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Rumination: Cognitive Consequences of Training to Inhibit the Negative

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Abstract

Background and Objectives: To explore cognitive factors in ruminative thinking, we assessed the effect of a single-session of inhibition training on subsequent biases in attention and interpretation.

Methods: We randomly assigned participants to either inhibit or attend to negative stimuli. Inhibition was assessed by using assessment trials embedded throughout the training, and interpretation bias was assessed following the training.

Results: Trait rumination moderated training effects on both measures. Low ruminators in the inhibition-training condition maintained their level of inhibition of negative stimuli, but those in the attention-training condition showed a non-significant trend for decreased inhibition. Participants also showed a transfer-congruent tendency in interpretation bias, with reduced bias by those trained to inhibit negative stimuli, compared to those trained to attend to negative stimuli. In contrast, high ruminators in the inhibition training condition showed a training-incongruent decrease in inhibition of negative stimuli, but no change in inhibition when trained to attend to negative stimuli. No effects of the training on interpretation bias were observed among high ruminators. Finally, the training did not affect subsequent measures of mood or state rumination, even when trait rumination scores were taken into account.

Limitations: This study used a single session of inhibition training rather than a multi-session training, and this may explain the null effects among high ruminators.

Conclusions: Findings highlight the critical role that trait rumination plays in moderating the effect of inhibition training. Our results suggest that inhibition training may provide an effective technique to change inhibition bias and later interpretation bias.

Rumination: Cognitive Consequences of Training to Inhibit the Negative

People who ruminate think repetitively about why they feel sad and about the possible consequences of feeling sad (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Rumination is characterized by a variety of cognitive biases, sometimes examined in an attempt to delineate mechanisms responsible for this maladaptive thinking style. Ruminators manifest cognitive inflexibility that undermines their ability to shift from one line of thinking to another (Davis & Nolen-Hoeksema, 2000; Yee Lo, Lau, Cheung, & Allen, 2012). Specifically, deficient inhibition is thought to play a main role in the inflexible style observed in ruminators. As we use the term in this report, inhibition refers to the process of suppressing, resisting, and ignoring interference from task-irrelevant information (Friedman & Miyake, 2004). Difficulty inhibiting irrelevant negative information makes ruminators stuck on negative thoughts and can possibly prevent them from changing the way they think (Davis & Nolen-Hoeksema, 2000; Joormann, 2006).

Although difficulty inhibiting negative information has been associated with rumination (Joormann, 2006; Zetsche & Joormann, 2011), the nature of this relationship is unclear. One possibility is that this difficulty is a causal factor in the tendency to ruminate. Fundamental difficulty in disregarding negative aspects of a situation may interfere with effective regulation of negative affect and thereby initiate a vicious cycle of ruminative thoughts and sustained negative mood. This possibility can be examined by utilizing a cognitive bias modification (CBM) procedure that targets inhibition and can assess its effect on rumination. CBM procedures encourage one or another emotional bias in attention, interpretation, or memory before assessing the effects of such training on a variety of transfer tasks (see Hertel & Mathews, 2011). Until now, most CBM research has not targeted rumination. In addition, no

studies have trained inhibition of negative material until our recent work (Daches &
Mor, 2013) in which we developed an inhibition training procedure for ruminators
based on the negative affective priming task (NAP; see Joormann, 2006). Compared
to those who were trained to attend to negative content, ruminators who were trained
to inhibit negative content showed improved inhibition of irrelevant negative content
and reduced rumination. These findings support the hypothesis that inhibition plays a
causal role in ruminative thinking.

Following this initial work on inhibition training in rumination, several
questions remain unanswered. First, we included only participants who reported high
levels of trait rumination. This inclusion criterion does not allow the examination of
individual differences in the effect of inhibition training. Although it has been
suggested that samples with higher levels of symptoms have greater room for change
and thus may benefit from training more than healthy individuals (Hallion & Ruscio,
2011), findings are inconclusive. For example, attention training reduced depressive
symptoms among people with mild depression, but not those with moderate to severe
depression who experienced an increase in depressive symptoms following the
training (Baert, Raedt, Schacht, & Koster, 2010). In contrast, Arditte and Joormann
(2014) found that only individuals high in trait rumination benefited from attention
training designed to teach individuals to shift their attention toward positive as
opposed to neutral stimuli. Therefore, a central aim of the current research was to
examine whether the effects of inhibition training are moderated by trait rumination

In our prior research (Daches & Mor, 2013), we used multiple training
sessions, but an important question is whether a single session of training can change
ruminative thinking, and what conditions are required for obtaining training effects in
a single training session. A recent meta-analysis found that multiple training sessions

produced larger symptom reduction than did a single training session (Hallion & Ruscio, 2011), but this difference was non-significant.. Although rumination-related outcomes were obtained in both multiple-session (e.g., Daches & Mor, 2013; Wells & Beevers, 2010) and single-session (e.g., Arditte & Joormann, 2014) protocols of attention and inhibition training, these studies cannot be easily compared because they used different training procedures and targeted different mechanism of change. Uncertainty therefore remains regarding the optimal 'dose' of training. In line with previous work, it is possible that trait rumination moderates the effect of inhibition training, and that varying amounts of training are needed to obtain an effect, depending on levels of trait rumination. Thus, a second aim of this study was to examine the effect of a single session of inhibition training, in a sample of high and low ruminators.

