9-2018

Rumination and Rebound from Failure: Investigating How Trait and State Forms of Ruminative Thought Influence Attention to Errors and the Ability to Correct Them in a Challenging Academic Environment

Ronald C. Whiteman
The Graduate Center, City University of New York

RUMINATION AND REBOUND FROM FAILURE: INVESTIGATING HOW TRAIT AND STATE FORMS OF RUMINATIVE THOUGHT INFLUENCE ATTENTION TO ERRORS AND THE ABILITY TO CORRECT THEM IN A CHALLENGING ACADEMIC ENVIRONMENT

by

RONALD C. WHITEMAN

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

2018

Rumination and Rebound from Failure: Investigating How Trait and State Forms of Ruminative Thought Influence Attention to Errors and the Ability to Correct Them in a Challenging Academic Environment

by

Ronald C. Whiteman

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

Date	Jennifer A. Mangels
	Chair of Examining Committee
Date	Richard J. Bodnar
	Executive Officer

Supervisory Committee:

Jennifer A. Mangels, Ph.D.

Jillian Grose-Fifer, Ph.D.

Nicholas J. Sibrava, Ph.D.

Elizabeth F. Chua, Ph.D.

Justin Storebeck, Ph.D.

THE CITY UNIVERSITY OF NEW YORK

ABSTRACT

RUMINATION AND REBOUND FROM FAILURE: INVESTIGATING HOW TRAIT AND STATE FORMS OF RUMINATIVE THOUGHT INFLUENCE ATTENTION TO ERRORS AND THE ABILITY TO CORRECT THEM IN A CHALLENGING ACADEMIC ENVIRONMENT

by

RONALD C. WHITEMAN

Advisor: Jennifer A. Mangels, Ph.D.

Rumination is a recurrent and repetitive manner of thinking that can be triggered by blockage of personally-relevant goals, creating a temporary state of abstract and evaluative self-focus that can also become a chronic trait-like style of responding to personal challenges. Despite claims that rumination helps down-regulate unwanted emotion, cope with problems, and lead to goal attainment, it often increases negative affect, interferes with problem solving, and exacerbates goal-state discrepancies, particularly for women. Given the pervasiveness of rumination and its potential impact on cognitive processes and emotional states, one important yet untested question is how it might impact individuals' ability to remediate goal-state discrepancies caused by negative outcomes in an academically-relevant context. In this research program, we examine both trait and state rumination effects in a challenging verbal general knowledge test-feedback-retest paradigm, where first-test failures accrue (65%), but attention must be paid to corrective feedback in order to learn and later rebound from those failures at a surprise retest. Based on prominent cognitive models of rumination, such as the attentional scope model (Whitmer &

Gotlib, 2013) and impaired disengagement hypothesis (Koster et al., 2011), individuals who ruminate exhibit a narrowed focus of attention on and impaired disengagement from negative self-referent information. Thus, we tested whether rumination would heighten and maintain focus on negative performance feedback (Aim 1) and therefore interfere with the ability to deploy attention toward learning opportunities that might facilitate remedial behavior (Aim 2). To assess attention processes, we employed both event-related potential (ERP; Study 1) and eye tracking (Study 3) techniques as covert and overt measures, respectively. To assess potential similarities and differences in trait and state rumination (Aim 3), we employed both an individual differences approach, utilizing a well-known self-report measure of trait rumination to predict measures of attention and learning (Studies 1-3), as well as an experimental approach, utilizing two different state rumination induction techniques, one from the clinical realm (Study 2) and the other from the social-cognitive realm (Study 3). Using state rumination induction methods not only afforded a more direct assessment of the causal relationship between rumination and the ability to learn and rebound from failure, but with each method rooted in a different area of research, such methods also permitted testing whether the effectiveness of a state rumination induction may depend on how well it overlaps with the domain of concerns related to the general knowledge task (i.e., academic). We also took participants' gender into account, as rumination been linked with a host of ill effects on cognition and emotion particularly among *women*. In response to negative performance feedback, a maladaptive *trait Brooding* style of rumination sustained *covert* (i.e., internally-focused) attention to errors, as measured by the Late Positive Potential (LPP; Foti & Hajcak, 2010), *but not overt* (i.e., externally-oriented) attention, as indexed by gaze fixation duration metrics (e.g., Owens & Gibb, 2017). In response to corrective feedback, however, *overt* attention was impacted, with a *brooding-like state* of rumination

attenuating visual fixation on learning-relevant information, but no apparent differences were found in *covert* measures of learning feedback (i.e., ERPs). Despite these effects on feedback processing, surprisingly, state and trait forms of Brooding rumination did not hinder error correction, though they worsened first-test memory performance. Trait Reflection, on the other hand, was found to consistently *improve* memory performance at first-test, with more mixed results at retest. Rumination effects among women were generally as predicted, while men exhibited null or unexpected effects. The implications of these findings are discussed with respect to how existing models of rumination might be updated to account for differences in internally-focused and externally-oriented attention in applied contexts.

ACKNOWLEDGEMENTS

I wish to thank a number of individuals for their support and encouragement as I worked to complete my dissertation research and final manuscript.

First and foremost, I am extremely grateful to my advisor, Dr. Jennifer Mangels, for her constant guidance and exceptional mentorship throughout all my years as her graduate student. Dr. M: Your unwavering dedication to me has always been both incredibly reassuring and highly inspirational, and I count as invaluable the numerous learning experiences you have thoughtfully afforded me in the Dynamic Learning Lab – my home away from home.

I would also like to acknowledge the many wonderful research assistants who, across the years, have devoted their time and effort to helping me successfully carry out various aspects of this line of research. Among this amazing group, I would especially like to thank Eshin Jolly, Alex Shusterman, Ronica Bennett, Rinor Preniqi, Tahmina Osmanzai, and Sherley Gonzalez.

In addition, I would like to express my heartfelt gratitude to Yuliya Ochakovskaya who, while also working on her doctorate in the Dynamic Learning Lab, consistently and selflessly offered moral support and countless insights that helped shape the success of this work.

Finally, I am forever thankful for the love and support of my dear family and close family friends from home. Mom, Dad, Kim, Fred, Summer, Sydney, Bruce, Stodd, and my extended family, as well as Marc, Carrie, Tim, TJ, Harold, Dave, Gail, & Linda: Your presence, as well as your thoughts and prayers, have always provided a constant source of comfort, encouragement, and joy as I worked towards completing my doctorate. I am also grateful for the support of and inspiration from so many others, both near and far: Armistead, Harvey, Jim, Karl, Jason, Laura, Felix, Geoff, Ivan, Rohit, Marisa, Aaron, Randall, Jordy, Don, Mark, Josh, & Francisco.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: General Introduction

Success in real-world settings depends to a large extent on the ability to correct errors. This concept is particularly evident in academic environments, where achievement not only relies on performing well, but also on the ability to learn and rebound from failure (Metcalfe, 2017). Remediating one's errors, however, may be particularly challenging for students who happen to ruminate over them. Rumination, a common manner of responding to negative events and outcomes, and the distressing feelings that accompany them, is a cognitive style of thinking characterized by passive and persistent, abstract and evaluative self-focus. Although prominent models such as Martin & Tesser's Control Theory (Martin & Tesser, 1996) and Nolen-Hoeksema's Response Styles Theory (Nolen-Hoeksema, 1987, 1990) highlight rumination as primarily being maladaptive for goal-directed behavior, only a small amount of empirical work has tested this claim within the context of academic learning (cf. Ciarocco, Vohs, & Baumeister, 2010; Lyubomirsky, Kasri, & Zehm, 2003). While focus has aptly been placed on other cognitive and affective challenges that students face in the classroom (e.g., test anxiety; Maloney & Beilock, 2012), the lack of focus on rumination is surprising given its purported involvement in the detrimental social-cognitive phenomenon of stereotype threat (Beilock, Rydell, & McConnell, 2007), as well as its pervasiveness among both clinical and mentally healthy populations (Moberly & Watkins, 2008; Nolen-Hoeksema, 1990). The current research program seeks to begin addressing this gap in the literature by testing whether rumination hinders the ability to learn and rebound from failure, perhaps because it heightens and sustains attention to errors, and therefore interferes with the ability to encode proximal corrective information that could facilitate error correction.

What is rumination and how might it affect cognition and emotion?

To help characterize rumination for the sake of the current work, we call upon the work of Martin and Tesser, who, in their Control Theory (Martin & Tesser, 1996), provide one of the most well-known and in-depth descriptions of ruminative thinking. They propose rumination to consist of "conscious thoughts that revolve around a common instrumental theme and that recur in the absence of immediate environmental demands requiring the thoughts" (Martin & Tesser, 1996, p. 7). They also state, however, that such recurrent thinking need not be *entirely* generated by internal cues, but rather can also be propagated by external stimuli and events. Regardless of the cue type, Martin and Tesser claim that rumination generally comes online when a goal-state discrepancy (i.e., desiring to achieve a particular goal-state, but demonstrating a lack of progress towards it) becomes active in a person's conscious awareness. Though many ruminators believe this recurrent thinking style to be helpful for reducing such discrepancies, it often, rather, exacerbates them by increasing negative thoughts and feelings about the discrepancy. Since a ruminative state tends to persist until such a discrepancy is resolved (either by attaining the desired goal-state or by making acceptable progress towards it), rumination can thus often be negative, unintentional and rather difficult to terminate.

Importantly, additional work has also highlighted how this cognitive style tends to differ from other types of recurrent thinking. For instance, as reviewed by Watkins (Watkins, 2008), rumination can be distinguished from worry and mind wandering. Worry, which involves anxious and recurrent thoughts about *future* uncertainties, particularly those related to potential risks or threats (Borkovec, Robinson, Pruzinsky, & DePree, 1983), differs along the temporal dimension from rumination, which instead focuses individuals on the meanings and causes of negative *past* issues and concerns. Moreover, mind wandering, though similar to rumination in that it is persistent, repetitive, and tends to shift attention away from tasks at hand (Smallwood & Schooler, 2006), differs from rumination in that it is not necessarily linked with *negative* appraisals of one's on-going situations or affective state.

Given the characteristics of this particular recurrent thinking style, people who tend to ruminate a lot, especially when they are feeling down or distressed, usually report experiencing a high degree of self-criticism and self-blame about their issues , as well as a high degree of passive, abstract, and over-general thoughts about them (Raes, Watkins, Williams, & Hermans, 2008). Because of such experiences, rumination therefore can lead to poor problem solving, either because ruminators simply fail to think of plausible solutions to their problems, or because the process of problem solving is construed as being too overwhelming (Lyubomirsky & Nolen-Hoeksema, 1993; Lyubomirsky, Tucker, Caldwell, & Berg, 1999). Thus, experiencing ruminative responsiveness can sap the very cognitive resources that are necessary for the kind of goal-directed behavior that would be useful for minimizing goal-state discrepancies.

With the potential for such negative consequences for those who ruminate, it is perhaps not surprising that having repeated experiences with rumination has been shown to contribute to a host of mental health issues (Aldao & Nolen-Hoeksema, 2010). Theorists straddling both cognitive and clinical domains have identified a tendency to habitually ruminate in response to personal challenges and negative mood states as being particularly integral to the development of depression, especially for women (e.g., Nolen-Hoeksema, 1987; Nolen-Hoeksema & Morrow, 1991; Watkins & Teasdale, 2001). Highlighting how insidious this recurrent and repetitive style of thinking can be, research has also characterized the relationship between rumination and depression as being reciprocal in nature (Nolen-Hoeksema, 1991). Indeed, experiencing depressive mood state is not only linked with subsequent increases in ruminative thinking (Treynor, Gonzalez, & Nolen-Hoeksema, 2003), but also, when an individual is in a depressive mood state, the negative influence of rumination on affect and cognition is exacerbated (Lyubomirsky & Nolen-Hoeksema, 1993, 1995).

In an attempt to find ways to break this negative cycle, recent efforts have been made to understand how experiencing repeated bouts in a *temporary state* of rumination might lead to the expression of more *habitual, trait-like* forms of rumination (Watkins & Nolen-Hoeksema, 2014). This endeavor is especially important because although trait rumination may be prevalent among many individuals, a temporary state of rumination is likely to be elicited for *any* individual who experiences a personally important goal-state discrepancy (Martin & Tesser, 1996). Attempts to understand the link between trait and state rumination were first mainly informed by the early research of Nolen-Hoeksema and colleagues, who developed and used the Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 1991) to show how a trait tendency to ruminate can adversely impact emotion and cognition. However, subsequent work of theirs and others, in which state induction techniques were used, showed how a temporary state of rumination can exert its ill effects (e.g., Nolen-Hoeksema & Morrow, 1993; Roberts, Watkins, & Wills, 2013). Of importance for the current research program, the majority of findings from across both these bodies of research have generally supported the conclusion that *regardless* of whether in trait or state form, this recurrent and repetitive manner of thinking holds adverse consequences for both affect and cognition (for a review see Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008).

Despite the numerous ill effects on affect and cognition for those who ruminate, surprisingly little is known about how trait and state forms of rumination subsequently influence goal-directed behavior. Given the aforementioned negative experiences associated with ruminating, however, it is easy to imagine that experiencing passive and repetitive self-focus at the hand of rumination might hijack attention and interfere with the ability to deploy cognitive resources more adaptively in service of achieving one's goal at hand. Indeed, rumination is associated with an attentional bias towards negative valenced stimuli (Donaldson, Lam, & Mathews, 2007), and difficulty inhibiting and disengaging from negative information (Vanderhasselt, Kuhn, & De Raedt, 2011), possibly because of repeated introspection on the perceived self-relevance of this material (Berman et al., 2010). Also, with focus directed inwardly on negative self-referential thoughts, during problem solving ruminators are less likely to retrieve potentially useful information that was previously encountered (Bernblum & Mor, 2010), or process new, surrounding information (Levens, Muhtadie, & Gotlib, 2009). Thus, rumination may interfere with goal-directed behavior because attention is primarily focused inwardly when encountering negative events, which leaves fewer resources available for processing external environmental cues and task demands.

Specific aims for the current research program

The current research program aims to test whether and how rumination influences an important kind of goal-directed behavior for the undergraduate student: learning. Within an academic setting, one meaningful way to operationalize learning is by assessing students' ability to use corrective feedback to remediate errors, especially in situations were they are experiencing repeated challenge or even failure. Contextualizing learning in this manner is particularly important for the current set of studies because rumination has been shown to be elicited by concerns about one's failures (cf. Pyszczynski & Greenberg, 1987).

To create an environment in which failure is elicited, we will employ a challenging test of verbal general knowledge that uses an adaptive computer algorithm to ensure a high rate of errors for all participants regardless of pre-existing knowledge. To assess how rumination may influence the ability to correct these errors, we will utilize a test—feedback—retest paradigm in which, at an initial test, undergraduate participants are provided with trial-by-trial feedback in two distinct forms as they complete the difficult general knowledge questions: Performance-relevant feedback will inform participants of their accuracy, and learning-relevant feedback will inform participants of the correct answer. A behavioral measure of learning will be defined by the ability to correct first-test errors on the subsequent surprise retest.

In such a situation, it is conceivable that rumination, whether in state or trait form, might give rise to difficulties for students who, when experiencing poor first-test performance and receiving repeated negative performance feedback, may sustain attention to their failures, perhaps because they introspect on the self-relevance of this information. Subsequently, this may interfere with the ability to attend to and adequately process the proximal corrective information that would help them to learn from their mistakes. Given the general structure of the context in which we will investigate the impact of rumination on the ability to learn and rebound from failure, this research program aims to ask the following important questions:

Aim 1: Does rumination sustain attention to errors?

According to the impaired disengagement hypothesis of Koster and colleagues (Koster, De Lissnyder, Derakshan, & De Raedt, 2011), when individuals experience stressors that elicit recurrent negative thoughts, attention is drawn to the discrepancy between their current state of affairs and an aspired goal state. While some individuals can disengage from such recurrent negative thinking, perhaps by reappraising their current situation or redirecting their attention toward processing goal-relevant information, ruminators, on the other hand, tend to exhibit impaired disengagement from reiterative self-focus. This may lead to an inability for ruminators to down-regulate a heightened attentional response to stressors, which may in turn continuously interfere with achieving a desired goal state. Complementary to this, the attentional scope model of rumination proposed by Whitmer and Gotlib (2013) proposes that rumination narrows and sustains attention onto negative, self-referent information. Such narrowing of attention, they suggest, may mean that less attention is allocated elsewhere, perhaps towards means for helping reduce the ill effects associated with ruminative thinking.

