions were negative, positive, or still ambiguous with respect to the rumination dimension. Kappas for each of the nine scenarios averaged .80 for both measures, and discrepancies were resolved by a third rater. Then the number of scenarios with such intrusions and the number of scenarios with negative and positive intrusions were counted separately, and each total was submitted to an analysis of variance. Due to experimenter error, data were missing for 1 participant in the benign condition.

The number of scenarios containing intrusions did not vary according to training condition ($p = .139$). This finding suggests that training did not differentially establish inaccurate recall. Means and standard deviations are reported in Table 3. The analysis regarding the valence of intrusions included a factor for training and a factor for intrusion valence (negative and positive). Both main effects were significant, as was the interaction showing that the valence difference significantly depended on training, $F(2, 56) = 3.51$, $MSE = 1.23$, $p = .037$, $\eta_p^2 = .11$. Tests of simple main effects within each training condition revealed that more negative than positive intrusions were produced only after ruminative training, $F(1, 19) = 6.47$, $MSE = 2.41$, $p = .020$, $\eta_p^2 = .25$.
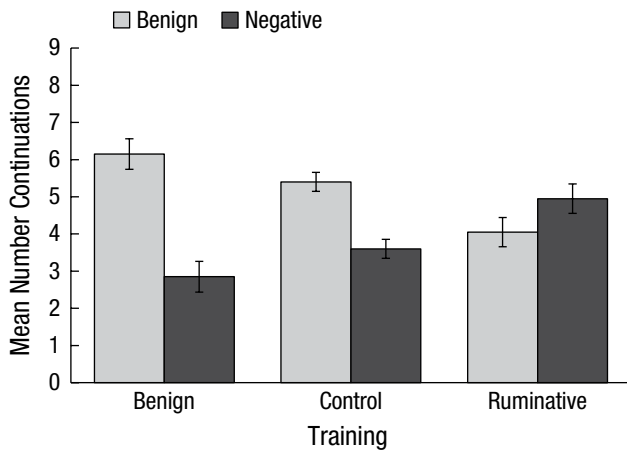
Fig. 1. Mean number of the nine scenario continuations that were judged to be negative or benign (the reciprocal of negative) in each training condition. Error bars depict 1 *SE* above and below the mean.

State rumination. Scores on the MRSI were obtained by summing responses to six items that indicated a participant's current ruminative state. The scores were submitted to an analysis of variance with a factor for training that resulted in a marginally significant effect, $F(2, 56) = 3.13$, $MSE = 32.66$, $p = .051$, $\eta_p^2 = .10$.[3] As shown in Table 3, compared with the control condition, scores in the benign condition did not differ, but participants in the ruminative condition judged their state as more ruminative, $t(56) = 2.04$, $p = .046$.

Other self-report measures. Scores on the BDI-II, RRS, and SIAS, obtained at the end of the session, did not differ significantly according to training condition (all $Fs < 1.0$; see Table 3).

Responses to the eight items on the first administration of the SMF were submitted to a factor analysis by conducting a principal axis factoring with oblique rotation (oblimin). The Kaiser-Meyer-Olkin measure (.80) verified the excellent sampling adequacy for the analysis (Field, 2009). Bartlett's test of sphericity, $\chi^2(28, N = 60) = 122.9$, $p < .001$, indicated that correlations among items were sufficiently large for the principal axis factoring. A Markov chain Monte Carlo simulation for parallel analysis and the scree plot both indicated that a single factor (accounting for 40% of the variance) best explained the structure of the data. Items with factor loadings of less than 0.5 were not retained. As a result, a composite mood score was created separately for each administration, averaging the responses to the following items: "in control," "relaxed," "worried" (reverse-scored), and "content" (Cronbach's α range = .72–.77). Higher scores indicated more positive mood. Composite scores were submitted to an analysis of variance with training condition as a between-subjects factor and administration time as a within-subjects factor. A priori contrasts across levels of administration time corresponded to linear and quadratic trends; the first corresponded to a gradual change across administrations and the second to a shift after training that returned to baseline. The analysis revealed a marginally significant mood-by-time interaction, using a Huynh-Feldt adjustment for violation of the sphericity assumption, $F(3.55, 101.27) = 2.47$, $MSE = 121.90$, $p = .056$, $\eta_p^2 = .08$. Only the quadratic interaction was significant, $F(2, 57) = 5.17$, $MSE = 92.40$, $p = .009$, $\eta_p^2 = .15$. Follow-up tests of simple comparisons showed that the quadratic function was significant only in the ruminative condition, $F(1, 19) = 5.60$, $MSE = 156.81$, $p = .029$, $\eta_p^2 = .23$. The means reported in Table 3 show that these participants' moods were less positive after