Our work demonstrated that the training was effective in modifying inhibition, but we did not assess the effect of the training on additional rumination-related cognitive biases. A perspective taken by Hirsch, Clark, and Mathews (2006) suggests that cognitive biases influence each other and can interact to maintain a psychological disorder. However, only few studies have examined such transfer effects of training one cognitive process on another. The majority of this work has demonstrated that training people to modify the way they interpret ambiguous information can affect the sort of information to which they attend and that they later remember (e.g., Amir, Bomyea, & Beard, 2010; Lange et al., 2010; Salemink, Hertel, & Mackintosh, 2010; Tran, Hertel, & Joormann, 2011). Investigating anxiety-related processes, Amir et al. (2010) showed that training individuals to make benign interpretations of ambiguous information improved their ability to disengage attention from negative stimuli. In examining the opposite causal direction, White, Suway, Bar-Haim, and Fox (2011)

showed that participants who were trained to attend to threat displayed an increase in anxiety-related negative interpretations of ambiguous events. Everaert, Tierens, Uzieblo, and Koster, (2013) have found, using a non-depressed and sub-clinically depressed sample, that a negative bias in attention indirectly affects memory via its effect on negative interpretation bias. To the best of our knowledge, the transfer of rumination-related training effects from one bias to another has not been examined. The exploration of these possible transfer effects was therefore the third goal of the current research.

Effects of training on interpretation biases can reasonably be expected. We now have experimental evidence regarding the correlation of rumination and interpretation bias (Mor, Hertel, Ngo, Shachar, & Redak, 2014). Participants performed a lexical decision task in which target letter strings were preceded by homographs that had both benign and ruminative meanings. Higher trait rumination was linked to response times to targets related to the ruminative meaning of these homographs that were faster than to targets related to the benign meaning. Although both inhibition and interpretation biases are implicated in rumination, the link between these biases—particularly possible causal pathways between them—has not been explored. We propose that difficulty inhibiting negative information can influence the resolution of meaning in ambiguous situations that permit a negative interpretation. Thus, the third aim of the present study was to explore the link between inhibition and interpretation biases by examining whether a trained inhibition bias affects interpretation bias on a subsequent lexical decision task.

In the current study we used a single session of training to encourage participants to either inhibit or attend to negative stimuli (IN vs. AN, respectively). In training trials, we presented a negative and a neutral word simultaneously.

Participants in the IN condition were trained to ignore the negative word, whereas those in the AN condition were trained to attend to it. Unlike our previous work (Daches & Mor, 2013), in which we examined the effect of such training on inhibition by using a pre-post assessment design, in this study we distributed inhibition assessment trials randomly throughout the training phase. We chose this assessment strategy (for a similar procedure see Hayes et al. 2010) because presenting an assessment task in which emotional and neutral stimuli are targets in equal probability at the end of a single session of training may influence training effectiveness (as suggested by Bar-Haim, 2010). Similarly, because participants underwent only a single training session, we expected that the training would have an effect on state rather than trait measures of rumination and negative affect. Moreover, in all of these tasks, we examined whether individual differences in trait rumination moderate the effect of inhibition-bias training.

The paucity of prior research examining moderating effects of trait rumination on transfer of training precluded specific predictions. However, two contrasting hypotheses arise from the literature. On the one hand, due to their initial difficulty in inhibiting negative information, high ruminators might profit more from IN training than would low ruminators (Arditte & Joormann, 2014). Indeed, based on our prior findings with high ruminators, it is likely that high ruminators in the IN condition would maintain, and possibly improve, their ability to inhibit negative stimuli whereas high ruminators in the AN condition would become worse at inhibiting negative stimuli.[1] By the same reasoning, high ruminators in the AN (vs. the IN) condition would be more likely to interpret ambiguous homographs negatively. On the other hand, the use of only one training session should make it more difficult for high ruminators, compared to low ruminators, to benefit from training (Hallion & Ruscio,

2011). Taking this possibility into account, we might find clearer effects of training among the low ruminators than among the high ruminators.

Method

Participants

Participants were 174 students (122 women) at the Hebrew University of Jerusalem, who took part in the study in return for course credit or payment. Participants' mean age was 24 (SD = 2.74). All participants were native Hebrew speakers. Male and female participants as well as high ruminators and low ruminators (based on the median split of the RRS) were equally and randomly assigned to one of two training conditions: inhibit negative (IN; $n = 86$) and attend to negative (AN; $n = 88$).