Based on these two accounts, the current research program tests whether rumination will heighten and sustain attention onto signals of failure (i.e., negative performance feedback) during the initial test of general knowledge. To help directly capture and assess participants' trial-by-trial attentional response to their errors, we make use of both electroencephalography (EEG) and eye tracking methodologies. In particular, through the use of EEG in Study 1 we will evaluate particular Event-Related Potentials (ERPs) that have been shown to index attention to visually salient stimuli, while through the use of eye tracking in Study 3 we will evaluate gaze fixation metrics that afford an assessment of how much time individuals spend looking at externally-presented information. While a main advantage of using ERPs is that assessments of endogenous attention can be made regardless of shifts in visual behavior, some key advantages of using eye tracking are that exogenous attention can be measured as it is sustained over long periods of time, and selective attention can be measured when separate but concurrently-presented pieces of feedback compete for one's focus. Thus, ERPs and gaze fixation metrics index *covert* and *overt* attention, respectively, and given their unique advantages, they in some sense complement one another, affording a more robust assessment of how attention may be sustained on failures during the general knowledge task.

Aim 2: Does rumination interfere with encoding of corrective information?

In addition to the sustained attention to errors that is expected for those who ruminate, both the impaired disengagement hypothesis and the attentional scope model of rumination would predict that in the face of failure, ruminating should also lead to an inadequate processing of proximally-presented learning-relevant feedback. Consequently, such inadequate processing would be expected to reduce the ability to use this information to learn and rebound from failure. First, as a behavioral measure of whether rumination interferes with the successful encoding of corrective feedback, error correction will be assessed in Studies 1-3. However, we will also address any influences on the encoding of corrective feedback by focusing on ERPs that are predictive of subsequent error correction on the later retest (Study 1). Specifically, we will assess whether rumination modulates ERP waveforms that are time-locked to the presentation of the learning-relevant feedback. Furthermore, we will also use eye tracking (Study 3) to assess whether sustaining attention to errors comes *at the cost of* processing corrective feedback, particularly when this novel and useful information is presented concurrently with reminders about one's failures, therefore competing for participants' focus.

Aim 3: Do state and trait forms of rumination differ in how they influence learning?

Study 1 in this research program will only focus on *trait* rumination, while Studies 2 and 3 will focus primarily on *state* rumination. In Study 1, the Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 1991) will be used to test whether individual differences in the trait tendency to express this recurrent style of thinking may predict ERP measures of attention and learning, as well as error correction rates in our general knowledge test—feedback—retest paradigm. One strength of employing an individual differences approach using the RRS is that this survey instrument is well-known and widely functions as the gold standard measure of trait rumination. Indeed, much of the early research indicating the adverse consequences of habitually ruminating has involved use of this measure (for a review see Nolen-Hoeksema et al., 2008). Importantly, however, since its inception, subsequent efforts were made to purge this scale of a number of items that overlapped with (and arguably measured) depression. The items that remained were purported to capture *two distinct sub-types* of trait rumination: Ruminative Brooding, highlighted as being a *maladaptive* sub-type, and Reflective Pondering, proposed to be more *adaptive* in nature (Treynor et al., 2003). Thus, an additional strength of using the RRS is that *both* 'Brooding' and 'Reflection' sub-types can be investigated uniquely as predictors. Of note, Study 1 in this research program has already been published (Whiteman & Mangels, 2016), and will be included here as it appears in *Brain Sciences*.

One weakness of using the RRS, however, is that any effects that may result are merely correlational in nature. To add to and extend the limited conclusions that can be inferred from this correlational research, Studies 2 and 3 will instead use an experimental design to *induce* rumination. Employing such an approach in these latter two studies is valuable because it affords a *direct* test of the *causal* relationship that this recurrent style of thinking may have with the ability to learn and rebound from failure. In addition, not only will Studies 2 and 3 complement the non-experimental methods used in Study 1, but compared to the initial study, these latter two studies will additionally afford an assessment of the effects of being in a *state* of rumination.

Regarding the state induction procedures employed in these latter two studies, Study 2 will use a staple induction manipulation developed by Nolen-Hoeksema and colleagues (Nolen-Hoeksema & Morrow, 1993) and used regularly in their clinical research. Study 3, on the other hand, will use a procedure guided more by social-cognitive work (e.g., Martin & Tesser, 1996; Roberts et al., 2013). Thus, Studies 2 and 3 will provide a robust assessment of the influence of being in a state of rumination, as these induction techniques are guided by distinct, yet somewhat complementary, theoretical backgrounds. In addition to using experimental induction methods, however, Studies 2 and 3 will also make use of the RRS. The inclusion of this measure will not only permit assessing potential replication effects from Study 1, but it will also afford an evaluation of whether any effects of being induced to experience a *state* of rumination are accentuated by participants' *trait* levels of rumination. Additionally, in Studies 1-3, participants' pre-task levels of depression will be captured using the Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996b) so that we will be able to test whether the influence of trait (and state) rumination may occur *over and above* individuals' depressive mood states, and/or whether in Studies 2 and 3 depression may at all *moderate* the influence of being in a state of rumination. Finally, to help us gain some sense for how trait and state rumination may shape the kinds of in-task thoughts and feelings that students have during all three studies, subjective experience self-reports will be captured *while students complete* the general knowledge test.

CHAPTER 2: Study 1

Introduction

Failing to achieve our goals can be disappointing at best, and devastating at worst. For some individuals, however, failure elicits a particular flurry of negative thoughts and feelings that come to monopolize their attention at the expense of other goal-relevant information. Given that the ability to learn and rebound from failure is a key predictor of life-long success (e.g., Bandura, 1993; Duckworth, 2007), it is important to understand how our cognition and emotions interact to influence goal-directed behaviors such as the ability to overcome failure (e.g., Dolan, 2002; Pessoa, 2010). In the present study, we use both behavioral and event-related potential (ERP) measures to examine how rumination, a cognitive response to negative mood states, stressful situations, or adverse life events (Nolen-Hoeksema & Morrow, 1991), impacts the response to negative feedback and the ability to effectively learn from it.

Rumination is characterized by repetitive and persistent evaluation of the meaning, causes, and consequences of one's affective state and personal concerns (Nolen-Hoeksema et al., 2008). Although ruminators often claim that this style of thinking helps them to down-regulate unwanted emotions and arrive at useful insight for solving problems, instead, it often increases negative affect and impairs problem solving (Lyubomirsky & Nolen-Hoeksema, 1995). According to recent social-cognitive models of rumination, such as Martin and Tesser's Control Theory (Control Theory; Martin & Tesser, 1989, 1996), rumination occurs in the presence of blocked goals, as an attempt to minimize the discrepancy between the desired goal state and one's current state of affairs. However, these models suggest that a ruminative response is not always maladaptive. Rather, repetitive attention to blocked goals can then either help or hinder an individual's chances at minimizing goal state discrepancies, depending on how attention is focused during ruminative thought (Martin, 1986). Specifically, studies using the Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 1991; Treynor et al., 2003) have shown that higher scores on the Brooding subscale, which taps the tendency to passively "brood" over one's problems and mood (e.g., "What am I doing to deserve this?"), relates to attentional biases toward (Donaldson et al., 2007), and difficulty disengaging from negative information (Vanderhasselt et al., 2011). In contrast, scoring higher on the Reflection subscale, which taps the tendency to deliberately "reflect" on concrete means for problem solving (e.g., "I write down what I am thinking and analyze it."), is more often associated with less distraction and interference by self-relevant stimuli (Daches, Mor, Winquist, & Gilboa-Schechtman, 2010), indicating that the tendency to reflect seems to direct attention more adaptively.

Past research also suggests that the extent to which rumination produces adaptive or maladaptive effects may depend on factors such as gender and length of time elapsing from the initial negative event. Early investigations of this cognitive style revealed that dysphoric women generally tend to ruminate more than dysphoric men (Nolen-Hoeksema, 1987; Nolen-Hoeksema & Morrow, 1991), and experience more adverse consequences for their affective and cognitive states as a result, including the onset of clinically-significant depression (Nolen-Hoeksema, Morrow, & Fredrickson, 1993; Nolen-Hoeksema, Parker, & Larson, 1994; Treynor et al., 2003). In addition, the effects of rumination may compound over time, even in healthy undergraduates. For example, trait measures of rumination predicted healthy undergraduates' levels of anxiety and feelings of hopelessness 4 to 8 h after they received the grade on their most difficult midterm exam, regardless of the actual score (Sarin, Abela, & Auerbach, 2005). Taken together, these findings suggest the effects of Brooding and Reflection may become more apparent the longer that a goal is blocked, and that women might be particularly vulnerable to these cumulative effects. To our knowledge, past studies have not yet examined how gender, along with the length of time over which negative outcomes are experienced, impact the relationship between different sub-types of rumination and goal-directed behavior.

In the present study, we examined these relationships within a scenario that might signal a blocked goal and elicit rumination for the typical college student—the failure to meet an important academic goal. To create this context in a laboratory setting, we used an academically-framed general knowledge task developed in our lab (Butterfield & Mangels, 2003; Mangels, Butterfield, Lamb, Good, & Dweck, 2006). In this computer-adaptive task, which is designed to elicit a pre-set rate of academic failure, students first answer a large set of questions and receive both performance feedback (colored asterisk) and learning feedback (correct answer) after each response. A surprise retest of all the items they initially answered incorrectly is then administered one to two days later. Because students are not informed that it is necessary to learn the correct answers during first-test, their rate of error correction on the retest provides a sense of how well they are able to incidentally learn from and use this feedback to rebound from their initial failures.

In addition to capturing behavioral measures of performance on the first-test and retest, we measured ERP responses to the performance and learning feedback to capture underlying mechanisms for how ruminative tendencies might influence rebound from failure. Our analysis of performance feedback focused on two waveforms: the medial frontal feedback-related negativity (FRN), which exhibits a relatively sharp deflection maximally at ~250 ms post-feedback (Miltner, Braun, & Coles, 1997; Simons, 2010), and the posteriorly maximal late positive potential (LPP), which typically begins about 400 ms post-stimulus (Foti & Hajcak, 2008; Schupp, Cuthbert, et al., 2004). The time course of these waveforms suggests that the FRN reflects an early, rapid, and relatively automatic detection of outcomes that are more negative (worse) than expected (Holroyd & Coles, 2002; Simons, 2010), whereas the LPP indexes later, more sustained attentional processes that are modulated by subjective levels of emotional arousal, regardless of emotional valence (Moser, Hajcak, Bukay, & Simons, 2006). Furthermore, the LPP appears to persist even after the offset of the evoking stimulus (Hajcak & Olvet, 2008), indicating that it can index not only externally-focused visual attention, but also motivated attention to an internal representation of an arousing stimulus.

Although the FRN has been studied extensively with regard to error feedback processing (Miltner et al., 1997; Simons, 2010), the LPP has traditionally been studied in response to affective picture stimuli (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Hajcak & Olvet, 2008), rather than to feedback stimuli. However, in a recent study that used a math variant of the feedback-based learning task employed here (Mangels, Good, Whiteman, Maniscalco, & Dweck, 2012), both the FRN and the LPP were observed following negative feedback and both influenced subsequent error correction, but in different ways. Specifically, Mangels and colleagues (Mangels et al., 2012) found that for women who took the math test in a context of stereotype threat, a larger FRN was associated with poorer rebound from failure on the retest due to active avoidance of learning opportunities (i.e., vigilance-avoidance pattern). In contrast, a larger LPP to negative feedback was associated not with avoidance, but with shallower processing of the learning opportunities, suggesting that working memory resources were not fully allocated toward task-relevant information and rather, might have been directed toward rumination on threat-related internal thoughts (Beilock et al., 2007; Schmader, Johns, & Forbes, 2008).

Taken together, these results would suggest that the LPP, even more so than the FRN, might be a prime candidate for modulation by trait rumination in the present study. Brooding should up-regulate arousal to negative feedback and, correspondingly, enhance LPP amplitudes, whereas Reflection should down-regulate this response, thereby attenuating the LPP. It is less clear, however, whether and how the FRN to negative feedback will be modulated by trait rumination. Even though recent evidence suggests that the FRN may partially index the affective response to negative outcomes (e.g., Marco-Pallares, Kramer, Strehl, Schroder, & Munte, 2010), rumination is typically conceptualized as a *reactive* response occurring after negative outcomes. Thus, rumination may modulate processes occurring after the early error detection processes associated with the FRN. However, it is also possible that the FRN might be enhanced for participants high in Brooding, who may have developed a habitual sensitivity to any context in which error signals might occur (e.g., Hertel, 2004). This sensitivity might be especially evident in situations, such as the current task, where error events are repetitive, leading brooders to focus on passive and abstract construal of these events (i.e., Watkins & Nolen-Hoeksema, 2014). In contrast, a tendency toward more reflective rumination may produce an attenuation of the FRN (e.g., Yang, Gu, Tang, & Luo, 2013). Finally, it is possible that habitual brooders and reflectors do not perceive repeated negative outcomes (e.g., failures) to be overly surprising, but rather have come to expect them. To the extent that the FRN is modulated by expectancy (Simons, 2010), this would mean that it may be attenuated for all ruminators—and given the prevalence of negative feedback in the task, this reduction in FRN amplitude may become even more evident as the task progresses.

Turning to the learning feedback processing, we focused this analysis on a group of sustained negative-going waveforms over inferior aspects of fronto-temporal and parietal-occipital regions. These electrode sites, which correspond to key regions of the semantic network (for review see Binder, Desai, Graves, & Conant, 2009), have previously been shown to predict successful encoding of the correct answer in similar versions of this task (Butterfield & Mangels, 2003; Mangels et al., 2006). Specifically, activity recorded at these sites during the initial presentation of the correct answer (i.e., first-test) is more negative-going for answers that participants later correctly recall on the subsequent retest, compared to those they later forget (i.e., a difference due to memory; Paller & Wagner, 2002). ERP studies have previously shown that activity at these sites is associated with activation of semantic representations (i.e., a sustained negative-going waveform over fronto-temporal sites; Kutas & Federmeier, 2000; Mangels et al., 2006; Nobre & McCarthy, 1995; Stern & Mangels, 2006), and may be particularly important for deep conceptual and elaborative encoding of verbal information (Johnson, Nessler, & Friedman, 2013; Mangels et al., 2006; Mangels, Picton, & Craik, 2001; Nessler, Johnson, Bersick, & Friedman, 2006). Thus, to the extent that Brooding or Reflection impacts the ability to correct errors, it may be through modulation of these encoding-related processes.

In sum, the aim of the present study was to examine whether trait tendencies toward Brooding and Reflection affected the feedback-based correction of errors in an academically-relevant general knowledge task. To understand the mechanisms associated with any effects on this goal-directed behavior, we investigated both overt measures of performance-related thoughts and feelings through subjective self-report, and covert measures of attention and arousal to errors using established ERP waveforms. We hypothesized that Brooding would be associated with poorer error correction on the retest, increased negative thoughts and feelings, and the up-regulation of arousal to these error signals (LPP). In contrast, Reflection would lead to preservation (or enhancement) of error correction, decreased negative thoughts and feelings about task performance, and correspondingly, an attenuated LPP to negative feedback. The predictions regarding the FRN were more complex and exploratory, as it is not clear whether and how this early component would be sensitive to conscious, reactive rumination processes. Finally, by dividing this lengthy task into four blocks and comparing across them, we examined how these behavioral and physiological responses changed as participants repeatedly and relentlessly received high rates of negative feedback regardless of efforts to improve. We hypothesized that any differential effects of Brooding and Reflection should become enhanced as the task progressed, particularly for women, who also might simply be more sensitive to the effects of rumination overall. Thus, this investigation will add to a growing dialogue on how cognition and emotion interact with moderating variables, such as gender and time, to bias attention and influence goal-directed behavior in practical, real-world situations.

Method

Participants

Fifty-four participants (27 women) were recruited from a larger cohort of Baruch College undergraduate students who had completed a prescreening session that included administration of the Ruminative Responses Scale (RRS; Treynor et al., 2003), as well as a series of questions assessing eligibility for EEG. Participants enrolled in the 2-day EEG study were 18 to 30 years of age (*M* = 20.43, *SEM* = 0.38), right-handed, and native speakers of English or fluent by age six. All had normal or corrected-to-normal vision and hearing, and no self-reported history of neurological, psychological, or substance abuse disorders. Because the average time that elapsed between the prescreening session and the first day of the EEG study was 38.21 days (*SEM* = 2.04), all participants completed the RRS again in a pre-test survey upon returning for EEG, and this latter score was used to predict electrophysiological and behavioral responses in the current study. All participants scored less than 19 (i.e., cutoff for moderate depression) on the Beck Depression Inventory II (BDI-II; Beck, Steer, & Brown, 1996a) in the pre-test survey on the day of EEG testing. Participants received either monetary compensation at the rate of $10/h (65%), or a combination of course credit and monetary compensation (35%), for participation. A bonus incentive of $10 or 1 h of course credit was offered to all participants who returned for the second day of testing.