Table 3. Memory Intrusions and Self-Report Results From Experiment 2

Measure	Training condition		
	Benign	Control	Ruminative
Number of memory intrusions (out of 9)	1.79 (1.32)	2.20 (1.11)	2.75 (1.92)
Positive	0.74 (0.73)	0.75 (0.85)	0.45 (0.61)
Negative	0.74 (0.73)	1.00 (0.86)	1.70 (2.00)
Momentary Ruminative Self-Focus Inventory	17.6 (5.5)	18.0 (4.9)	21.8 (6.6)
Ruminative Response Scale (final)	46.8 (10.8)	46.2 (12.5)	47.4 (13.8)
Brooding scale	10.6 (4.0)	9.8 (3.3)	11.0 (2.9)
Reflective pondering	10.0 (3.1)	10.2 (3.1)	11.4 (4.6)
Beck Depression Inventory–II	9.8 (5.6)	11.0 (6.5)	12.0 (7.7)
Social Interaction Anxiety Scale	28.0 (11.9)	28.0 (9.2)	30.7 (15.0)
State-of-mind form (factor score)			
Before training	60.5 (18.5)	56.0 (14.9)	62.5 (17.6)
After training	65.2 (17.2)	59.4 (12.5)	54.1 (14.8)
After transfer	63.9 (16.3)	60.1 (13.3)	62.0 (14.6)

Note: The table presents means for each measure. Standard deviations are shown in parentheses. Number of participants in each condition is 20 in all cells except for memory measures ($n = 19$ for benign) and the Momentary Ruminative Self-Focus Inventory ($n = 19$ for ruminative). State-of-mind form ratings were measured on a 100-point scale. The Beck Depression Inventory–II excludes the "suicide" item.

training, but the mood returned to baseline before the memory test. Therefore, it would be difficult to conclude that memory intrusions were mood congruent or that mood mediated the effects on the state-rumination measure.[4]

Training latencies. Mean latencies in milliseconds to respond to probe scenarios during training were analyzed after we set aside data from 5 participants whose means on either negative or benign trials were greater than 2.5 *SD* from the overall mean. Latencies were measured from the presentation of the fragment to the keystroke for the first missing letter. Latencies to solve benign fragments were longer than were those for negative fragments (mean benign = 2,863 ms; mean negative = 2,071 ms), $F(1, 54) = 5.86$, $MSE = 1,086,189$, $p = .019$, $\eta_p^2 = .10$. This main effect probably indicates a bias in our materials toward ruminative endings because even the control condition showed a mean difference of 335 ms. The difference was large enough to make it difficult to detect an interaction with training conditions, even though the difference in the ruminative condition was more than twice the difference in the other two conditions (mean ruminative = 730 ms; mean benign = 355 ms). Moreover, these means were likely unstable, given their basis on only six trials. Another possible reason for the failure to find a significant interaction with this measure, unlike a similar measure in Experiment 1, is that the latency to type the missing letter was used instead of the latency to type the complete word. This method seemed to have increased the average time to respond and the associated variance.

General Discussion

These experiments were designed to document and simulate rumination-related biases in the interpretation of ambiguous events. Experiment 1 revealed that students with high scores on the brooding component of rumination completed word fragments to disambiguate ambiguous scenarios in a negative direction faster than fragments that resolved the ambiguity in a benign direction, but they did so only if they had previously engaged in a self-focused mental set. Experiment 2 successfully simulated the interpretation bias found in Experiment 1, as judged by the endings to open-ended scenarios produced by nonbrooding participants who had been randomly assigned to the ruminative condition. Moreover, performance on other tasks in Experiment 2 suggested that the induced negative bias produced consequences for state rumination. One consequence was negative intrusions in memory for the ambiguous beginnings of the transfer scenarios. Of equal importance, after recalling unpleasant events in their recent personal past, the newly trained "ruminators" reported higher levels of state rumination.