Training Task

The training was designed based on the Negative Affective Priming task (NAP; Joormann, 2006). In this task, following a centrally located fixation cross, displayed for 1000 ms, participants are presented with a trial which is comprised of two consecutive displays (a prime and a probe), each consisting of two stimuli, a distractor and a target. On each display, participants are instructed to indicate, by pressing selected keys on the keyboard, the valence of the target word presented in one color (blue or red), while ignoring the word in the other color (distractor). Words remain presented until the participant's response. The task includes two types of trials: inhibition and inhibition control. On *inhibition trials*, the prime display contains a negative word as the distractor and a neutral word as the target, and the probe display contains a negative word as the target and a neutral word as the distractor. On *inhibition control trials*, the prime display contains neutral words as both the distractor and the target, and the probe display contains a negative word as the target and a neutral word as the distractor. Thus, on inhibition trials participants respond to a

negative word that was of the same valence that they had just attempted to inhibit, whereas on control trials they respond to a negative word in the probe display but without attempting to inhibit a similarly valenced distractor on the prime display.

In our training version of the NAP task, participants perform the same valence evaluation as in the original NAP task. However, the trials consist of only a single display of two words: one negative and one neutral, each in a different color (blue or red). Figure 1 presents a sample trial for each training condition. In the IN condition, negative words were the distractors on most displays (85% of trials) and in the AN condition negative words were the targets on most displays (85% of the trials). We used 85% of the trials instead of 100% to encourage participants to process the words before they respond to them. Thus, participants in the IN condition were trained to regard negative words as irrelevant, whereas participants in the AN condition were trained to regard these negative words as relevant. Participants were not provided with feedback on their performance during the training. Training in each condition consisted of 430 trials separated into ten blocks. Between blocks, participants were offered a short break. Within each training block, we embedded inhibition and control inhibition trials in order to assess inhibition (described below). Reaction times (RT) and participants' classifications were recorded.

Assessment trials. Assessment of inhibition bias was also based on the NAP task. In the NAP task, bias is typically computed by comparing the response time on inhibition and on control inhibition trials. In the current study, assessment trials were embedded in the training, and three inhibition and three control inhibition trials were included in each training block. Assessment trials were evenly and randomly distributed across the training session, to expose participants to the same trials

throughout the entire training. In total, participants were presented with 30 inhibition and 30 control inhibition trials throughout the training.

Inhibition bias scores were derived by subtracting latencies for negative target words on control trials probe displays (for which the prime display consisted of two neutral words) from latencies for negative target words on inhibition trials probe displays (for which the prime display consisted of a neutral target and a negative distractor). This index is a measure of the relative latency to respond to negative stimuli that were inhibited previously, compared to negative stimuli that were not inhibited previously. Higher values denote lower inhibition bias in processing negative content. In order to examine the change in bias from the beginning of training to its end with the best similarity to pre-post assessment method, inhibition bias scores were calculated for trials in the first and last three blocks of training (for a similar procedure see Sharpe et al., 2012)[2].

Stimuli. The same stimulus set was used for both the training and assessment. The stimulus set was used by Daches and Mor (2013) and consisted of 40 negative and 46 neutral words, repeated across blocks. Only 4- 6-letter words were used. Words with extreme frequency of usage in Hebrew were excluded (< 4 to a million or > 400 to a million, Frost & Plaut, 2005). Negative words were included if all judges ($N = 15$, in a separate pilot study) rated them as 3 or lower on a 7-point scale ($7 =$ very positive, $1 =$ very negative) and neutral words were included if all judges rated them between 3 and 5. Letters were 1 cm in size, presented 1 cm apart.

Transfer Task – Interpretation Bias

A lexical-decision task (LDT; Mor et al., 2014) consisted of 80 trials that appeared in a random order. On each trial, a target word was preceded by a prime. Prime words were homographs that each had at least one benign and one negative,

rumination-related meaning and appeared only once during the task. Participants were instructed to decide as quickly and accurately as possible whether the target stimulus was a word or a non-word by pressing designated keys on the keyboard. Each trial was preceded by a fixation cross, presented for 2000 ms. The homograph was presented for 750 ms and was followed by the target, which remained on the screen until the participant responded. Forty homographs were followed by word targets and 40 homographs were followed by non-word targets. Word targets belonged to one of four categories: (1) words related to the negative meaning of the prime (negative-related), (2) words related to the neutral meaning of the prime (neutral-related), (3) negative words that were unrelated to the prime (negative-unrelated) or (4) neutral words that were unrelated to the prime (neutral-unrelated). Non-word targets were created by changing one letter of each benign word in order to produce a pronounceable non-word. All Homographs appeared in a random order.

We used the same homographs that were used by Mor et al. (2014). Homographs and targets were selected via the procedure outlined by Richards and French (1992), because there are no homograph norms in Hebrew. The 80 homographs used in the study were selected from a pool of 140 homographs. Homographs were selected if they had negative and benign associates that differ significantly in valence, and are used in similar frequency in the Hebrew language. The selection procedure is described by Mor et al. (2013).