Some participants were excluded because critical aspects of their data did not conform to pre-determined standards. Three women had RRS scores that varied widely between the initial prescreen session and the latter pre-test survey (i.e., greater than 2 SDs away from the sample mean difference), generating uncertainty that they completed one or both questionnaires of this trait measure appropriately. Five participants (two women) completed only three of four total first-test blocks in the time they had available. One man performed well above (55%) the pre-determined first-test accuracy rate (35%) despite titration efforts (see Design and Procedure section), and at retest evidenced error correction rates that were at ceiling, suggesting that the task was not as challenging for this individual as it was for others. One woman used a confidence rating of 1 (lowest confidence rating) on 93% of first-test question items, casting doubt not only on how she made use of this scale, but even on her engagement in the task. Two men had excessive EEG noise and too few usable trials in critical conditions (see EEG Recording). Finally, two participants (one woman) had unusable data due to computer malfunction.

Table 1. Study 1 Sample Characteristics. Mean scores of pre-test self-report questionnaires and demographics. Standard errors of the mean appear in parentheses here and in all subsequent tables.

	Overall	**Range**	**Men**	**Women**
n	40	—	20	20
Age	20.43 (0.38)	18.16–29.91	20.87 (0.66)	19.99 (0.38)
Years of Education	14.20 (0.18)	13–16	14.20 (0.25)	14.20 (0.27)
BDI-II	7.45 (0.74)	0–17	7.80 (1.03)	7.10 (1.07)
RRS Total	39.23 (1.65)	23–69	38.80 (2.66)	39.65 (2.03)
Brooding	9.05 (0.46)	5–16	8.90 (0.76)	9.20 (0.52)
Reflection	9.28 (0.56)	5–19	9.50 (0.93)	9.05 (0.64)

The final sample included 40 participants (20 women). As seen in Table 1, men and women groups were evenly matched for age, years of education, and depressive mood state. Overall scores on the 22-item RRS scale, as well as the 5-item Brooding and 5-item Reflection subscales, were highly similar to those originally reported by Treynor et al. (2003), as well as other studies involving non-depressed undergraduate samples (De Lissnyder et al., 2012; Zetsche & Joormann, 2011). All rumination scores were equivalent between men and women (all *p*s > 0.69). Brooding and Reflection sub-scores did not differ from one another, whether splitting by or collapsing across Gender (all *p*s > 0.38). Measures of internal consistency were good, (RRS: $\alpha = 0.91$, Brooding: $\alpha = 0.79$, Reflection: $\alpha = 0.81$) and comparable to Treynor et al. (2003).

Design and Procedure

Overview. The study took place over two days. On the first day, participants filled out a pre-test survey that contained both the RRS and BDI-II. After completing the survey packet, participants were fitted with the EEG cap and answered 200 general knowledge questions divided into four blocks of 50 trials. A titration algorithm that used the normative difficulty of each question attempted to maintain a stable accuracy rate of 35% correct (i.e., failure) for all participants across all four blocks. This algorithm has been used previously in our research (for details about the titration algorithm, see Butterfield & Mangels, 2003). Participants were then asked to return 24–48 h later to complete a second set of general knowledge questions. Although participants were given no further information about the type of questions they would receive on this second day, the questions were comprised solely of the items they had answered incorrectly on the first day. No EEG measures were captured on the second day of testing.

First Day of Testing. The general knowledge trial sequence used on the first day is represented in Figure 1. Questions were presented one at a time and participants were asked to provide their best response within a 3-minute time limit. If they did not know an answer to a question they were prompted to type their best guess, or otherwise wait out the full duration of the time limit, after which they would be marked incorrect. Stimuli were taken from a pool of 434 general knowledge question-answer pairings tapping a wide variety of academic domains, including the natural and physical sciences, U.S. and world history, music and art history, literature, geography, and religion. All correct answers were one word, 3–12 letters in length. The mean difficulty of all questions in the pool was 35% correct, as specified from a norming study previously undertaken to determine the free response accuracy rate of each question within the Baruch College undergraduate population. In that study, each correct answer was rated as being a familiar word to at least 95% of the normative sample.

After submitting their response, participants rated their confidence in their response on a 1–7 scale, where selecting 1 indicated "sure wrong", 7 indicated "sure right", and 4 indicated being "unsure" about the accuracy of their response. In the feedback sequence that followed, they were presented first with a blank screen for 500 ms, followed by a fixation crosshair for 2.5 s. Then, 1 s of performance-relevant feedback was given both visually and aurally in the pairing of a green-colored asterisk and a high tone for correct responses (i.e., positive performance feedback), or a red-colored asterisk and a low tone for incorrect responses (i.e., negative performance feedback). After another 2.5 s fixation point, learning-relevant feedback was presented for 2 s, consisting of the correct answer. We intentionally used relatively long pre-feedback wait periods (2.5 s) to allow time for participants to turn attention inward toward any ruminative thoughts that might be generated both before and after the performance feedback (e.g., Berman et al., 2010). We expected that this would increase the likelihood of finding any effects of trait rumination on the processing of performance or learning feedback.

In order to gain insight into subjective experiences throughout the task, we asked participants to answer four short post-block surveys about the thoughts ("How many recurring negative thoughts did you experience in the block of questions you just attempted?") and feelings ("In this block of questions, whenever you made an error, how unpleasant or pleasant did you feel?") they encountered in each block. All questions were rated on a 1-to-9 Likert scale, with 1 reflecting the negative or low end of the subjective experience, 9 reflecting the positive or high end, and 5 indicating an experiential midpoint (i.e., neutrality). At the conclusion of the first day of testing, the EEG cap was removed and participants were asked to return within 24–48 h to complete a second set of general knowledge questions.

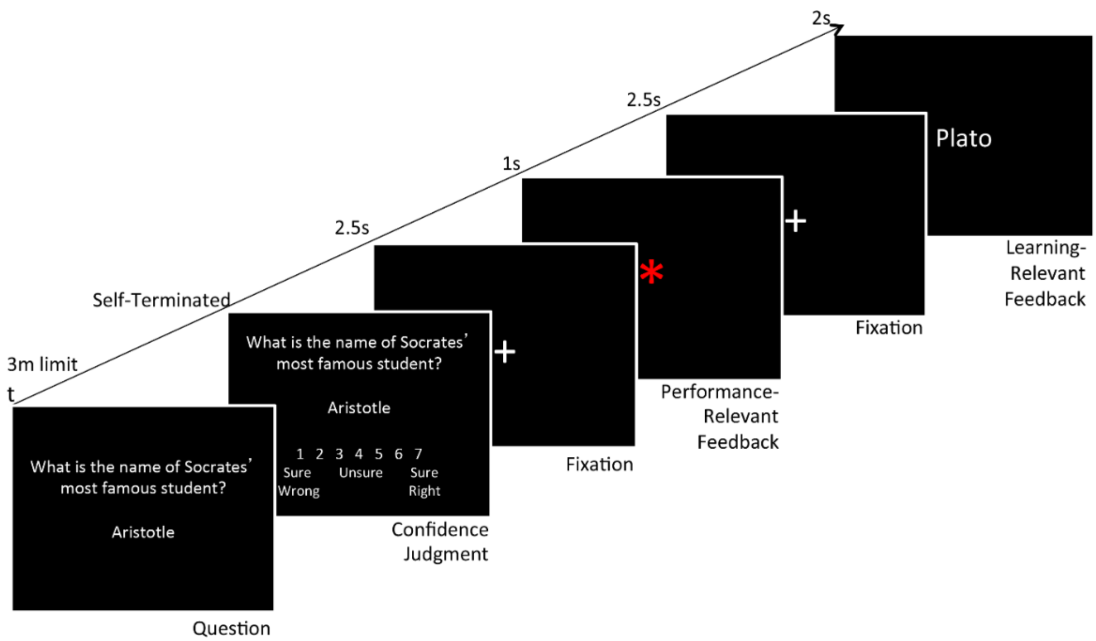

Figure 1. Study 1 First-Test Trial Structure. Example of a trial with an incorrect answer. If the answer had been correct, a green asterisk would have been shown.

Second Day of Testing. The retest trial sequence differed from that of first-test in that the feedback was presented all at once in order to minimize the amount of time participants had to spend in the lab on the second day of testing. Correct answers appeared in green text and were paired with a high tone, and incorrect answers appeared in red text and were paired with a low tone. This combined feedback was presented immediately following participants' confidence ratings and lasted for 1 s. All re-queried questions were presented in one large retest block. Question order was randomized with the exception that, to decrease variability in study-test delay and preserve some aspects of test context, all questions from first-test blocks 1 and 2 were binned and re-queried before the questions from first-test blocks 3 and 4. Only at the outset of this second day of testing were participants made aware that they were being retested on a subset of questions they had answered on the first day. Upon completion of these questions, all participants reported being surprised by the retest.

EEG Recording

EEG was recorded continuously using a sintered Ag/AgCl 64-electrode QUIKCAP. The analog signal was amplified using Neuroscan Synamps 2 and converted to digital at a rate of 500 Hz with a bandpass of DC-100 Hz. Impedance was kept below 11 kΩ. EEG was initially referenced to Cz during recording, and afterwards converted to an average reference off-line. We used 4–6 PCA-derived ocular components to compensate for blinks and other eye movement artifacts. The continuous EEG data was cut into epochs separately for performance- and learning-relevant feedback and then time-locked to the onset for each type (−100 ms to 1000 ms). After conducting baseline correction to the 100 ms window preceding the feedback stimulus, we rejected any epochs containing excessive noise (±100 µV) and averaged all remaining epochs for event-related potential (ERP) analysis. Single-subject averages were generated at the overall and block levels. Prior to averaging, both low-pass (35 Hz) and high-pass (0.12 Hz) filters were applied to the EEG data.

Data Analysis

Overview. Our study focuses on the relationship between Brooding and Reflection RRS sub-scores (hereafter referred to as Brooding and Reflection) and measures of memory, subjective experience, and ERP waveforms. To this aim, we used a customized general linear model to test these relationships by entering Brooding and Reflection RRS sub-scores as simultaneous covariates (i.e., predictor variables) in a 2 (Gender) by 4 (Block) mixed-measures Analysis of Covariance (ANCOVA) and rendering parameter estimates (converted to standardized beta coefficients) for individual difference measures. We also included all 2- and 3-way interaction terms (including those with Brooding or Reflection) in the customized model for the purpose of testing how the two sub-types of rumination may have interacted with Gender and/or Block to influence the measures of interest.

As in previous studies of rumination in non-depressed samples, our customized ANCOVAs included not only Brooding and Reflection, but also BDI-II scores, entered as another simultaneous covariate (see Bernblum & Mor, 2010; Davis & Nolen-Hoeksema, 2000). Indeed, although all students had BDI-II scores under the threshold for moderate depression, BDI-II was correlated with both Brooding ($r = 0.38$, $p < 0.05$) and Reflection ($r = 0.47$, $p < 0.005$). Including BDI-II as a simultaneous predictor variable helped to ensure that we were evaluating the effects of trait rumination after contributions from depression had been removed (Bernblum & Mor, 2010; Davis & Nolen-Hoeksema, 2000; De Lissnyder et al., 2012; Joormann, 2006; Zetsche & Joormann, 2011). The effect of BDI-II was also evaluated as a main effect, as well as across all 2- and 3-way interactions involving Gender and/or Block factors. Because depression is not of central interest to this study, however, the relationships involving BDI-II are not addressed here, but elsewhere (Supplemental Section S1 of Whiteman & Mangels, 2016).

All dependent measures were adjusted to control for the potential confounding influence of first-test accuracy prior to their inclusion in the customized ANCOVAs, as we typically do for this paradigm (Butterfield & Mangels, 2003; Mangels et al., 2012). We adjust for first-test performance because, even after titration, individuals who perform better at first-test typically also perform better at retest, perhaps because they have slightly fewer items to correct, or because they have a stronger knowledge base. To control for this variable, we regressed first-test accuracy from our dependent variables prior to inserting those measures into our analyses. This approach permitted use of the properly adjusted block scores in our ANCOVAs and maximized degrees of freedom when conducting our customized general linear models.

Across all analyses, we used the conventional alpha level of $p \leq 0.05$ as the criterion for significance, but also report marginally significant findings ($0.05 < p \leq 0.10$), specifying effect sizes in all cases. Where necessary, Greenhouse-Geisser corrections were used for violations of sphericity. In addition, where appropriate, linear trend analyses were conducted across the within-subjects factor of Block to determine how any particular dependent measure may have changed over time. Any *post hoc* explorations of significant main effects or interactions were carried out using the Holm-Bonferroni procedure for corrections for multiple comparisons (Holm, 1979).

ERP Responses to Performance-Relevant Feedback. ERPs for performance-relevant feedback were averaged according to first-test accuracy (average number of correct trials: 63.78, *SEM* = 1.19; average number of incorrect trials: 116.38, *SEM* = 1.52). All participants had at least 10 trials in each of the four blocks for both correct and incorrect responses, thus permitting ample signal-to-noise ratios for analysis of the FRN and LPP at the block level (Olvet & Hajcak, 2009). There were no gender differences in the amount of trials available for the analysis of the ERP response to negative performance, whether overall or by Block (all Fs < 1.70, all ps > 0.17).

The Feedback-Related Negativity (FRN). Visual inspection of grand average waveforms corroborated the existence of an FRN that was visibly larger for errors, most prominently over midline anterior scalp regions (Fz; refer to Figures 4A,B; Mangels et al., 2006; San Martín, 2012). To measure this waveform, we first identified the largest negativity from 200–350 ms post negative feedback at Fz (i.e., the peak), and then measured the average amplitude within a 30 ms time window centered over that peak (e.g., Holroyd, Pakzad-Vaezi, & Krigolson, 2008; Nieuwenhuis et al., 2005). We refer to this ERP response to negative feedback as the FRN_{neg}. Although peak-picking the FRN_{neg} was relatively straightforward, most participants lacked a definitive FRN to positive feedback, and thus, in an attempt to reduce sampling error, we opted to measure this ERP response (FRN_{pos}) at the same peak latency that was used for the FRN_{neg}.

Consistent with past research (Hajcak, Moser, Holroyd, & Simons, 2006), the FRN_{neg} was more negative-going than the FRN_{pos} regardless of Gender or Block, although both the FRN_{neg} and FRN_{pos} became more negative-going as the task progressed (see Supplemental Section S2.1 of Whiteman & Mangels, 2016). Because our study focuses on the neural and behavioral response to negative feedback, our primary RRS analyses focused on the FRN_{neg} and, to address the downward trend of both FRN waveforms, the FRN_{diff} (i.e., $FRN_{neg} - FRN_{pos}$).

The Late Positive Potential (LPP). Visual inspection of grand average waveforms and topographies corroborated the existence of the LPP over multiple posterior-superior sites (see Figures 5A–C; e.g., Hajcak, Dunning, & Foti, 2009). To simplify our investigation of RRS effects on the LPP, we focused on the LPP to negative feedback (LPP_{neg}), and analyzed the mean amplitude averaged over central-parietal and parietal scalp regions (CP1/CPz/CP2, P3/Pz/P4; see Supplemental Section S2.2 of Whiteman & Mangels (2016) for analyses relating to use of this averaged electrode cluster, as well as comparison of the LPP_{neg} and LPP_{pos}). We analyzed this averaged amplitude within two separate time windows: 400–600 ms and 600–1000 ms (see also Weinberg, Hilgard, Bartholow, & Hajcak, 2012). We hereafter refer to these two windows as the early and late LPP, respectively.