The evidence for a rumination-related interpretation bias in Experiment 1 is consistent with results from a few previous efforts to discover interpretation biases of the depressive kind. For example, Wenzlaff and Bates's (1998) scrambled-sentence task is similar to an interpretation task, given that participants make sentences with or without negative connotations; in their experiment and subsequent similar ones, they found that dysphoric students more often unscrambled the words to form negative sentences. These findings and others that have shown depression-related memory biases can be considered depressive habits of thought (Hertel, 2004). The most characteristic cognitive habit in depression, however, is rumination, and the results of Experiment 1 suggest that a component of rumination is indeed the tendency to interpret ambiguity in a negatively biased direction. Experiment 1 results replicated previous demonstrations of a ruminative-related interpretation bias (Mor et al., 2014), this time with materials more ecologically valid than individual homographs and, it is important to note, with the type of stimuli frequently used to modify interpretation biases of other kinds.

Experimental control over an aspect of a naturally occurring habit permits statements about cause and effect.[5] The transfer results in Experiment 2 indicate that multiple experiences in interpreting ruminatively can establish the habit to do so under unconstrained conditions for interpreting ambiguity. Evidence for the development of such a cognitive habit was provided in a near-transfer task in which the participants completed ambiguous scenarios by writing continuation sentences that were training congruent. The request to write a sentence to continue a paragraph (not merely a word to end a sentence, as in training) is arguably less subject to demand characteristics than are other transfer tasks that present benign and negative alternatives. Participants in the ruminative training condition wrote more negative continuations than did those in the other two conditions. Moreover, a far-transfer task of thinking about a recent personal experience revealed training effects on a subsequent measure of state rumination.

Of course, neither set of effects can be claimed to have changed the way the participants think in the long term—thankfully. And although we also cannot claim that the effects were short-lived, we believe they were, given that even longer sessions of training anxiety-related interpretation biases have not been shown to last longer than a day or so, unless training sessions are repeated (Hertel & Mathews, 2011; MacLeod, Koster, & Fox, 2009). The important aspect of these transfer effects, for our purpose, is their proof of principle. We assume that learning to see the dark side through experiences in the real world is durable in part because the "training trials" are distributed across time and context.

Another essential feature of real-world training to ruminate surely is the memorial "side effect" of interpretation bias: once interpreted, thus remembered. Our memory results are therefore important to the case for rumination training. Like the biased continuations of transfer scenarios, the memory bias occurred only with respect to ruminative training, although the lack of effect of benign training might be due to the low level of memory errors in general (i.e., floor effects in comparison with the control condition). Our participants were remarkably accurate in remembering the transfer scenarios and in distinguishing them from their own continuations, no doubt due to the low number of scenarios employed as well as to the immediacy of the recall test. Nevertheless, almost two of the nine scenarios were remembered with a ruminative slant by participants in the rumination training condition. This proportion is comparable with other demonstrations of interpretation-based memory intrusions (e.g., Hertel et al., 2008; Tran et al., 2011).

In addition, we believe that even a few reconstructive errors are meaningful, given their reliance on interpretation biases during initial encounters and the reliance of those biases on individually meaningful situations. Specific scenarios cannot seem personally relevant to everyone. Bartlett's (1932) view of reconstructive errors reflected similar reasoning. Moreover, in the context of clinical treatment, memory errors need not be numerous to serve as meaningful bases for ruminative episodes and as relevant bases for modification by therapeutic challenges. What is lacking in this analysis, however, is a clear demonstration of interpretation-based memory bias by people who self-report high degrees of rumination. Such a demonstration should be a high priority for future research, given the strong anecdotal evidence for memorial confabulations in ruminative thinking.

We turn now to a consideration of the lack of evidence of effects from benign training, compared with the control condition, because it indicates a possible limitation in the use of our paradigm. One possible and admittedly post hoc explanation is related to the fact that the scenarios all potentiate ruminative responses. Benign training might involve an initial ruminative interpretation that is counteracted when the final word leads to a benign resolution. This counteraction—first negative, then benign—possibly occurred in a way that resulted in benign participants' performance on all measures being similar to that of control participants' who saw only a few such scenarios. In short, the benign training might have exerted strong effects that could not be observed because our control condition did not control for this possibility. A control condition in which participants were allowed to find their own completions for all training scenarios might reveal a natural tendency to appear ruminative

when placed in the hypothetical situations we invented. We believe that this condition must be included in future experiments, but in the meantime, it is important to consider that any tendency to first interpret in a ruminative direction before counteraction would probably produce negative memory intrusions in the benign condition, and this outcome did not occur. Still, we recommend further research concerning the absence of a difference between the control and benign conditions. If it is truly a null effect, perhaps it can be attributed to the nature of the sample, selected in this case on the basis of preexperimental tendencies not to brood when sad.