Self-Report Measures

The Ruminative Responses Scale (RRS) of the Response Styles Questionnaire (RSQ; Nolen-Hoeksema & Morrow, 1991) was used to measure trait rumination. Participants also completed the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996), a six-item mood rating VAS based on the PANAS-X (Watson & Clark,

1994), and the Momentary Ruminative Self-focus Inventory, a new six-item measure designed to assess state rumination that was reported to have adequate psychometric properties as well as good construct and concurrent validity (MRSI; Mor, Marchetti, & Koster, 2013). Mood and state-rumination items were intermixed, to disguise the true purpose of the assessment. The MRSI and mood assessment were administered pre and post training.

General Procedure

At the pre-training session, participants completed the RRS and the BDI-II. During the training session (that took place one to two days following the pre-training session), participants completed the mood and state rumination questionnaire, and were then randomly assigned to one of the two training conditions: IN or AN. Inhibition assessment trials were embedded throughout the training. After training, participants completed post-training measures of mood and state rumination, followed by the lexical decision task. Finally, they were thoroughly debriefed and were invited to ask questions about the experiment. Participants assigned to the AN condition were offered the opportunity to participate in IN training as a means to achieve emotionally positive outcomes.

<div align="center">

Results

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One participant (from the IN condition) dropped out of the study following the pre-training session. In addition, due to computer malfunctioning, data from 10 participants were lost (eight from the AN condition). In the results of analyses of variance reported below, significant lower-order effects that were qualified by significant higher-order effects are not reported. The significance level was set to .05.

Data Reduction

Training. All trials with incorrect responses were excluded (2.37% of trials). Trials with response latencies less than 200 ms or greater than 2000 ms were also excluded (3.49% of correct trials). The two conditions did not differ in the number of remaining trials, $t(155) = .52$, $p = .6$. All data from nine participants—four from the AN condition—were removed due to an extreme number of excluded trials (over 30%,).

Assessment of inhibition. Only RTs for assessment probes were analyzed. As in the training, false trials (6% of responses) and trials involving extreme RTs (longer than 2000 ms or shorter than 200 ms, 2.5% of responses) were eliminated. Data from six participants—one from the AN condition—were removed due to extreme inhibition bias score in the first three blocks of training (3 SDs above the mean inhibition bias score of the sample).

Interpretation bias. False trials (5% of responses) were removed from further analysis; these error rates did not differ by condition, $F < 1.0$. Trials with latencies faster than 200 ms and slower than 2000 ms were also eliminated (3% of true responses). Data from five participants—four from the AN condition—were removed due to an extreme loss of trials (over 30%). We computed an interpretation bias score by subtracting the latency to respond to targets related to the negative meaning of the homograph from the latency to respond to targets related to the benign meaning of the homograph. We removed data from three additional participants —all from the IN condition—due to an extreme interpretation bias (3 SDs above the mean interpretation bias of the sample).

Participant Characteristics

The final sample size was 140. Descriptive statistics for the two conditions are presented in Table 1. No group differences emerged in age, inhibition bias scores in

the first three blocks of training, pre-training trait rumination, depression, mood, and state rumination scores (all F's <1). Similarly, the two conditions did not differ in gender ratio (χ^2 (2, N = 140) = 0.104, p = .747).

Training Effects on Inhibition Bias

Inhibition bias scores were submitted to a 2 (condition: IN, AN) by 2 (time: beginning, end) mixed design ANOVA with standardized trait rumination scores entered into the model as a covariate. The three way interaction between time, condition, and trait rumination was significant ($F(1,136) = 4.054$, $MSE = 8744.588$, $p = .046$, $\eta_p^2 = .029$). We conducted a median split based on trait rumination scores in order to examine inhibition-training effects among high ruminators and low ruminators separately. The three-way interaction between time, training condition, and the grouping variable for trait rumination was significant, $F(1,136) = 5.707$, $MSE = 8636.451$, $p = .018$, $\eta_p^2 = .04$. Within each group, mean inhibition bias scores in each condition are presented in Figure 2. Follow-up analyses were conducted within groups.[3]

Among high ruminators. The significant simple interaction between time and condition ($F(1,68) = 3.787$, $p = .049$, $\eta_p^2 = .053$), was explored via independent sample t-tests. These tests showed that the difference between training conditions was non-significant at the beginning of training, $t(68) = 0.837$, $p = .406$, Cohen's $d = .255$; $M_{IN} = 27.71$, $SD_{IN} = 80.01$, $M_{AN} = 13.86$, $SD_{AN} = 57.72$, but significant at the end of training, $t(68) = 2.096$, $p = .039$, Cohen's $d = .511$). Contrary to expectations, the bias was greater in the IN condition than in the AN condition ($M_{IN} = -38.16$, $SD_{IN} = 100.69$, $M_{AN} = 11.27$, $SD_{AN} = 95.95$). Following up on this simple two-way interaction with paired sample t-tests revealed that high ruminators exhibited a significant training-incongruent decrease in inhibition bias in the IN condition, $t(32) =$

2.643, p = .013, Cohen's d = .724, but change in inhibition following AN training was non-significant, $t(36)$ = 0.122, p = .903, Cohen's d = .063.