ERP Response to Learning-Relevant Feedback. Evaluation of the ERPs to learning-relevant feedback (i.e., the correct answer) focused on a posterior-inferior cluster (TP9/TP10, CB1/CB2, and O1/O2) and a left-inferior cluster (F7, FT9, T7, TP9, CB1, O1) from 500–1000 ms, post-stimulus onset, reflecting the spatiotemporal distribution of "difference due to memory (Dm)" effects in the present study (see Supplemental Section S2.3 in the Whiteman and Mangels (2016) publication), which were consistent with those typically found for this paradigm (Butterfield & Mangels, 2003; Mangels et al., 2006). Because we did not have sufficient trials to conduct traditional Dm analyses for each block, however, our main analyses involving Block and RRS sub-scores used the overall learning-feedback ERP after errors (i.e., collapsing across items subsequently recalled and not recalled), which we refer to as the Learning Event-Related Negativity (LERN; see Figures 6A,B; Mangels et al., 2006).

We created both the posterior-inferior and left-inferior LERN ERPs by averaging first-test errors, regardless of whether those errors were later corrected or not during the retest (average number of trials: 112.33, *SEM* = 1.73). All participants had at least 18 trials in each block, and no gender differences emerged in the amount of trials used for ERP analysis, whether overall or by Block (all Fs < 0.45, all ps > 0.51) (The proportion of later corrected and not corrected LERN trials that survived artifact rejection was not statistically different from the proportion of corrected and not corrected trials measured behaviorally at retest within any block, whether overall, or as a function of Gender (all *t*s < 1.30, all *p*s > 0.20), lending confidence to the view that the LERN should accurately scale with actual memory behavior.). The LERN from 500–1000 ms at these locations was strongly correlated with remedial behavior for women (Posterior cluster: $r = -0.57$, $p < 0.01$; Left cluster: $r = -0.65$, $p < 0.005$), although surprisingly for men, this effect was only marginal in the left-inferior cluster: $r = -0.40$, $p = 0.08$, while in the posterior-inferior cluster it was not significant: $r = -0.32$, $p = 0.17$ (though the relationship was in the expected direction).

Results

Memory Performance

Table 2 shows both the proportions of items initially correct at first-test (where the target accuracy for the titration algorithm was 0.35) and the proportions of items initially incorrect at first-test that were later corrected on the subsequent surprise retest. Both overall performance (task-wide) and performance during each 50-item block are shown as a function of Gender.

First-Test Accuracy. As shown in Table 2, men outperformed women at first-test despite titration efforts (main effect of Gender, $F(1, 32) = 5.31$, $p < 0.05$, $\eta_p^2 = 0.14$). Indeed, men's overall performance significantly exceeded the target titration value, as verified by a one-group t-test against 0.35, $t(19) = 2.20$, $p < 0.05$, whereas women's performance was within range of titration, $t(19) = 1.36$, $p = 0.19$. Nonetheless, the lack of a Block effect, or a Gender by Block interaction, indicated that within each gender, the titration was effective in keeping first-test performance stable (all *F*s < 0.87, all *p*s > 0.46).

Table 2. Study 1 Memory Performance. Proportion correct at first-test and retest as a function of Gender and Block. Means are adjusted for BDI-II, Brooding, and Reflection covariates.

Behavior	Overall	Block 1	Block 2	Block 3	Block 4
First-Test Accuracy					
Women	0.340 (0.007)	0.346 (0.006)	0.349 (0.008)	0.335 (0.012)	0.328 (0.016)
Men	0.363 (0.007)	0.363 (0.006)	0.360 (0.008)	0.377 (0.012)	0.352 (0.016)
Retest Error Correction					
Women	0.606 (0.021)	0.578 (0.025)	0.643 (0.030)	0.605 (0.026)	0.598 (0.031)
Men	0.545 (0.021)	0.597 (0.025)	0.573 (0.030)	0.499 (0.026)	0.513 (0.031)

Men's superior performance at first-test was related to neither Brooding nor Reflection, whereas both RRS sub-scores predicted women's performance in some way. Specifically, we found an overall effect of Reflection, $F(1, 32) = 7.93$, $p < 0.01$, $\eta_p^2 = 0.20$, that was qualified by both a Gender by Reflection interaction, $F(1, 32) = 4.49$, $p < 0.05$, $\eta_p^2 = 0.12$, and a marginal 3-way interaction additionally involving Block, $F(2.11, 67.45) = 2.65$, $\varepsilon = 0.70$, $p = 0.08$, $\eta_p^2 = 0.08$. Focusing on the significant 2-way interaction, we found that Reflection predicted significantly better overall performance at first-test in women, $\beta = 0.80$, $t = 3.02$, $p < 0.01$, $\eta_p^2 = 0.22$ (see Figure 2A), but not men, $\beta = 0.21$, $t = 0.61$, $p = 0.55$, $\eta_p^2 = 0.01$.

The influence of Brooding on first-test performance also differed across Gender, $F(1, 32) = 4.91$, $p < 0.05$, $\eta_p^2 = 0.13$, but not Block. Women with higher Brooding scores had marginally poorer performance throughout the task, $\beta = -0.51$, $t = 1.94$, $p = 0.06$, $\eta_p^2 = 0.11$. There was no significant relationship between Brooding and first-test performance in men, $\beta = 0.36$, $t = 1.09$, p

= 0.28, $\eta_p^2 = 0.04$, although the finding that it was in the opposing direction to women likely contributed to the strength of the 2-way interaction (see Figure 2B).

As can be seen in the Figure 2A,B, women who were lower on trait Reflection and higher on trait Brooding exhibited lower retrieval success at first-test compared to men. For men, in contrast, RRS sub-scores had little bearing on performance.

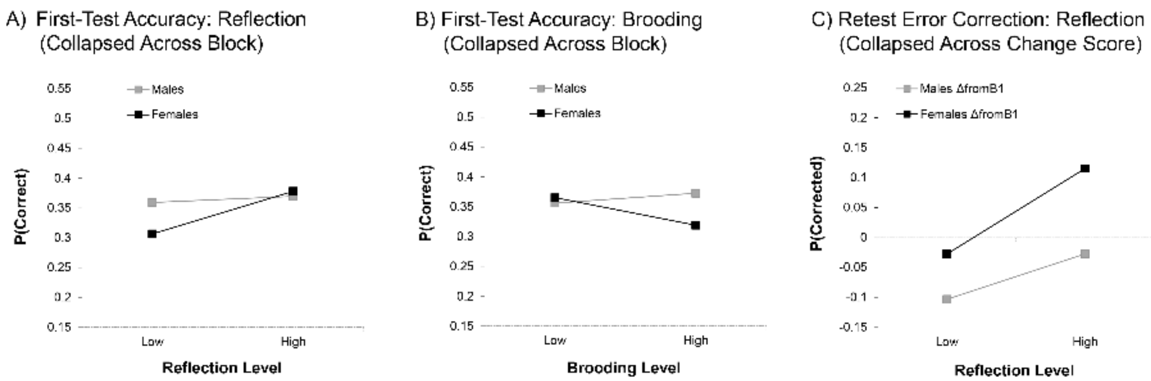

Figure 2. Study 1 Memory Performance as a Function of RRS and Gender. Effects of Reflection (**A**) and Brooding (**B**) on the proportion of first-test questions answered correctly across all blocks; (**C**) Effects of Reflection on change in error correction between Block 1 and subsequent blocks.

Error Correction. Despite women's poorer first-test performance overall, they outperformed men on the retest, an effect that was right at the conventional level of significance, $F(1, 32) = 4.11$, $p = 0.05$, $\eta_p^2 = 0.11$ (see Table 2). Time in the task (i.e., Block) also had an overall effect on error correction, $F(3, 96) = 2.90$, $p < 0.05$, $\eta_p^2 = 0.08$, such that correction rates decreased over the course of the task. However, both of these main effects were qualified by a significant Gender by Block interaction, $F(3, 96) = 3.39$, $p < 0.05$, $\eta_p^2 = 0.10$. Exploration of this interaction indicated that while men corrected fewer errors as the task progressed, as evidenced by a significant downward linear trend across Block, $F(1, 16) = 6.24$, $p < 0.05$, $\eta_p^2 = 0.28$ (see

Table 2), women exhibited fairly stable error correction across the task. As a result, the womens' relative advantage over men on error correction appeared to increase as the task progressed (i.e., in Blocks 3 and 4), although none of the *post hoc* comparisons of gender differences at each block survived Holm-Bonferroni corrections.

When then considering the effects of RRS on error correction, we found no effects of Brooding, either overall or as a function of Gender or Block, in contrast to our predictions. More in support of our hypotheses, however, significant effects of Reflection emerged that appeared to differ across blocks, $F(3, 96) = 2.75$, $p < 0.05$, $\eta_p^2 = 0.08$, though not between genders. When unpacking the interaction as a function of Block, however, none of the parameter estimates survived Holm-Bonferroni corrections. Nonetheless, it is worth noting that numerically, the parameter estimates in Block 1 demonstrated a slightly negative relationship between Reflection and error correction (Block 1: $\beta = -0.13$), whereas the parameter estimates in the three subsequent blocks were all in the *positive* direction (Block 2: $\beta = 0.45$; Block 3: $\beta = 0.10$; Block 4: $\beta = 0.13$). Thus, it is possible that these opposing, though non-significant effects drove the significant interaction of Reflection with Block.

To explore this possibility further, we calculated the change in error correction between the initial block (Block 1) and each of the subsequent blocks. In this way, Block 1 was treated as a baseline to produce the following change scores: the change from Block 1 to Block 2 (i.e., ΔB1-to-B2), Block 1 to Block 3 (i.e., ΔB1-to-B3), and Block 1 to Block 4 (i.e., ΔB1-to-B4). We then used these change scores as a 3-level "Change" factor (to replace the 4-level "Block" factor) in a 2 (Gender) by 3 (Change) mixed-measures ANCOVA that included the customized 2- and 3-way interaction terms. Using these Change scores, we found an overall Gender effect, $F(1, 32) =$

9.30, $p < 0.01$, $\eta_p^2 = 0.23$, where men showed a change for the worse in performance from Block 1 relative to women, similar to what was described by the Block analysis above.

In addition, we found a main effect of Change, $F(2, 64) = 4.23$, $p < 0.05$, $\eta_p^2 = 0.12$, but no interaction between Gender and Change. *Post hoc* testing of the Change effect indicated that participants overall demonstrated a greater change for the worse (i.e., decrease) in error correction rates during the later two blocks relative to the ΔB1-to-B2 period (vs. ΔB1-to-B3: $p < 0.05$; vs. ΔB1-to-B4: $p < 0.05$). The change in error correction in these latter two periods did not differ from each another ($p = 0.89$). More importantly, however, a main effect of Reflection emerged, $F(1, 32) = 4.10$, $p = 0.05$, $\eta_p^2 = 0.11$, with a positive parameter estimate ($\beta = 0.37$).

Figure 2C illustrates the simple effects for this relationship, showing that change in error correction across the task benefitted from a greater tendency toward Reflection in both genders. For women, higher Reflection scores were associated with relative improvement in error correction in later blocks relative to Block 1, whereas lower Reflection scores were associated with little change in either direction. For men, however, lower Reflection scores were associated with decline across the task, whereas for those with higher Reflection scores, little change was evident.

Subjective Experiences

The extent to which men and women participants reported experiencing recurring negative thoughts (RNTs) and negative feelings after errors (FAEs) is reported in Table 3, both overall and over the course of the four task blocks.

Table 3. Study 1 Subjective Experiences. Means are adjusted for BDI-II, Brooding, and Reflection covariates.

Subjective Experience	Overall	Block 1	Block 2	Block 3	Block 4
RNTs					
Women	4.50 (0.40)	4.45 (0.40)	4.46 (0.42)	4.78 (0.51)	4.29 (0.51)
Men	3.97 (0.40)	4.55 (0.40)	4.09 (0.42)	3.62 (0.51)	3.61 (0.51)
FAEs					
Women	3.44 (0.24)	3.53 (0.27)	3.45 (0.35)	3.19 (0.29)	3.59 (0.31)
Men	3.66 (0.24)	2.98 (0.27)	3.48 (0.35)	3.96 (0.29)	4.21 (0.31)

Notes: Recurring Negative Thoughts (RNTs) were rated on a scale of 1 (none at all) to 9 (an extreme amount), with 5 meaning a moderate amount. Feelings After Errors (FAEs) were rated on a scale of 1 (extremely unpleasant) to 9 (extremely pleasant), with 5 meaning neither pleasant nor unpleasant.

Recurring Negative Thoughts (RNTs). As shown in Table 3, RNTs lessened somewhat over the course of the task for both women and men, as supported by a marginal effect of Block, $F(3, 96) = 2.28$, $p = 0.09$, $\eta_p^2 = 0.07$, and a significant linear trend analysis, $F(1, 32) = 4.95$, $p < 0.05$, $\eta_p^2 = 0.13$. Although this downward direction was unexpected, analysis of the effect of RRS on RNTs indicated that this effect had to be considered in light of moderation by Brooding, Reflection, and Gender.

In line with our predictions that the effects of Brooding might differ as a function of Gender or time in the task, we found a significant 3-way interaction amongst Brooding, Gender, and Block, $F(3, 96) = 5.32$, $p < 0.005$, $\eta_p^2 = 0.14$. Although *post hoc* analysis of the source of this interaction did not find any parameter estimates that survived Holm-Bonferroni corrections, as with the analysis of error correction, further inspection of these estimates demonstrated that for women, the relationship between Brooding and RNTs became increasingly positive across the four blocks (Block 1: β = 0.04, Block 2: β = 0.21, Block 3: β = 0.56, Block 4: β = 0.59), whereas for men it started out as positive-going in Blocks 1 (β = 0.11) and 2 (β = 0.12), but became negative-going in Blocks 3 (β = −0.29) and 4 (β = −0.29). These apparent gender differences in the direction of Brooding effects on RNTs was further substantiated by a significant interaction in the linear trend across blocks as a function of Gender, $F(1, 32) = 10.74$, $p < 0.005$, $\eta_p^2 = 0.25$.

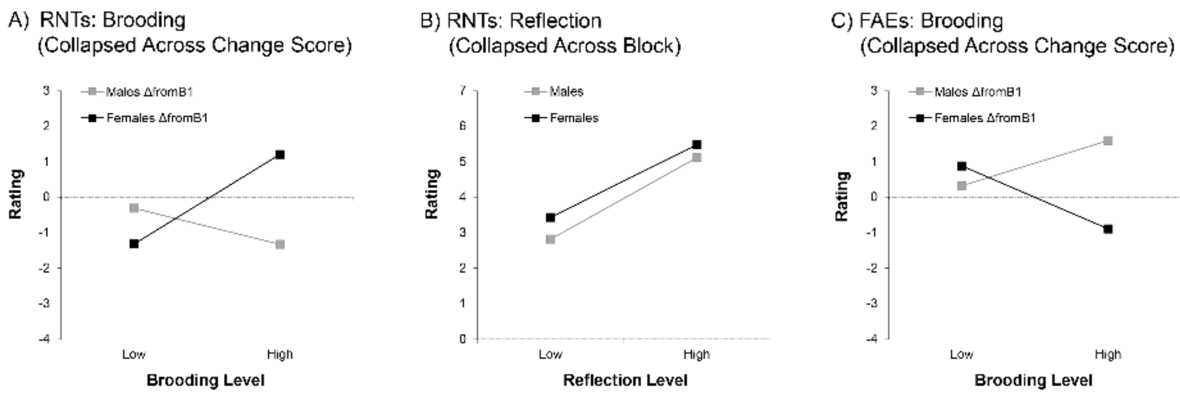

Figure 3. Study 1 First-Test Subjective Experiences as a Function of RRS and Gender. (**A**) Effects of Brooding on change in RNTs between Block 1 and subsequent blocks; (**B**) Effects of Reflection on RNTs collapsed over four blocks; (**C**) Effects of Brooding on change in FAEs between Block 1 and subsequent blocks.

Given these apparent differences in Brooding effects in the early compared to later blocks, we again applied our Change score approach to this analysis. We found both a 2-way interaction between Gender and Brooding, $F(1, 32) = 5.45$, $p < 0.05$, $\eta_p^2 = 0.17$, and a 3-way interaction of Gender, Change score and Brooding, $F(2, 64) = 5.21$, $p < 0.01$, $\eta_p^2 = 0.14$. When *post hoc* investigation of the 3-way interaction again did not reveal any parameter estimates that survived Holm-Bonferroni corrections, we turned our attention to closer examination of the 2-way interaction. Here, as illustrated in Figure 3A, we found evidence that Brooding marginally increased women's RNTs throughout the task compared to Block 1, $\beta = 0.61$, $p = 0.06$, $t = 1.98$, $\eta_p^2 = 0.11$. In contrast, it had no significant effect on men's RNT scores, which numerically demonstrated a negative relationship, $\beta = -0.38$, $t = 1.23$, $p = 0.23$, $\eta_p^2 = 0.05$.