Despite its nonclinical samples, the present research is clinically relevant in two main ways. First, and more directly, our findings may help in understanding temporal fluctuations in rumination. They suggest that for people who do not ruminate habitually (e.g., our participants), ruminative episodes of the sort made possible during our far-transfer task of pondering a recent personal event are more likely to arise after negative or self-involving interpretations of ambiguous events. Measures taken to monitor and discourage self-focused interpretations of ambiguity might thereby function prophylactically to aid resilience (e.g., Hertel & McDaniel, 2010).

Second, our evidence for causal contributions of interpretation bias to aspects of rumination encourages work in the other direction: bright-side training for those individuals who habitually ruminate and are vulnerable to depression (e.g., Holmes et al., 2009). One obvious reason to continue investigations of benign-interpretation training is its possible application in decreasing stable ruminative tendencies as well as state rumination. By adding to current efforts to identify fundamental cognitive causes of rumination (e.g., Daches & Mor, 2013), our findings can perhaps assist in designing interventions to reduce this maladaptive habit. It is important that although there are documented efforts to apply CBM procedures as a treatment for anxiety (e.g., Amir & Taylor, 2012a, 2012b), development of CBM protocols for rumination and depression lags behind (cf. Blackwell & Holmes, 2010). A major goal in designing new treatments for depression should therefore involve extended explorations of ways to decrease ruminative habits. Ruminative habits do not develop overnight and, therefore, will likely not be remediated by CBM sessions that are simply conceived. Successful application of CBM will likely require training across various types of ambiguity and contexts to prevent relapse (Bouton, 2000), and training must be spaced (Bjork & Bjork, 2011).

In addition to manipulating interpretations of ambiguity, training must incorporate other processing methods (e.g., Miller et al., 2013; Watkins et al., 2009). The training of cognitive control, of the sort encouraged by mindfulness training (e.g., Teasdale, Segal, & Williams, 1995),

might ultimately be necessary to establish controlled opposition to old habits as new habits are developed (see Hertel, Holmes, & Benbow, 2013). In the meantime, however, we emphasize the importance of the present bias demonstration and simulation. Resolving ambiguity with a self-focused and reflective slant clearly not only is associated with but also contributes to ruminative thinking.

Author Contributions

P. Hertel and N. Mor developed the experimental designs. All authors contributed to method development. C. Ferrari, O. Hunt, and N. Agrawal performed the testing and collected the data, and they analyzed the data under the supervision of P. Hertel. P. Hertel drafted the manuscript, and N. Mor provided critical revisions. All authors approved the final version of the manuscript for submission.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Notes

1. Students who enroll in introductory psychology classes are representative of the population of Trinity University students, who are mainly middle class and identify as Black/African American (4%), Asian (7%), Latina/Latino (17%), White/Caucasian (58%), or Other (14%). Less than 1% of students are older than 22 years (but our pool consisted mainly of 18- to 19-year-olds).
2. We note the apparent trend in the social-anxiety data for a negative bias exhibited by brooders in the distraction condition. Without a priori prediction and significant overall effects, however, specific comparisons are not justified.
3. One participant in the ruminative condition chose a rating of 1 (*not at all*) for all six items and was the only participant to score less than 10. After discovering that the participant's written description was quite negative and that her RRS score was relatively high, we set aside her MRSI score because we believed that it was not genuine.
4. When the scales were each separately submitted to analyses of variance, only two scales obtained significant interactions: contentment, $F(3.43, 97.84) = 3.16$, $MSE = 32.66$, $p = .023$, $\eta_p^2 = .10$ (Huynh-Feldt adjustment due to violation of sphericity), and sadness, $F(4, 114) = 3.55$, $MSE = 176.49$, $p = .009$, $\eta_p^2 = .11$. Participants

felt sadder and less content after ruminative training, but the effects had dissipated by the beginning of the memory task, as indicated by significant quadratic but not linear trends.
5. A reviewer of this manuscript was concerned that we are suggesting levels of cause corresponding to necessity and sufficiency of interpretation bias in the development of a ruminative style. Our manipulation, like most, is capable of establishing evidence for contributory cause, nothing more.

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