Among low ruminators. The simple interaction between time and condition was non-significant, $F(1,68)$ = 2.873, p = .095, η_p^2 = .042. Nevertheless, to be consistent with our previous analysis we conducted independent sample t-tests within each block of assessment trials. These tests showed that the participants in the two conditions did not differ in inhibition bias either at the beginning or at the end of training; respectively, $t(66)$ = 1.358, p = .179, Cohen's d = .334; $t(66)$ = 1.062, p = .292, Cohen's d = .261. Examining change across training blocks by using paired sample t-tests showed that low ruminators in the IN condition exhibited no change in inhibition bias, $t(34)$ = 0.304, p = .763, Cohen's d = .073; $M_{\text{BEGINNING}}$ = -9.15, $SD_{\text{BEGINNING}}$ = 64.07, M_{END} = -3.45, SD_{END} = 89.07. Consistent with our predictions, however, there was a non-significant trend of decreased inhibition among low ruminators in the AN condition, $t(34)$ = 1.909, p = .065, Cohen's d = .442; $M_{\text{BEGINNING}}$ = 15.03, $SD_{\text{BEGINNING}}$ = 81.71, M_{END} = -31.09, SD_{END} = 122.79).

In summary, we found support for the prediction that the experimental conditions had a differential effect on bias depending on levels of trait rumination. High ruminators in the IN condition showed a training-incongruent decrease in inhibition, but high ruminators in the AN condition showed no change from the beginning of training. Unexpectedly, low ruminators in the IN condition maintained their ability to inhibit negative stimuli, but in the AN condition they exhibited a training-congruent trend towards decrease in inhibition.

Interpretation Bias

Interpretation bias scores were submitted to a 2 (condition: IN, AN) by 2 (time: beginning, end) mixed design ANOVA with standardized trait rumination

scores entered into the model as a covariate. The effect of condition was non-significant ($F(1,136) = 0.004$, $MSE = 7872.026$, $p = .949$, $\eta_p^2 < .03$). However, similar to the effect of trait rumination scores on inhibition of negative stimuli, the interaction of condition by trait rumination was significant ($F(1,136) = 4.132$, $MSE = 7872.026$, $p = .044$, $\eta_p^2 = .031$). We then included rumination as a grouping variable in the analysis of interpretation bias scores, along with a factor for the condition of training, as we performed a two-way ANOVA. The interaction of training condition by group was significant, $F(1,136) = 5.017$, $MSE = 7836.73$, $p = .027$, $\eta_p^2 = .036$.

In order to assess the post-training interpretation bias in each rumination group, we performed independent t tests. Among high ruminators, the training effect was non-significant, $t(69) = 1.485$, $p = .142$, Cohen's $d = .354$; $M_{IN} = 4.48$, $SD_{IN} = 83.64$, $M_{AN} = -27.88$, $SD_{AN} = 98.56$). Among low ruminators, the training effect was also non-significant but showed a trend in the expected direction ($t(67) = 1.696$, $p = .094$, Cohen's $d = .408$), with those in the AN condition showing greater bias than those in the IN condition ($M_{IN} = -38.07$, $SD_{IN} = 85.38$, $M_{AN} = -3.78$, $SD_{AN} = 82.48$).

Thus, although the interaction of condition by group was significant, the comparisons within rumination groups were non-significant. In order to explain the interaction, we therefore compared the rumination groups within each training condition. In the IN condition, the effect of group was significant, ($t(66) = 2.076$, $p = .042$, Cohen's $d = .511$), such that high ruminators exhibited a stronger interpretation bias compared to low ruminators ($M_{non} = -38.67$, $SD_{non} = 85.38$, $M_{ruminator} = 4.48$, $SD_{ruminatior} = 83.64$). In the AN condition, the group difference was non-significant, ($t(70) = 1.122$, $p = .266$, Cohen's $d = .265$).

In summary, we found that training differentially affected interpretation bias among high ruminators compared to low ruminators. Although this interaction was

significant, the training effect was non-significant within each of the rumination groups. However, among low ruminators there was a non-significant trend indicating greater bias in the AN condition than the IN condition. Viewed differently, in the IN condition, low ruminators exhibited a lower interpretation bias than did high ruminators, but no group differences were detected in the AN condition.

Relationship between Inhibition and Interpretation Bias

The degree to which change in inhibition bias from beginning to end of training predicts interpretation bias, was examined using a regression analysis, with training condition, trait rumination, and inhibition-bias residual score as predictors. (We computed a residual score via a regression model in which inhibition bias at the end of training were predicted by inhibition bias in the beginning of training.) The overall model was non-significant, $F(3,137) = .153$, $p = .928$, Cohen's $f^2 = .003$.