Interestingly, in the Block analysis, Reflection was also a significant predictor of increased RNTs ($\beta = 0.53$; see Figure 3B), indicating that both sub-types of rumination resulted in the generation of negative thoughts about the task, $F(1, 32) = 6.95$, $p < 0.05$, $\eta_p^2 = 0.18$. This effect did not interact with Gender and/or Block (all Fs < 0.50, all ps > 0.67). The fact that this effect was consistently found across all four blocks was substantiated by the lack of any effect of Reflection when analyzing Change scores relative to Block 1 (all Fs < 0.52, all ps > 0.48).

Feelings After Errors (FAEs). Men's FAEs started off as somewhat unpleasant in Block 1, but became more neutral as the task progressed (see Table 3). Women on the other hand, while reporting roughly similar FAEs to men in Block 1, maintained these somewhat unpleasant FAEs throughout the task. These gender differences were supported by a significant Bender by Block interaction, $F(3, 96) = 3.57$, $p < 0.05$, $\eta_p^2 = 0.10$, that superseded an overall Block effect, $F(3, 96) = 3.89$, $p < 0.05$, $\eta_p^2 = 0.11$. This interaction appeared to be related to the fact that for men, there was a significant upward linear trend for FAEs, $F(1, 16) = 19.04$, $p < 0.001$, $\eta_p^2 = 0.54$, whereas for women, there appeared to be no such change, $F(1, 16) = 0.04$, $p = 0.84$, $\eta_p^2 = 0.003$.

Reflection did not appear to have any influence on participants' feeling about their errors, either overall or as a function of Gender or Block, all Fs < 0.52, all ps > 0.62. In contrast, Brooding did influence FAEs, although this effect differed as a function of Block and Gender, as indicated by a significant 3-way interaction, $F(3, 96) = 2.93$, $p < 0.05$, $\eta_p^2 = 0.08$. Although none of the *post hoc* evaluations of parameter estimates revealed significant effects following Holm-

Bonferroni corrections, further inspection suggested men and women began to diverge in how Brooding affected their feelings about errors after Block 1. Whereas men exhibited a negative-going coefficient in Block 1 ($\beta = -0.50$), in the subsequent three blocks, this relationship reversed to be positive-going (Block 2: $\beta = 0.20$, Block 3: $\beta = 0.17$, Block 4: $\beta = 0.30$). Women started Block 1 with a near-zero coefficient ($\beta = -0.07$), which then became more negative-going during the remainder of the task (Block 2: $\beta = -0.56$, Block 3: $\beta = -0.48$, Block 4: $\beta = -0.50$).

Once again, these apparent contrasts in the direction of change in FAEs for men and women following Block 1 motivated us to shift our analysis to Change scores. We found an overall effect of Gender on change scores, $F(1, 32) = 6.46$, $p < 0.05$, $\eta_p^2 = 0.17$, consistent with what was found above when analyzing all four blocks. Women felt more negatively about their errors in later blocks compared to Block 1, whereas men felt more neutral. However, these opposing effects for men and women were exacerbated by Brooding, as revealed in a significant Gender by Brooding interaction, $F(1, 32) = 7.30$, $p < 0.05$, $\eta_p^2 = 0.19$. As shown in Figure 3C, men and women who were lower in Brooding showed relatively similar levels of change across the task; but for men higher in Brooding, FAEs became more positive over the task relative to Block 1, $\beta = 0.59$, $t = 2.07$, $p < 0.05$, $\eta_p^2 = 0.12$, while for women higher in Brooding, FAEs became marginally more negative, $\beta = -0.59$, $t = 1.87$, $p = 0.07$, $\eta_p^2 = 0.10$.

Event-Related Potentials (ERPs)

Amplitudes of the waveforms of interest for the performance feedback (FRN, early and late LPP) and learning feedback (posterior and left hemisphere LERN) are shown in Table 4 for each gender, both over the entire task and as a function of Block.

Table 4. Study 1 Event-Related Potential Amplitudes (μV). Means are adjusted for BDI-II, Brooding, and Reflection covariates.

ERP	Overall	Block 1	Block 2	Block 3	Block 4
FRN_{neg}					
Women	−2.18 (0.45)	−1.58 (0.53)	−1.83 (0.44)	−2.34 (0.54)	−2.97 (0.49)
Men	−2.53 (0.45)	−1.82 (0.53)	−2.48 (0.44)	−2.78 (0.54)	−3.06 (0.49)
FRN_{diff}					
Women	−1.91 (0.33)	−1.18 (0.51)	−1.72 (0.47)	−2.38 (0.39)	−2.34 (0.42)
Men	−1.87 (0.33)	−1.71 (0.51)	−2.07 (0.47)	−1.83 (0.39)	−1.84 (0.42)
Early LPP_{neg}					
Women	3.05 (0.29)	3.43 (0.32)	3.10 (0.31)	3.06 (0.34)	2.61 (0.31)
Men	1.96 (0.29)	2.43 (0.32)	2.02 (0.31)	1.70 (0.34)	1.68 (0.31)
Late LPP_{neg}					
Women	2.09 (0.21)	1.98 (0.24)	2.26 (0.24)	2.09 (0.27)	2.02 (0.24)
Men	1.68 (0.21)	1.83 (0.24)	1.96 (0.24)	1.48 (0.27)	1.44 (0.24)
Post LERN					
Women	−3.22 (0.39)	−2.33 (0.34)	−3.47 (0.42)	−3.60 (0.43)	−3.47 (0.48)
Men	−2.75 (0.39)	−2.77 (0.34)	−2.94 (0.42)	−2.78 (0.43)	−2.51 (0.48)
Left LERN					
Women	−2.18 (0.28)	−1.50 (0.26)	−2.39 (0.30)	−2.32 (0.32)	−2.52 (0.33)
Men	−2.03 (0.28)	−1.82 (0.26)	−2.08 (0.30)	−2.22 (0.32)	−1.99 (0.33)

Feedback Related Negativity (FRN). Figure 4A shows the FRN_{neg} in the first and last block, providing an illustration of the negative trend for this waveform, in both genders, as the task progressed (see also Supplemental Section S2.1 in Whiteman and Mangels (2016); also see Whiteman and Mangels (2016) for all *additional* supplemental material subsequently referenced). The scalp topography of this waveform, collapsed across the task, is shown in Figure 4B.

Neither Brooding nor Reflection RRS sub-scores were predictive of the FRN_{neg}, either overall, or as a function of Gender and/or Block (all Fs < 1.36, all ps > 0.26, see Figure 4C illustrating the null findings for Brooding only). Similarly, Brooding and Reflection also did not predict amplitude of the FRN difference wave (FRN_{diff}; all Fs < 1.21, all ps > 0.28; see Supplemental Section S2.1). An exploration of the effects of Brooding and Reflection on FRN_{neg} and FRN_{diff} change scores also yielded null effects (all Fs < 2.40, all ps > 0.13).

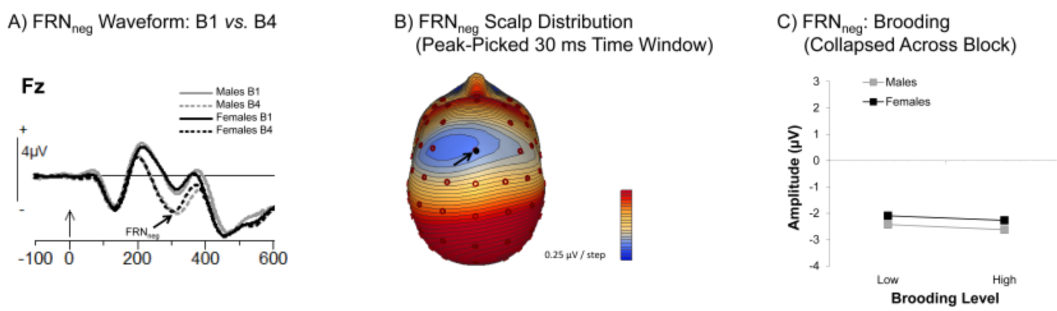

Figure 4. Feedback-Related Negativity in Response to Errors (i.e., FRN_{neg}). (**A**) FRN_{neg} grand mean waveforms plotted at Fz for the first (B1) and last (B4) blocks, as a function of Gender; (**B**) Scalp distribution of the FRN_{neg} for all participants, collapsed over all four blocks. The arrow points to Fz, which is highlighted in black; (**C**) Null effects of Brooding on FRN_{neg} amplitude.

Late Positive Potential (LPP). Figure 5A shows the LPP to negative feedback (LPP_{neg}) as a function of Gender and Block (Block 1 *vs.* 4) at the midline parietal electrode (Pz), a representative site that illustrates effects on both the early (400–600 ms) and later (600–1000 ms) aspects of this waveform (Figure 5B,C; see also Supplemental Section S2.2).

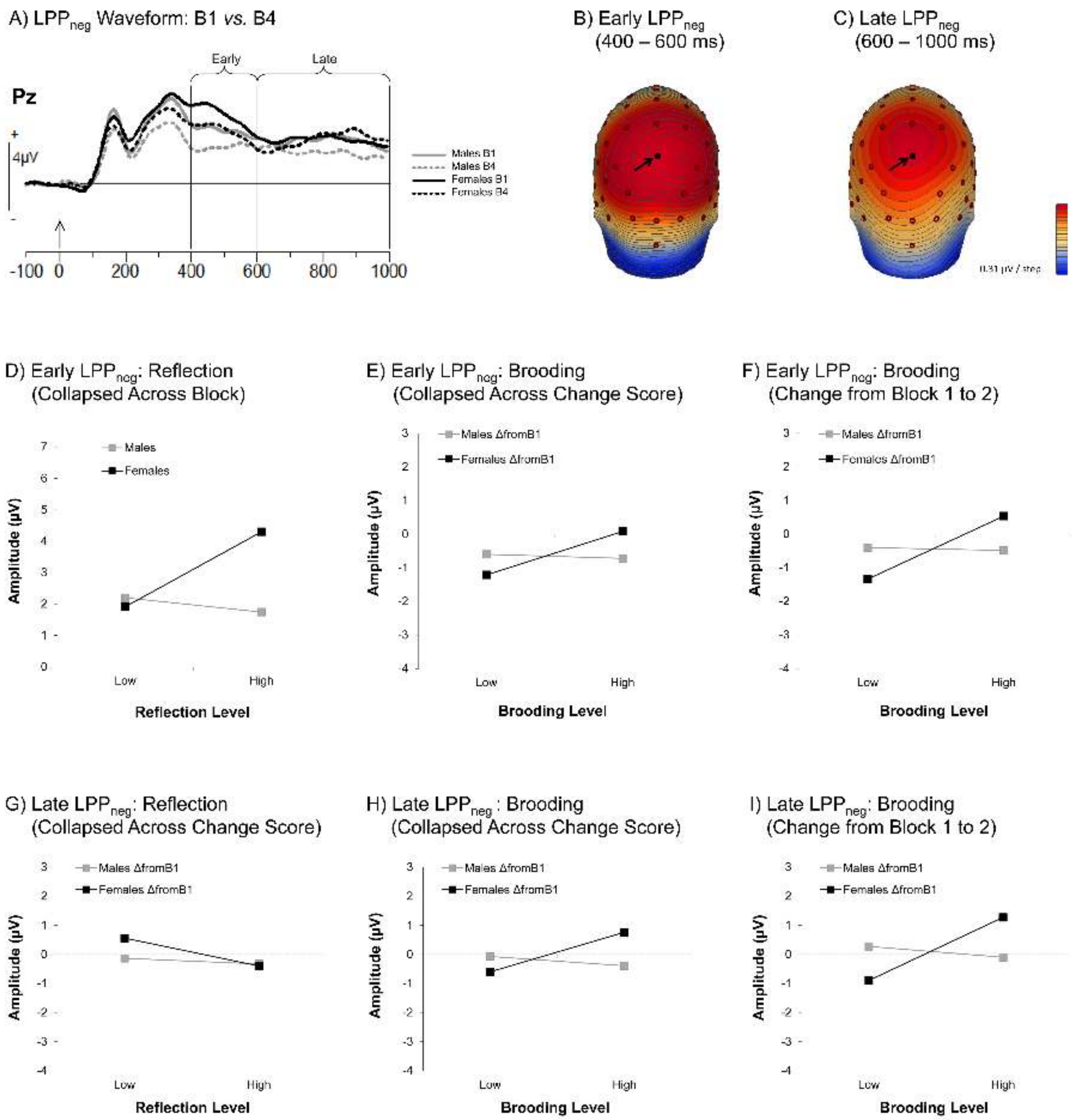

Figure 5. Late Positive Potential in Response to Errors (i.e., LPP_{neg}) as a Function of RRS and Gender. (**A**) Early (400–600 ms) and Late (600–1000 ms) LPP_{neg} grand mean waveforms plotted at Pz for the first (B1) and last (B4) blocks. (**B**,**C**) Scalp distribution of the LPP_{neg} in the early and late periods, respectively, for all participants, collapsed across all four blocks. The arrows point to Pz, which is highlighted in black. (**D**) Effects of Reflection on early LPP_{neg} amplitude. Effects of Brooding on change in early LPP_{neg} amplitudes between Block 1 and subsequent blocks (**E**), and during the change from Blocks 1 to 2 only (**F**). (**G**) Main effect of Reflection on late LPP_{neg} amplitude. Effects of Brooding on change in late LPP_{neg} amplitudes between Block 1 and subsequent blocks (**H**), and during the change from Blocks 1 to 2 only (**I**).

The Early LPP_{neg}. The amplitude of the early LPP_{neg} was larger overall for women than men, $F(1, 32) = 8.13$, $p < 0.01$, $\eta_p^2 = 0.20$. However, this gender difference was moderated by Reflection, $F(1, 32) = 5.54$, $p < 0.05$, $\eta_p^2 = 0.15$, in that the women with a greater tendency to Reflect demonstrated an enhanced early LPP_{neg}, $\beta = 0.63$, $t = 2.41$, $p < 0.05$, $\eta_p^2 = 0.15$ (see Figure 5D). Assessment of this effect also indicated that women with lower Reflection scores exhibited an early LPP_{neg} similar to that of men, whose early LPP_{neg} did not differ as a function of Reflection.

Although this finding is consistent with the general prediction that the LPP_{neg} would be the ERP response particularly sensitive to rumination, particularly in women, it contrasts with our prediction that Reflection would down-regulate (reduce) this response. In addition, our prediction that this effect would interact with time in the task was not upheld, as there were no interactions involving both Reflection and block (all Fs < 1.86, all ps > 0.14.). Indeed, no significant effects of Reflection were found when we conducted a Change score analysis, further supporting the view that this gender-specific Reflection effect occurred consistently across the task, including as early as Block 1.

The relationship between Reflection and early LPP_{neg} amplitude in women did not appear to change across the task; however, we did find a significant overall effect of Block, $F(3, 96) = 12.33$, $p < 0.001$, $\eta_p^2 = 0.28$, coupled with a significant downward linear trend, $F(1, 32) = 25.92$, $p < 0.001$, $\eta_p^2 = 0.45$ (see also Supplemental Section S2.2.1), supporting the impression that the early LPP_{neg} became attenuated as the task progressed (see also Table 4). In contrast to Reflection, however, Brooding interacted with this Block effect, as well as Gender, as indicated by a significant 3-way interaction, $F(3, 96) = 3.98$, $p < 0.05$, $\eta_p^2 = 0.11$. Specifically, exploration of parameter estimates uncovered a *negative* relationship between Brooding and early LPP_{neg} for women that was strongest in Block 1 ($\beta = -0.52$) and weakened across all remaining blocks (Block 2: $\beta = -0.07$, Block 3: $\beta = -0.45$, Block 4: $\beta = -0.17$), although no parameter estimates for individual blocks survived Holm-Bonferroni correction.

When we used Change scores to explore this apparent weakening further, however, we found a marginal 2-way interaction of Brooding by Gender, $F(2, 64) = 3.95$, $p = 0.06$, $\eta_p^2 = 0.11$, and a significant 3-way interaction of Brooding, Gender, and Change, $F(2, 64) = 3.99$, $p < 0.05$, $\eta_p^2 = 0.11$. *Post hoc* exploration of the 2-way interaction indicated that a greater tendency toward Brooding in women predicted less attenuation of the early LPP to error signals across all change periods compared to the Block 1 baseline period, $\beta = 0.70$, $t = 2.17$, $p < 0.05$, $\eta_p^2 = 0.13$ (Figure 5E). When pursuing the source of the 3-way interaction, we found that this effect was driven primarily by the ΔB1-to-B2 period, $\beta = 0.83$, $t = 3.09$, $p < 0.05$, $\eta_p^2 = 0.23$ (Figure 5F).