Momentary rumination

In order to examine the effect of training condition and possible moderation of this effect by trait rumination, on change in state rumination, state rumination scores were submitted to a 2 (training condition: IN, AN) by 2 (time: beginning, end) mixed design ANCOVA with RRS scores as a covariate. Only the two-way interaction of time by rumination was significant, $F(1,136) = 4.854$, $MSE = 81.368$, $p = .029$, $\eta_p^2 = .035$. In particular, the predicted three-way interaction among time, training condition, and trait rumination scores was non-significant, $p = .341$.

To explore the significant two-way interaction, we examined the correlation between trait rumination and change in state rumination. We computed a residual score, by predicting the post-training state rumination score from the pre- training state rumination score in a regression model, with lower scores indicating greater reduction in state rumination. State rumination residual scores correlated significantly

with initial trait rumination scores in the overall sample, $r(140) = .263$, $p = .002$, so that the greater the initial trait rumination score was, the greater the increase in state rumination.

Current Mood

Mood scores were submitted to a 2 (condition: IN, AN) by 2 (time: beginning, end) mixed design ANOVA with RRS scores entered to the model as a covariate. No significant effects were found.

Discussion

The current study examined the efficacy of a single-session inhibition training designed to modify inhibition toward negative stimuli, negative mood and state rumination and affect interpretation bias. There were two training conditions; in one condition, participants were trained to inhibit negative stimuli, whereas in the other condition they were trained to attend to them. Based on our prior findings (Daches & Mor, 2013), we expected that high ruminators trained to inhibit negative stimuli would maintain, or possibly improve, their ability to inhibit negative stimuli. In contrast, we expected that high ruminators trained to attend to negative stimuli would show decreased ability to inhibit negative stimuli. We also anticipated that the use of only one training session might make it more difficult for high ruminators, compared to low ruminators, to benefit from the training, and predicted that the training would be more effective among low than among high ruminators. In line with our predictions, we found that trait rumination moderated training efficacy. When trained to attend to negative stimuli, low ruminators showed a trend towards decreased inhibition following training but high ruminators showed no significant change in inhibition of negative stimuli. In contrast, when trained to inhibit negative stimuli,

low ruminators maintained their level of inhibition but high ruminators showed a training-incongruent decrease in inhibition.

We also predicted that the effects of inhibition training on inhibition of negative stimuli would transfer to an interpretation task and mirror the change produced by the training on inhibition bias. Among low ruminators, we found a statistical trend (consistent with the effect of training on inhibition bias), that suggests that those trained to inhibit negative stimuli exhibit lower interpretation bias compared to those trained to attend to these stimuli. High ruminators in the two conditions did not differ in interpretation bias. We also found that when trained to inhibit negative stimuli, low ruminators exhibited lower interpretation bias compared to high ruminators. When trained to attend to negative stimuli, no difference was found between high and low ruminators.

Our findings pertaining to both inhibition and interpretation bias show that the tendency to ruminate when experiencing negative mood is an important moderator of training effects. Low ruminators presented a training congruent tendency similar to that found in studies that train attention bias in non-anxious individuals (MacLeod, et al., 2002; Krebs, Hirsch, & Mathews, 2010). However, our findings suggest that a reduction of training dosage to a single training session, may pose an obstacle for individuals who tend to passively and repetitively focus on their distress. In contrast to our prior findings (Daches & Mor, 2013), high ruminators did not profit from training to inhibit negative stimuli and they even exhibited a training-incongruent decrease in inhibition. Methodological differences that resulted in a higher degree of cognitive depletion in the current compared to the previous study, may explain the discrepant findings. The training session in the present study was longer than each of the sessions in our previous study, demanding extensive focus on benign words while

disregarding negative words presented simultaneously. Moreover, the inclusion of assessment trials throughout the training may have posed additional demand because these trials require participants to respond to negative words that they repeatedly inhibited. High ruminators are known to have deficient cognitive control (Hertel, 1994; Philippot & Brutoux, 2008; Watkins & Brown, 2002) which plays a significant role in the ability to suppress negative information. Therefore, a single and intensive training session may have led to a rebound of negative thoughts following repeated attempts to inhibit them (Nolen-Hoeksema, Wisco & Lyubomirsky, 2008; Wenzlaff & Wegner, 2000). The possibility for a rebound effect of negative thoughts was highlighted in a recent study (Haeffell, Rozek, Hames, & Technow, 2012) that found that among people who were cognitively vulnerable to depression and underwent attention training, negative cognitive patterns began to re-emerge after only approximately 20 training trials. Thus, they were unable to maintain the training effect even during the training period itself. Moreover, Baert et al., (2010) found that attention training was ineffective in altering cognitive biases when levels of depression were moderate to severe. Thus, it is possible that ruminators maintain or even experience a worsening of their inhibition bias when trained in a single and intensive session. In contrast, a smaller training dosage that is repeated across several weeks may provide them the opportunity for change. Our findings as well as others' suggest that training provided to individuals vulnerable to depression should be provided, at least initially, in low-doses.