The Late LPP_{neg}. When considering how RRS sub-scores related to the late LPP_{neg}, we found evidence that both trait Reflection and Brooding influenced the amplitude of this waveform. However, whereas the effects of Brooding were largely similar across the early and late LPP_{neg}, there were some important differences with regard to Reflection.

Effects involving both RRS subscales were found to differ as a function of both Gender and Block (Reflection, $F(3, 96) = 2.69$, $p = 0.05$, $\eta_p^2 = 0.08$; Brooding: $F(3, 96) = 4.76$, $p < 0.005$, $\eta_p^2 = 0.13$). These three-way interactions subsumed marginally significant 2-way interactions with both Block (Brooding: $F(3, 96) = 2.43$, $p = 0.07$, $\eta_p^2 = 0.07$), and Gender (Reflection: $F(1, 32) = 3.84$, $p = 0.06$, $\eta_p^2 = 0.11$; Brooding: $F(1, 32) = 3.67$, $p = 0.06$, $\eta_p^2 = 0.10$). To put these 3-way interactions with Gender and Block in perspective, we note that they occurred despite no overall effect of Gender, or a 2-way interaction between Gender and Block (all Fs < 2.32, ps > 0.14). As with the early LPP_{neg}, however, there was still a significant main effect of Block, $F(3, 96) = 2.72$, $p < 0.05$, $\eta_p^2 = 0.08$, corresponding to a significant downward linear trend in the amplitude of this waveform as the task progressed, $F(1, 32) = 4.29$, $p < 0.05$, $\eta_p^2 = 0.12$.

In prior analyses involving key variables, we have repeatedly found that the analysis of Change scores produced a clearer understanding of the interactions involving time on task than those involving Block; thus, with the goal of simplifying our analyses, we chose to move directly to Change scores for analysis of the late LPP_{neg}. In doing so, we found that both RRS subscales exhibited 3-way interactions with Gender and Change (Reflection: $F(2, 64) = 3.18$, $p < 0.05$, $\eta_p^2 = 0.09$; Brooding: $F(2, 64) = 3.74$, $p < 0.05$, $\eta_p^2 = 0.11$). In addition, we found a significant 2-way Gender by Brooding interaction, $F(1, 32) = 7.33$, $p < 0.05$, $\eta_p^2 = 0.19$.

For Reflection, none of the *post hoc* comparisons examined in the process of unpacking the 3-way interaction reached significance after Holm-Bonferroni correction, with only the ΔB1-to-B2 parameter estimate for women approaching even marginal significance, $\beta = -0.64$, $t = 2.45$, $p = 0.12$, $\eta_p^2 = 0.16$. When coupled with a marginal main effect of Reflection, $F(1, 32) = 3.30$, $p = 0.08$, $\eta_p^2 = 0.09$, also showing a negative parameter estimate ($\beta = -0.26$; see Figure 5G), we can infer that the early and late LPP_{neg} were influenced by Reflection in different ways. In this later portion of the LPP_{neg}, a tendency toward Reflection did not heighten the LPP response, and rather may have somewhat attenuated it.

The effects of Brooding on the late LPP_{neg} change scores, on the other hand, were more similar to the pattern found for the early LPP_{neg}. Consistent with findings for the early LPP_{neg}, exploration of the significant 2-way interaction indicated that women's Brooding scores predicted less overall attenuation in the late LPP_{neg} compared to baseline, $\beta = 0.72$, $t = 2.61$, $p < 0.05$, $\eta_p^2 = 0.18$ (Figure 5H). When we additionally addressed the 3-way interaction indicating that this Gender by Brooding interaction varied across Change score, we found these effects were once again driven primarily by reduced attenuation in sustained attention to error signals during Block 2 relative to Block 1, $\beta = 0.96$, $t = 3.67$, $p < 0.01$, $\eta_p^2 = 0.30$ (Figure 5I).

Learning Error Related Negativity (LERN). Figure 6A illustrates effects of Gender and Block (Block 1 *vs.* 4) on the LERN at CB1, a site at the convergence of both posterior and left hemisphere regions (see also Figure 6B). These regions were the most sensitive to overall subsequent memory effects (see Supplemental Section S2.3).

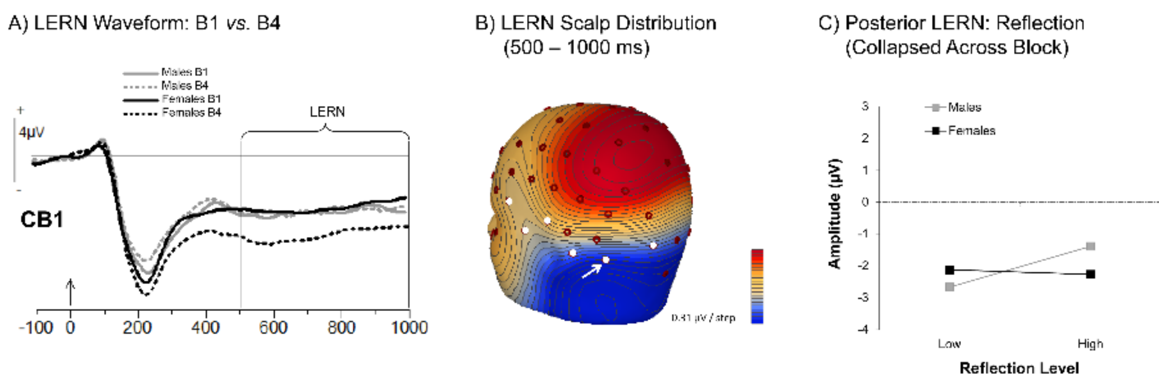

Figure 6. Learning Error-Related Negativity (LERN). (**A**) LERN grand mean waveforms plotted at CB1 for the first (B1) and last (B4) blocks, as a function of Gender; (**B**) Scalp distribution of the LERN plotted for all participants, collapsed across all four blocks. Left hemisphere electrodes included in the analysis are highlighted in white, with an arrow pointing to CB1; (**C**) Null effects of Reflection on Posterior LERN amplitude.

As illustrated by Figure 6A, women's LERN became more negative-going subsequent to Block 1, whereas men evidenced no such change. This observation was corroborated by *post hoc* comparisons following significant Gender by Block interactions found at both the posterior-inferior electrode cluster, $F(3, 96) = 5.32$, $p < 0.005$, $\eta_p^2 = 0.14$, and left hemisphere electrode cluster, $F(3, 96) = 3.64$, $p < 0.05$, $\eta_p^2 = 0.10$. The finding that women's Block 1 was different from all subsequent blocks was further substantiated by a Change score analysis, which found only a main effect of Gender, $F(1, 32) = 10.43$, $p < 0.005$, $\eta_p^2 = 0.25$.

In contrast to predictions that RRS might directly influence encoding of the correct answer, neither Brooding nor Reflection demonstrated any relationship to either the posterior-inferior or left hemisphere LERN waveforms (Brooding: all *F*s < 0.09, all *p*s > 0.76; Reflection: all *F*s < 1.42, all *p*s > 0.24; see Figure 6C illustrating the null findings with the left hemisphere LERN for Reflection only). Exploratory analyses using Change scores also rendered no significant effects involving either RRS sub-score in either region (all *F*s < 1.45, all *p*s > 0.24).

Discussion

The present study sought to investigate how cognition and emotion interact to influence the ability to learn and rebound from failure in the context of a challenging general knowledge task. Toward this end, undergraduates' trait levels of Brooding and Reflection rumination were used to predict both subjective and event-related potential (ERP) responses to negative feedback, as well as the ability to use this feedback to correct errors on a subsequent surprise retest. We further explored whether any effects of rumination might be moderated by the gender of the student and the length of time the student experienced persistent failure in the task. These findings could serve to clarify the role that different sub-types of rumination play in the important academic challenge of learning after failure, as well as the potential cognitive and affective mechanisms underlying these effects.

Our conceptual approach was guided by Martin and Tesser's Control Theory (Martin & Tesser, 1989, 1996), which proposes that the rumination that arises in response to blocked goals can either hurt or help goal-oriented processing depending on whether attention is directed toward active, concrete means for problem solving (Reflection) or situated on one's mood and problem history (Brooding). In support of the view that Reflection can be adaptive, we found that it positively influenced retest error correction. However, in contrast to this theory's predictions, no negative (or positive) learning-related effects were found for the more passive style of Brooding. Nonetheless, despite the selective effects of Reflection on our measures of rebound from failure, Brooding and Reflection were both related to other key task variables, including first-test performance, subjective experiences in the task, and the late positive potential (LPP) to negative feedback—the ERP waveform we expected to be the most sensitive to rumination. For some of these measures (i.e., first-test performance, FAEs, and the late LPP_{neg}), Brooding and Reflection largely acted in expected, opposing ways to one another (or one acted in the expected direction and the other showed a null effect or trend in the opposite direction). Interestingly, for other measures (i.e., RNTs and the early LPP_{neg}), they exhibited more similar patterns.

With regard to the potential moderating influences of time on task and gender, we also found that these factors generally influenced the effects of Brooding and Reflection differently. For example, significant Brooding effects were only found when referencing later task blocks to the initial block (i.e., Change scores), suggesting that Brooding was most likely to emerge as a robust predictor after students had experienced persistent failure (due to the titration by the program) for a period of time. In contrast, with the exception of the effects on retest performance and the late LPP_{neg}, the influence of Reflection occurred across the task as a whole, being equally evident during the initial blocks as during later ones. Finally, whereas the majority of Reflection-related effects did not differ as a function of gender, gender-specific effects were found for all relationships involving Brooding. In the discussion that follows, we address these findings in detail, highlighting the differential sensitivity of Reflection and Brooding to cognitive and affective measures, as well as to gender and time on task.

Reflection Benefits First-Test and Retest Memory

A tendency toward thinking about and purposefully analyzing the causes and outcomes of negative events (i.e., Reflection) was associated with positive memory outcomes at both the first-test and retest. At first-test, trait Reflection predicted better performance for women, who as a group had performed at a lower level than men in their ability to generate correct answers to general knowledge questions. Indeed, women with higher levels of Reflection had levels of first-test performance within the range of men, whose performance did not appear to be influenced by rumination. Given that first-test performance was titrated by presenting the more difficult items from our question pool when students began performing above the target level (35%), these findings suggest that those women who reported higher trait Reflection were able to answer more difficult questions. Thus, it is possible that Reflection provided a protective or even facilitative effect for semantic retrieval in the face of persistent failure during the task. However, it is also possible that students with higher Reflection scores simply had higher levels of pre-existing semantic knowledge.

More direct support for the positive influence of Reflection on memory encoding and retrieval comes from our analysis of retest performance. These analyses, which controlled for performance at first-test, demonstrated beneficial effects of trait Reflection on rebound from failure in both men and women. Specifically, students who indicated they were more likely to Reflect in the context of negative situations were more likely to show improvement (or at least no decrement) in their ability to rebound from failure during the later blocks of the test compared to the initial block. For men, this manifested as higher Reflection scores mitigating the general tendency to show poorer error correction as the task progressed. For women, a trait tendency to Reflect was associated with greater improvements in error correction in the remainder of the task. Taken together, these results suggest that Reflective rumination allows individuals to maintain task-related effort in the face of challenge and failure, and is consistent with other research finding it to be associated with less distraction and interference by self-relevant stimuli (Daches, Mor, et al., 2010).

Brooding was associated with marginally poorer first-test performance in women, but somewhat surprisingly, had no negative impact for either men or women on the ability to overwrite these incorrect answers and provide the correct responses at retest. This null effect for Brooding on learning the correct answer (and inhibiting retrieval of the incorrect answer) appears to contrast with previous studies where Brooding was found to impair the ability to update memories in the presence of emotional stimuli (Bernblum & Mor, 2010), or otherwise inhibit no-longer-useful material (De Lissnyder, Derakshan, De Raedt, & Koster, 2011; De Lissnyder, Koster, Derakshan, & De Raedt, 2010). Although the failure to find a retest effect might be due to power issues stemming from our relatively small sample size, significant effects of Brooding did emerge elsewhere within this task, including effects on subjective experiences and ERP responses to errors. Thus, if an effect on error correction was masked by low power, then the effect size was most likely fairly small. Alternatively, presentation of the correct answer a few seconds after the negative feedback may actually have given brooding students an external stimulus that reoriented their attention, pulling them out of the negative mindset induced by the negative performance feedback.

Hertel and colleagues (Hertel, Benbow, & Geraerts, 2012) found that brooders were equally as likely as non-brooders to later freely recall target words when a trigger for rumination was interrupted by a cue to interact with (i.e., type) the word, bringing attention back to the target stimulus. However, brooders recalled fewer words when a cue to brood came after interaction with the word, perhaps because it disrupted focus on encoding. In the current task, presenting the correct answer after the negative feedback may have afforded brooders an explicit opportunity to redirect their attention externally toward corrective information. By this view, it is possible that if we had presented the correct answer simultaneously with the negative feedback (i.e., as during the retest), brooders might have been more likely to focus attention on the negative outcome and directed attention internally to the feelings generated by it. If this internal focus came at the expense of externally-focused attention to the correct answer, such interference might have more likely resulted in Brooding-related impairments in rebound from failure.

If, for students with higher trait Reflection, corrective feedback may not have simply served as a distractor from negative thoughts, but rather, may have provided information directly relevant to their goal of purposefully thinking about and analyzing the causes of the error, we might expect Reflection-related modulation of the ERP response to the corrective feedback itself. However, no such relationship was found, at least when examining the portions of this waveform that demonstrated sensitivity to subsequent memory in our validation analysis (Supplemental S2.3; see also (Butterfield & Mangels, 2003; Mangels et al., 2006). Although it is not clear why this relationship was lacking, it is possible that Reflection modulated encoding-relevant processes at sites or epochs other than the sites where memory-related processes were most evident in the sample as a whole. Additionally, it is important to consider that error correction on the retest is related to many factors that include not only how well items were initially encoded, but also post-encoding consolidation, as well as processing at the time of retest retrieval. Given that we measured rumination as a trait tendency, it is possible that such a habitual style of responding could have impacted these consolidation and/or retrieval processes, as well.

To our knowledge, only one other study has measured the influence of rumination on the use of feedback to improve performance in a similar type of sample (Ciarocco et al., 2010). In that study, following the presentation of false negative feedback after an attempt to complete a set of simple tasks (e.g., declaring creative uses for various objects, finding words in a word search task), the authors found that inducing action-focused rumination (e.g., instructing participants to think about how to their improve performance) *versus* state-focused rumination (e.g., instructing participants to think about how their poor skills on that task might impact their future) resulted in better performance on a second attempt at the task. State-focused rumination, if anything served to impair subsequent performance. To the extent that action- and state-focused rumination are similar to Reflection and Brooding, respectively, our findings echo their results, but also show how these types of effects may manifest as a function of trait rumination and in a task where learning is central.

Brooding and Reflection Influence Thoughts and Feelings in Response to Negative Feedback

To understand the effect of rumination on how students processed failure signals in this challenging task, we measured students' response to negative feedback using both subjective self-reports and neural correlates previously associated with error detection (FRN; Simons, 2010) and motivated attention to arousing events (LPP; Hajcak, MacNamara, & Olvet, 2010). Reflection was associated with significant increases in recurring negative thoughts (RNTs), and Brooding with marginal increases. These effects could be viewed simply as a type of manipulation check showing that the task was effective in evoking ruminative tendencies in participants more predisposed to ruminate. Notably, however, Reflection influenced this type of thinking throughout the task, for both genders, whereas the marginal effects of Brooding were only found when referencing later blocks to the first block (i.e., Change scores) and only in women. These different patterns might have arisen because our measure of RNTs focused only on the quantity of these thoughts rather than the specific content of these thoughts. In other words, the content of the thoughts might have been different for those high in Reflection and Brooding, consistent with the differences in analytical *versus* affective thinking characterizing these sub-types of rumination. Indeed, students' feelings after errors (FAEs), a more affectively-focused measure, was only influenced by Brooding. For women, we found evidence of the expected pattern of relatively more negative FAEs for higher Brooding as the task progressed. Surprisingly, however, Brooding was associated with significantly less negative (more neutral) FAEs as the task progressed for men. As this is a self-report measure, it is not clear whether this finding indicates that men who were higher in Brooding were attempting to regulate negative feelings through affective disengagement or whether they might have been presenting a false front to mask actual distress from the persistent negative feedback of this task (see also Nolen-Hoeksema & Jackson, 2001).