The null effect of the training on mood and ruminative thinking may suggest that this effect reflects a far-transfer (Hertel & Mathews, 2011) because mood and rumination involve different processes than do inhibition. Indeed, CBM training procedures often have a small effect on symptoms (Hallion & Ruscio, 2011). We

previously did find that inhibition training can reduce brooding, the harmful subtype of rumination (Daches & Mor, 2013). Possibly, a change in symptoms and in ruminative thinking may require a more dramatic change in cognitive biases than was demonstrated when using a single session of inhibition bias training. These null findings are inconsistent with Arditte and Joormann's (2014) findings that low ruminators who were trained to shift attention towards positive stimuli experienced more positive affect following a stressor than did low ruminators in a control condition. Importantly, in the current study, mood and rumination were examined immediately post training, but Arditte and Joormann (2014) and others (e.g., Beard, 2011; Cohen, Mor, & Henik 2014; Macleod et al., 2002) have shown that the effects of CBM on symptoms do not emerge following the training itself but rather in response to an emotional stressor. Thus, it is possible that inhibition training is ineffective by itself in changing mood and rumination, but would play an important role in preventing ruminative responses and negative mood in response to challenging emotional situations. This possibility should be explored in future research.

Because both the inhibition training and the following interpretation task are cognitive tasks that depend on processing of verbal information and involve selection processes, transfer-congruent trend on our interpretation task from inhibition training might seem to provide an example of near transfer of training. However, the transfer from one task to the other is not so obvious (Hertel & Mathews, 2011). Inhibition training and interpretation task differ in the extent of the material that is being selected. Whereas in the inhibition training the stimulus is physically present and selected, in the interpretation task the meaning being selected is implied. Recently, Hertel, Mor, Ferrari, Hunt, and Agrawal (2014) reported similar transfer of training when they trained individuals to resolve ambiguous situations in a ruminative or in a

benign direction. Ruminative training led to more negative continuations of new ambiguous situations in a subsequent task and to more negatively valenced errors in recalling the new ambiguous situations. We can cautiously suggest that our findings regarding the effect of inhibition training on interpretation bias provide support for the combined cognitive biases hypothesis (Hirsch et al., 2006), which postulates that cognitive biases do not operate in isolation but influence one another. There may be a sequential effect of rumination, whereby difficulty inhibiting negative information may facilitate negative as compared to benign interpretations of ambiguous situations. The trend we found among low ruminators and the recent findings of Hertel et al., (2014), highlight the importance of exploring the boundaries of the effects of CBM in rumination and the extent to which such training transfers to similar cognitive functions.

There are a number of limitations to this research. First, as discussed above, although the procedure used in this study and in our multi-session inhibition training are similar, there are few differences (length of training, the assessment procedure of inhibition and the self-report measures). Thus, a systematic comparison of single session protocols and various multiple-session training procedures is needed. Second, because we used assessment trials that were embedded throughout the training session, we had to use the same stimuli set for both training and assessment trials. Only a small number of studies used this assessment strategy (e.g., MacLeod et al., 2002; Sharpe, et al., 2012) mainly because the number of embedded trials must be small (i.e., a small percentage of the training trials) and may limit the reliability of this assessment method. This methodological dilemma between a careful monitoring of bias and a maximization of the training effect may be an important key factor to take into account when constructing new CBM procedures. To increase generalizability,

inhibition should be assessed either by using different stimuli sets for training and assessment or by using an entirely different assessment task. Possible tasks include the emotional flanker task (Zetsche & Joormann, 2011) or the affective shift task (De Lissnyder, Koster, Derakshan, & De Raedt, 2010). Third, we did not assess the effects of CBM on state rumination and mood following an emotional challenge.

Despite these limitations, the current study adds to the literature in this field by providing evidence for the critical role that trait rumination plays in inhibition training. Furthermore, this study presents a possible link between changing inhibition bias and later interpretation bias. Future studies are clearly needed in order to systematically examine parameters that may facilitate implementation of this form of CBM among individuals vulnerable for depression.

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Footnotes

[1]This prediction is based on findings from our previous study. Because the index of inhibition bias is calculated as the difference between RT to control and inhibition trials, and "good" inhibition is indicated in slower responses to inhibition trials compared to control trials, it is difficult to obtain improved inhibition on the task. Overall, people become faster as the task progresses, and therefore, increased inhibition would require people to actually become slower on inhibition trials.

[2]We also examined the change in inhibition bias by comparing bias scores in the first and second halves of training. The three-way interaction between time, training condition, and the grouping variable for trait rumination approached statistical significance, $F(1,136) = 3.835$, $MSE = 8636.451$, $p = .052$, $\eta_p^2 = .028$. However, follow-up analyses that were conducted within rumination groups resulted in non-significant effects.