Turning to ERP measures, which presumably would be less influenced by demand characteristics, we found no effects of either rumination sub-type in either gender on our earliest marker of error processing, the FRN. The lack of rumination effects on the FRN is consistent with our earlier prediction that rumination would modulate processes occurring after initial error detection, rather than those associated directly with the detection itself. Rumination is typically conceptualized as a reactive response to negative outcomes, rather than anticipatory vigilance for them, as would be more typical of worry (Borkovec, Hazlett-Stevens, & Diaz, 1999; McLaughlin, Borkovec, & Sibrava, 2007). Although null effects are always subject to criticisms regarding power and sensitivity, we note that this component was enhanced in men with higher pre-task depression (see Supplemental Section S1). This finding is consistent with past research finding the FRN to be sensitive to depressive mood (Santesso et al., 2008; Tucker, Luu, Frishkoff, Quiring, & Poulsen, 2003), and lends support for the view that the FRN in the current study is otherwise representative of the typical FRN. Interestingly, we also found that the task-wide FRN_{neg} was enhanced in men who reported more neutral FAEs on average (see Supplemental Section S3), paralleling the paradoxical finding that Brooding was associated with increasingly more neutral FAEs. Taken together, these results suggest that the more salient the negative feedback, the more men were motivated to self-report that they were not negatively affected by this feedback.

With regard to the LPP_{neg}, we found that for women, the early portion (400–600 ms) was similarly enhanced by both Reflection and Brooding, whereas the later portion (600–1000 ms) demonstrated a significant enhancement by Brooding in women, and a marginal attenuation by Reflection in both genders. Moreover, the significant effects of Reflection on the early LPP_{neg} were found across the task as a whole, whereas the effects of Brooding on both the early and late LPP_{neg} only emerged when examining Change scores. Indeed, they were most pronounced in the block immediately following the initial block (i.e., ΔB1-to-B2). Generally speaking, the emergence of rumination effects on the LPP, but not the FRN, corroborates behavioral findings showing that ruminators, and brooders in particular, tend to exhibit heightened arousal and/or protracted attention to negatively-valenced information (e.g., Donaldson et al., 2007). The LPP is thought to represent activity in extrastriate cortex that is amplified by feedback connections from the amygdala (Sabatinelli, Lang, Keil, & Bradley, 2007). Correspondingly, past fMRI research has shown that ruminators demonstrate increased and prolonged neural activity in the amygdala, a subcortical, limbic brain structure responsible for emotional processing when viewing emotional stimuli (Ray et al., 2005; Siegle, Steinhauer, Thase, Stenger, & Carter, 2002).

The LPP has been shown to index not only spontaneous and passive (i.e., bottom-up) responses to motivationally-relevant stimuli (Codispoti, Ferrari, & Bradley, 2007), but also more active and deliberate (i.e., top-down) cognitive and affective appraisals (Hajcak, Moser, & Simons, 2006). Research on the time course of the LPP has shown that modulation by bottom-up perceptual processing of emotionally evocative stimuli can occur as early as 160 ms post-stimulus onset, whereas more active, top-down control over this emotional reaction (e.g., down-regulation through cognitive reappraisal) becomes apparent just after 600 ms (Hajcak et al., 2009). Thus, it appears that women's tendency towards Brooding facilitated a rapid "bottom-up" increase in arousal and attention to negative feedback (i.e., early LPP), followed by further up-regulation of sustained attention and arousal (or at least prevention of the normal habituation to these signals) through top-down processes. Reflection, on the other hand, facilitated the rapid, "bottom-up" orienting response to negative outcomes, but unlike Brooding, it may have acted in a "top-down" fashion to down-regulate, or at least prevent further sustained arousal to this stimulus.

Differential Effects of Brooding and Reflection as a Function of Time on Task

Significant effects of Brooding emerged only after participants had experienced failure in the initial block. Specifically, the significant impact of this ruminative style on both subjective self-reports and the LPP_{neg} was only found when referencing later blocks against the initial block (i.e., Change scores). In addition, whereas the effects of Brooding on feelings (FAEs) were found to be similar across all Change scores as the task progressed, both the early and late LPP_{neg} appeared to show a particularly rapid reversal between the effects of Brooding in the initial block and the following block (Block 2). In contrast, significant effects of the Reflective style of rumination on first-task performance, RNTs and the early LPP_{neg} were apparent across the task as a whole. Only the influence of Reflection on error correction and the marginal impact on the late LPP_{neg} showed an effect that emerged through Change scores.

To understand why these different patterns occurred it is useful to consider that we employed an "adaptive task" in which a titration algorithm created a persistent level of challenge and failure throughout the task, for all students, regardless of either their pre-existing knowledge or their in-task efforts. Students would have only become aware the constant difficulty of the task as they made their way through the first block, however, and found that whatever attempts they made to garner a higher percentage of correct responses were simply met with harder questions. Thus, from the perspective of the student, as the task progressed they not only may have been blocked in their general goal of performing well on the task, but also in improving their performance with increased effort. Brooding, which relates to a more passive fixation on the negative mood caused by a blocked goal, may have been particularly evident in the context of this additional goal discrepancy, when active strategies to improve performance failed. In contrast, for those with a tendency toward Reflection, even initial encounters with negative feedback triggered increases in RNTs and bottom-up attention toward negative feedback (i.e., early LPP_{neg}), leading these effects to emerge consistently across the task. However, when additional goal challenges compounded as the task progressed, the more action-focused ruminative style of those higher in Reflection may have been particularly useful for fostering more adaptive responses (i.e., no greater up-regulation of the late LPP_{neg}, enhanced error correction).

To our knowledge, this is the first study to demonstrate time-based effects of either rumination sub-type within a single task. However, other studies indirectly support the view that time is a key factor in understanding the effects of rumination. First, rumination itself may persist over long periods, particularly when individuals feel far from attaining their goals, whether due to poor task performance or lack of task completion (e.g., Lassiter, Pezzo, & Apple, 1993; Martin, 1986). Furthermore, according to Martin and Tesser (1996), rumination and its influence on affect and cognition may become exacerbated over time depending on how one appraises goal blockage. For instance, viewing an inability to attain a short-term, lower-order goal (e.g., losing weight) as indicative of being unable to achieve a longer-term, higher-order goal (e.g., happiness, well-being) may actually interfere with the ability to attain both short-term and longer-term goals (McIntosh & Martin, 1992).

Differential Effects of Brooding and Reflection as a Function of Gender

It was notable that all Brooding-related effects showed gender differences, whereas gender effects were more mixed for Reflection. Specifically, for women only, Brooding resulted in less habituation of the early LPP_{neg} and greater up-regulation of the late LPP_{neg}. It also marginally impaired women's first-test performance and resulted in a trend toward increased RNTs and greater negative affect following errors. As discussed previously, the only significant effect of Brooding observed for men suggested that this sub-type of rumination led to decreased, rather than increased, negative feelings about errors—an effect in the opposite direction to that found for women. These women-specific effects of Brooding extend earlier clinically-focused work showing that dysphoric women ruminators are particularly vulnerable to depression and other negative consequences (e.g., perceived lower mastery over life events, increased chronic stress; Nolen-Hoeksema, Larson, & Grayson, 1999), as well as other empirical evidence that rumination tends to influence affect, cognition, and behavior primarily for women (Johnson & Whisman, 2013; Nolen-Hoeksema, 1987, 1990). In contrast, the Reflection-related enhancements observed for error correction outcomes and RNTs were not gender-specific, suggesting that men and women were equally able to use the adaptive aspects of Reflective rumination in the service of encoding corrective information and overcoming failure.

Past studies have noted that women are less likely than men to feel "in control" of their emotions and more likely to turn to rumination as a means of gaining back some control, even if in practice it does not necessarily serve as an adaptive means of emotion regulation (Nolen-Hoeksema & Jackson, 2001). In our present study with non-depressed women, however, there were no gender differences in pre-test Brooding or Reflection RRS sub-scores or the quantity of self-reported RNTs during the task. Thus, the lack of negative Brooding effects in men does not appear to stem simply from a quantitatively lower level of rumination. However, this does not rule out the possibility that the content and/or the manner of men's rumination differed from that of women participants. Some qualitative difference might underlie why Brooding enhanced the overall pattern of men's growing indifference (i.e., neutrality) to negative feedback (i.e., FAEs), whereas for women, it maintained their pattern of continual concern and unpleasant feelings. Some studies show that men demonstrate greater challenges in recognizing, attending to, and interpreting negative emotional information compared to women (Thayer & Johnsen, 2000; Thayer, Rossy, Ruiz-Padial, & Johnsen, 2003). Thus, scores on the Brooding scale may be less sensitive to measures in our task for men compared to women because the RRS asks respondents to merely consider *hypothetically* how they would ruminate over emotional events, and men can find these kinds of emotional judgments difficult (Thayer & Johnsen, 2000).

Conclusions

Extending Martin and Tesser's Control Theory (Martin & Tesser, 1989, 1996), the findings from the current study support the view that the more deliberate and concrete thinking associated with the Reflection sub-type of rumination serves to prevent sustained up-regulation of arousal to negative self-relevant information, and yields better outcomes for rebounding from failure (see also; Nolen-Hoeksema et al., 2008; Treynor et al., 2003). In contrast, the state and mood-focused Brooding sub-type enhances women's attention to signals indicating blocked goals (i.e., negative feedback), particularly as these blockages persist and compound over time. Although Brooding did not have immediate effects on women's (or men's) ability to remediate errors in the present study, it is possible that over time, desire to avoid this greater arousal to negative feedback would adversely affect the motivation to engage in challenging tasks where negative feedback might be anticipated. It would be worthwhile to extend both of these findings further by testing the longitudinal effects of rumination on learning and rebound from failure (e.g., over the course of an academic semester or school year; see also Sakamoto, 2001), particularly in STEM fields where stereotype threat might exacerbate Brooding ruminative tendencies in women (Beilock et al., 2007; Mangels et al., 2012).

Even though these findings are largely aligned with patterns of rumination effects found elsewhere, they extend them in important ways. First, in addition to providing evidence for the general sensitivity of the LPP to rumination on failure signals (see also Mangels et al., 2012), the high temporal resolution of ERPs afforded the ability to dissociate the effects of Brooding and Reflection on putative correlates of bottom-up and top-down attention. Specifically, although the bottom-up salience of negative feedback was enhanced for both sub-types of rumination, through top-down processes (i.e., late LPP_{neg}), Brooding further up-regulated women's attention to this feedback, whereas Reflection showed some evidence of down-regulating this response. Second, we were able to demonstrate these and other meaningful cognitive and affective effects of rumination in an academically-relevant task and in non-depressed students. This supports the view that rumination not only has implications for clinical outcomes, but may contribute important non-cognitive variance to student outcomes, particularly when students experience persistent challenges to their goals of performing well.

CHAPTER 3: Introduction to State Rumination

Overview

Study 1 in this research program examined how one's trait tendency to exhibit Brooding and Reflective styles of rumination would predict performance in a challenging academic task, modulate attention to errors, and impact the ability to learn and rebound from failure (Whiteman & Mangels, 2016). Interestingly, recent attempts to understand how individuals come to exhibit these trait ruminative styles have focused on understanding the link to state rumination (Watkins & Nolen-Hoeksema, 2014). Specifically, Watkins and Nolen-Hoeksema proposed that the *trait tendency* to ruminate is born over time out of contexts in which goal-state discrepancies are repeatedly met with a *temporary state* of rumination. That is, long before rumination becomes habitual to the point of being expressed as a trait, individuals may find themselves temporarily in a context that readily welcomes this kind of thinking. In these contexts, the way in which attention is deployed to information, both in the external environment and with regard to internal thoughts, may be very similar to that experienced by those expressing a trait tendency to ruminate. Repeatedly experiencing these momentary states of ruminative responsiveness is then proposed to be fundamental in establishing (for better or worse) internally generated biases in how attention will be subsequently deployed in the face of future negative moods and difficult life events.

Considering contemporary theory that links momentary and habitual forms of ruminative thought (e.g., Watkins & Nolen-Hoeksema, 2014), it is reasonable to speculate that state rumination might exert effects in a comparable manner to trait rumination in the face of cognitive challenges such as academic failure. However, other research suggests that the effects of inducing a state of rumination may rely on one's current mood state (e.g., Nolen-Hoeksema, 1996), or on the focus of the ruminations, themselves (e.g., Johnson et al., 2006), suggesting that the implications of experiencing a momentary ruminative state in a challenging academic setting may differ compared to when rumination is expressed through trait tendencies. Indeed, the consequences of exhibiting trait ruminative responsiveness often tend to persist *over and above* the effects of one's affective state or current goal set (e.g., Joormann, 2006; Whitmer & Banich, 2007).

To directly address the influence of state rumination on learning in the context of failure, Studies 2 and 3 will test the impact of two established methods of inducing a ruminative state on the ability to correct errors in a challenging academic environment that is already likely to welcome recurrent self-focus. While the research to date involving similar induction methods (particularly that of Study 2) has focused primarily on characterizing how rumination may develop as a transdiagnostic factor that can lead to a wide range of mental health issues (Aldao & Nolen-Hoeksema, 2010; Nolen-Hoeksema & Watkins, 2011), the present studies will serve to better elucidate how cognitive mechanisms associated with feedback-based learning are affected by a style of thinking purported to be very common even among mentally healthy individuals (Martin & Tesser, 1996; Moberly & Watkins, 2008). These investigations will consider how the inductions influence cognition over and above current mood state and trait rumination tendencies. Below we will first introduce some of the issues common to both induction studies, and then provide details regarding the background and motivation specific to each individual study.

Inducing rumination versus distraction

Rumination induction methods have most typically been employed in research with a clinical focus, and such work has primarily discovered adverse effects for individuals who are concurrently in a depressive mood state (for a review see Nolen-Hoeksema et al., 2008). This is because ruminating over a depressed mood and negative life events tends to up-regulate arousal levels and direct attention to the meanings, causes, and consequences of one's problems and current depressive symptoms (Moberly & Watkins, 2010; Nolen-Hoeksema & Morrow, 1991; Siegle et al., 2002). In experimental studies of rumination, an induced state of rumination is often pitted against an induced *state of distraction*, particularly because the act of distracting oneself momentarily from one's mood and problems has been theorized as a useful means for dealing with such difficulties and tempering the effects of rumination (Nolen-Hoeksema, 1991). From a mechanistic perspective, distraction may therefore serve as an adaptive emotion regulation strategy (e.g., McRae et al., 2010), helping to down-regulate negative affect and redirect attention onto actions or objects of thought that are external to the self.

A few fMRI studies involving experimental induction methods have helped to identify the neural substrates associated with being in state of rumination versus distraction (Cooney, Joormann, Eugène, Dennis, & Gotlib, 2010; Johnson, Nolen-Hoeksema, Mitchell, & Levin, 2009). In these two studies, both mentally healthy and clinically depressed individuals were given induction cues that prompted either analytical self-focus (state rumination condition) or mental visualization of external events (state distraction condition). Importantly, these studies discovered neural regions more active in rumination than distraction. Some of these were *common* to the mentally healthy and clinically depressed populations. Regions in common primarily included posterior midline brain areas (i.e., parts of the anterior medial parietal lobe, including the precuneus, cuneus, and aspects of the posterior cingulate cortex) all widely known to be linked to the default mode network (DMN; Greicius, Krasnow, Reiss, & Menon, 2003), a neural system shown to be active while individuals are engaged in some type of self-referential processing. Perhaps not surprisingly, increased activity in the DMN has also been linked with increases in trait levels of rumination among depressed individuals (Hamilton et al., 2011), and even among the mentally healthy population (Berman et al., 2010). Thus, it is conceivable that any individual induced to enter a ruminative state could encounter the kind of analytical self-focus that is typical of those who habitually exhibit a ruminative style of thinking.