[3]We also submitted inhibition bias scores to a 2 (condition: IN, AN) by 2 (time: beginning, end) mixed design ANOVA with standardized brooding scores entered into the model as a covariate. Brooding is the particularly maladaptive component of rumination that is most associated with psychopathology (e.g., Nolen-Hoeksema, Stice, Wade, & Bohon, 2007; Watkins, 2009). It is defined as a passive and judgmental focus on one's mood. The three way interaction between time, condition and brooding was non-significant ($F(1,136) = 1.781$, $MSE = 8870.191$, $p = .184$, $\eta_p^2 = .013$), thus further analysis in this direction was not conducted.

Table 1.

Demographic Characteristics and Means (Standard Deviations) for all Measures at Pre-training Assessment

	IN (n=68)	AN (n=72)
Age	23.96 (3.33)	23.95 (2.54)
Gender ration (F/M)	48/20	49/23
BDI	9.26 (7.79)	9.03 (7.48)
RRS	42.84 (12.11)	42.79 (12.26)
Current mood	37.37 (20.13)	35.18 (20.67)
MRSI	38.92 (19.11)	40.21 (16.86)
Inhibition bias (blocks 1-3)	7.61 (74.51)	14.52 (69.24)

Note. IN = Inhibit negative condition; AN = Attend to negative condition; BDI = Beck Depression Inventory-II; RRS = Ruminative Responses Scale; MRSI = Momentary Ruminative Self-focus Inventory;
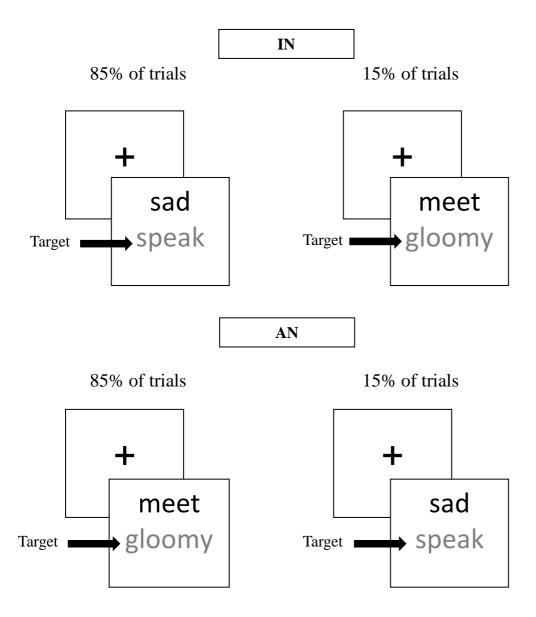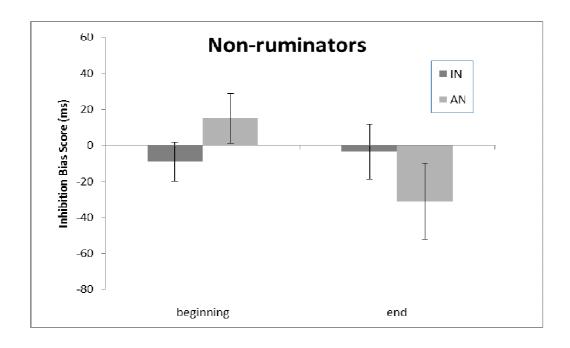
IN

85% of trials   15% of trials

+

sad
Target → speak

+

meet
Target → gloomy

AN

85% of trials   15% of trials

+

meet
Target → gloomy

+

sad
Target → speak

Figure 1. Example of training trials. Participants were required to attend to the stimuli

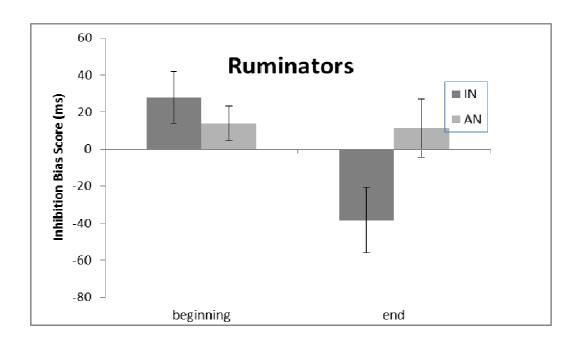marked by one color and inhibit the stimuli in the other color.

Figure 2. Inhibition bias score at the beginning and end of training for rumination and

non-rumination groups in the inhibit negative (IN) and attend to negative (AN)

training conditions and corresponding 95% confidence intervals (CIs).

Highlights

- This study assesses the efficacy of a single-session inhibition training.
- Trait rumination moderated the effect of training on inhibition of negative stimuli.
- Training effects on inhibition transferred to an interpretation task.
- Training did not affect mood and state rumination.