However, there are also neural regions that appear to be differentially active during state rumination (compared to distraction) for depressed versus mentally healthy individuals. This suggests that the induction of state rumination may manifest differently depending on concurrent mood state. Cooney and colleagues (Cooney et al., 2010) found that compared to mentally healthy control participants, depressed individuals induced to ruminate evidenced greater activation in anterior brain regions generally associated with the generation and regulation of mood (e.g., subgenual anterior cingulate cortex, orbital frontal cortex, dorsolateral prefrontal cortex, thalamus). These researchers interpreted these activations as indicating that depressed individuals experienced the rumination induction with a greater degree of emotion compared to mentally healthy participants. Interestingly, however, Johnson and colleagues (Johnson et al., 2009) found other anterior brain regions (i.e., aspects of the medial prefrontal cortex, including the medial frontal gyrus and more caudal aspects of the anterior cingulate cortex) to be *less* active for depressed individuals in the state rumination condition compared to healthy control participants. Since these particular anterior midline regions are known to be recruited during positively-valenced and approach-oriented self-focus (Johnson et al., 2006; Sharot, Riccardi, Raio, & Phelps, 2007), these researchers took this reduction to indicate that depressed individuals may be less likely than mentally healthy individuals to spontaneously generate positive self-focused thoughts when momentarily ruminating.

Taken together, this work demonstrates that state rumination and distraction induction methods can serve as valid means for differentiating how individuals direct their thoughts during experimental research, but also that the type and/or degree of this differentiation may depend on participants' pre-existing levels of depression. As such, those in a negative mood state might be more sensitive to such an induction manipulation. Yet, while the rumination induction research to date has begun to characterize the affective consequences of being in a state of rumination, particularly for depressed individuals, less focus has been placed on the potential impact on goal-directed behavior. Critically for the purposes of the present investigations, to the extent that an internal focus of attention can interfere with encoding of external information (Kluger & DeNisi, 1996; Weinberg & Hajcak, 2011), these experimental inductions could also have downstream implications for how information is later encoded in a failure context likely to elicit self-evaluation and negative affect.

Induction methods

The two studies that follow are both aimed at using state induction methods to test how experiencing momentary bouts with rumination might impact cognitive function in mentally healthy individuals who may experience negative affect as they attempt learn and rebound from academic failure. Although these studies have similar central goals, they differ in how state rumination is induced.

In Study 2, we make use of an adaptation of the commonly employed rumination induction technique developed and used by Nolen-Hoeksema and colleagues (Nolen-Hoeksema & Morrow, 1993) in support of her Response Styles Theory (Nolen-Hoeksema, 1987, 1990). These induction prompts are designed to escort one's attention towards an abstract and self-focused style of thinking about his or her current affective state, and thus, these prompts convey particular costs to those who might already be in a depressive / dysphoric state (e.g., "Think about the possible consequences for the way you feel"; see Introduction: Study 2). Although the present studies are not focused on assessing clinically depressed participants, these rumination and distraction induction techniques should also be suitable for use with mentally healthy undergraduates who, in the current research, will repeatedly encounter negative feedback, which is likely to tax their affective state and bring about general feelings of dysphoria, distress and unease. Indeed, undergraduate participants in Study 1 reported feeling negative affect after committing errors in the general knowledge task, and this negative affect was largely maintained across the task, especially for women (Whiteman & Mangels, 2016). However, since this induction procedure is being used in a novel context, focus in this study will be placed on capturing behavioral and subjective experience measures only (i.e., no psychophysiological measures of attention or encoding will be acquired).

In Study 3, however, gaze fixation metrics from eye-tracking technology will be used to index attention to learning opportunities in the face of failure while mentally healthy undergraduates are induced into a state of rumination versus distraction. The manipulation procedure used here will differ, though, in that it will draw primarily from a technique rooted in the social-cognitive realm (i.e., Roberts et al., 2013). Central to this procedure is the long-theorized claim that bringing one's immediate and personal goal-state discrepancies into awareness causes momentary ruminative thought to come online and attention to be deployed toward related, self-relevant content (Martin & Tesser, 1996). Thus, rather than prompting participants generally towards abstract and evaluative self-focus, as in Study 2, this induction procedure will aim to direct participants' focus very specifically onto a concrete and important real-world concern that remains on-going for them (see Introduction: Study 3). For all individuals experiencing repeated bouts with failure in our general knowledge task, ruminative thoughts are likely to ensue, but they should especially become exacerbated for those who are induced to think about salient, unresolved issues of theirs in their own lives. On the other hand, individuals induced to distract themselves from both task-related and real-world concerns, may experience relief from the effects of rumination in the face of failure.

CHAPTER 4: Study 2

Introduction

Background and rationale

Nolen-Hoeksema's (Nolen-Hoeksema & Morrow, 1991) earliest empirical work in support of her Response Styles Theory used the Ruminative Responses Scale (RRS) to show that the trait tendency to ruminate is both predictive of depression and linked with a host of maladaptive cognitions about the self and how one relates to others and the surrounding environment (e.g., Nolen-Hoeksema et al., 1993; Nolen-Hoeksema et al., 1994). Because findings using the RRS are merely predictive in nature, however, Nolen-Hoeksema's subsequent empirical work used an induction technique to test whether being in a ruminative state versus a state of distraction would causally disrupt cognition and maintain negative affect for depressed individuals (Nolen-Hoeksema & Morrow, 1993). This manipulation, now a staple induction method in the rumination literature (for a review see Nolen-Hoeksema et al., 2008), asks individuals to read over and think about a series of statements designed to elicit the analytical and abstract style of self-evaluation that is characteristic of the ruminative process (e.g., "Think about the possible consequences for the way you feel"; "Think about why you react the way you do"). Individuals in the distraction condition, however, place their focus on mental images of external events (e.g., "Think about the structure of the Eiffel Tower"; "Think about raindrops sliding down a window pane"). Investigators using these induction procedures typically ask participants to dwell on these prompts one at a time, for a few minutes in total, prior to engaging in the task at hand. For operationalizing their depressed groups, investigators have used either clinical diagnoses, typical of studies assessing Major Depressive Disorder (e.g., Cooney et al., 2010; Johnson et al., 2009), or a state mood scale like the Beck Depression Inventory (BDI; Beck & Beck, 1972) for studies that assess milder forms of depression (e.g., dysphoria; Lyubomirsky et al., 2003; Lyubomirsky & Nolen-Hoeksema, 1993, 1995).

Using these manipulations, studies have generally found that rumination particularly bears its adverse impact on affect and cognition in conjunction with depression, whether for more major, clinical manifestations of it, or for more mild, sub-clinical forms. In the latter case, mildly depressed (i.e., dysphoric) individuals induced to ruminate have been shown to exhibit increased spontaneous retrieval of negative autobiographical memories, and rate these negative events as having occurred more frequently in their lives (Lyubomirsky, Caldwell, & Nolen-Hoeksema, 1998). When confronted with difficult life events, dysphoric individuals in a state of rumination are also more likely to be self-critical and under-confident, and more apt to blame themselves for their problems and be less optimistic about their future compared to either dysphoric individuals in a state of distraction or even non-depressed individuals who are induced to ruminate (Lyubomirsky & Nolen-Hoeksema, 1995). Thus, when a state of rumination is experienced concurrently with negative affect, it tends to lead to a high degree of negative thinking and self-focus that interferes with appraisals of adaptive solutions to problems and successful execution of goal-directed behavior (e.g., Lyubomirsky et al., 1999).

Moreover, Lyubormirsky et al. (Lyubomirsky et al., 2003) tested the influence of rumination on concentration and performance in academic tasks that were somewhat similar to those of the current research, although they did not test error correction (i.e., learning and rebounding from failure). Across three experiments, they found that undergraduate students who were induced to ruminate, but were also identified as concurrently being dysphoric (e.g., scores of 12 or higher on the BDI), were more impaired on executing strategic approaches to completing reading and writing tasks than either dysphoric students induced to distract or non-dysphoric students (e.g., scores of 3 or lower on the BDI) in either a state of rumination or distraction. The investigators reasoned that greater self-reported introspection and attention to negatively-valenced feelings particularly for those in the dysphoric rumination group could have reduced the availability of cognitive resources needed for optimal focus on the academic tasks. In an attempt to extend these findings to learning, Study 2 will test whether inducing a ruminative state impairs undergraduate students' ability to effectively use feedback to correct the errors they commit on our challenging task of verbal general knowledge. To assess whether pre-existing levels of depression moderate any of the anticipated effects, scores on the updated BDI-II (Beck et al., 1996b) will also be captured during the pre-test period and included in the analyses.

Importantly, Nolen-Hoeksema and Morrow (Nolen-Hoeksema & Morrow, 1993) originally constructed their rumination and distraction induction prompts to be conceptually non-specific to the individual and also emotionally neutral, and it was assumed that one's current emotional state would influence how they would be interpreted (Lyubomirsky & Nolen-Hoeksema, 1993). In the current research program, it is conceivable that even non-dysphoric individuals who begin to experience failure in our general knowledge task could construe any accompanying increases in negative affect as an indicator of difficulties in the ability to achieve the desired goal of performing well (e.g., Frijda, 1988). The repercussions of such a construal would likely welcome self-evaluative thinking, but this should be exacerbated for those induced to ruminate, particularly when they are prompted by cues intended to elicit the relatively automatic, analytical, and passive brooding style of rumination (e.g., “Think about the possible consequences of the way you feel” or “Think about how different / similar you are relative to other people”). Also, being induced to ruminate on such conceptually open-ended (i.e., abstract) cues, versus being prompted to distract oneself by focusing on concrete mental images of an external event (e.g., “Think about a double-decker bus driving down a street” or “Think about raindrops sliding down a windowpane.”), could result in an attentional focus that is directed toward the self and not toward the task (e.g., Hertel et al., 2012), minimizing the likelihood that learning opportunities will be used effectively for remedial behavior.

Study design and predictions

The current study will therefore test whether being induced to ruminate versus distract during our challenging task of verbal general knowledge will impact, either independently or interactively with depression, engagement with and successful encoding of corrective feedback as evidenced by remediation of any initial retrieval errors on a subsequent surprise retest. Toward this end, undergraduate students recruited to participate in this study will first be asked to complete the BDI-II and RRS (Treynor et al., 2003), and then be randomly assigned to either the rumination or distraction induction condition. The induction manipulation will only be introduced, however, after participants have first completed a preliminary block of general knowledge questions that will serve as a pre-induction baseline for behavior and task-related subjective-experiences. Rumination or distraction inductions will then be introduced twice – once at the outset of each of the two remaining blocks. Short surveys querying subjective experiences will be administered at the completion of each of the three blocks, and measures assessing the sensitivity of the manipulation will be acquired after each of the two induction procedures and again at completion of participants' initial pass through the general knowledge task.

We predict that while there will be no group differences in task behavior or subjective experiences during the preliminary, pre-induction baseline period (i.e., Block 1), induction of a ruminative state in Blocks 2 and 3 will worsen task-related subjective experiences and ultimately cause interference with feedback processing that impairs retest error correction, compared to the distraction condition. However, what is less certain is how these effects may unfold over time. As was predominantly discovered in Whiteman and Mangels (2016; Study 1) effects may be most prominent in Block 2 and then taper off in Block 3, perhaps due to fatigue or habituation to the task. On the other hand, effects may be evident in Block 2 but become more pronounced in Block 3 as encounters with failure continue to accrue and feelings worsen.

Regardless of how these effects unfold across the task, we also expect that the ill effects of being in a ruminative state may be exacerbated for individuals reporting higher pre-task levels of depression, as measured by the BDI-II (e.g., Lyubomirsky et al., 2003; Lyubomirsky & Nolen-Hoeksema, 1993, 1995). Additionally, state rumination and distraction effects may also be shaped by participants' predilection towards the Brooding or Reflective styles of ruminative thinking, as measured by the RRS. Indeed, research elsewhere has revealed that an increased tendency towards trait rumination has been linked with experiencing more intense bouts of state rumination (Key, Campbell, Bacon, & Gerin, 2008; Rosenbaum et al., 2017). However, additional work shows that during state distraction inductions, the trait tendency to ruminate is predictive of increased activity in brain regions subserving self-reflection, despite instructions to internally direct attention towards non-self-referential objects of thought (Johnson et al., 2009).

Thus, participants' pre-task mood state or trait levels of rumination may moderate group differences throughout the task, as well.

Finally, based on findings from Whiteman and Mangels (2016; Study 1), we expect that participants' gender may play a role in defining the effects of the induction procedure across the task. Although most experimental studies using this induction manipulation do *not* report any effects of gender (e.g., Lyubomirsky et al., 1998; Lyubomirsky et al., 2003; Lyubomirsky & Nolen-Hoeksema, 1995), other non-experimental investigations of rumination have observed that women more than men tend to ruminate over their affective state in the face of negative outcomes and difficult life events (Johnson & Whisman, 2013; Mezulis, Abramson, & Hyde, 2002; Nolen-Hoeksema & Jackson, 2001). Thus, it is possible that given the novel context in which this induction procedure is being used (i.e., a challenging academic task in which participants repeatedly encounter negative feedback), women may uniquely (or at least to a greater extent) demonstrate the anticipated deleterious effects of being in a state rumination – and this may especially be the case for those women who are in a depressive mood state or exhibit a higher trait tendency toward rumination.

Method

Participants

Ninety-eight students (48 women) were recruited from the Baruch College undergraduate population via the institution's online research participation subject pool. This sample of participants ranged from 18.1 to 28.5 years of age (M = 20.80, SEM = 0.23), and self-reported as being native English speakers or fluent by age eight, and as having normal or corrected-to-normal vision and hearing. All participants scored less than 19 (i.e., lower cut-off for moderate depression) on the BDI-II (Beck et al., 1996b) in the pre-test survey on the first day of testing. As compensation for their participation, participants either received research credit as part of a course requirement (46.9%), or they received a combination of credit and money at a rate of $10 / h (53.1%). A bonus incentive of $5 or 0.5 h of course credit was offered to all participants who returned for the second day of testing.

Some participants were excluded because critical aspects of their data did not conform to pre-determined standards. Three participants (two women) did not complete all three blocks of the general knowledge task during the time they had available on day one, while three additional men did not return for day two. Three participants (one woman) reported strongly expecting to be retested on the errors they had made on day one, and also reported studying the general knowledge material prior to their arrival for the retest, thus calling into question whether their scores on the general knowledge task would accurately index incidental learning of this semantic information. Five participants (four women) performed well above (one woman, 42.5%) or well below (three women, one man; $M = 26.9$, $SEM = .003$) the pre-determined first-test accuracy rate for Block 1 (35%) despite titration efforts, again casting uncertainty that the task at baseline was as relatively challenging for these individuals as it was for others. This was confirmed by a boxplot outlier analysis, revealing that the Block 1 accuracy rate for these five participants was outside 1.5 times the interquartile range of scores for the entire sample in this initial block. Finally, 14 participants (six women) had unusable data due to computer malfunction. Thus, in total, 28 subjects were excluded from analyses, 14 subjects (five women) from the Rumination condition and 14 subjects (eight women) from the Distraction condition.

Table 1. Study 2 Sample Characteristics. Mean scores of pre-test self-report questionnaires and demographics. Standard errors of the mean appear in parentheses in this and all other tables.

			State Rumination		**State Distraction**	
	Overall	**Range**	**Men**	**Women**	**Men**	**Women**
n	70	—	17	18	18	17
Age	20.83 (0.27)	18.05-28.52	20.70 (0.54)	21.63 (0.52)	20.18 (0.52)	20.80 (0.54)
Yrs Edu[a]	13.87 (0.10)	12.5-15.5	13.82 (0.22)	13.97 (0.21)	13.39 (0.21)	14.00 (0.22)
BDI-II	8.80 (0.52)	0-18	6.77 (1.00)	10.01 (0.98)	7.57 (0.98)	10.82 (1.00)
RRS total	40.79 (1.09)	25-66	38.94 (2.15)	45.39 (2.09)	39.28 (2.09)	39.35 (2.15)
Brooding	9.80 (0.34)	5-20	9.35 (0.66)	11.28 (0.64)	9.11 (0.64)	9.41 (0.66)
Reflection	9.11 (0.41)	5-18	8.59 (0.81)	10.67 (0.79)	8.57 (0.79)	8.59 (0.81)

Note: [a]Years of education.

The final sample included 70 participants that were evenly distributed across Gender (35 women) and Condition (35 state rumination). The two sets of induction prompts for each condition were counterbalanced within each condition, thus rendering an additional factor of induction prompt order (see more details below under the *First Day of Testing* sub-section). As shown in Table 1, there were no gender differences in age or years of education, whether overall or as a function of Induction Condition (all *p*s > 0.15). However, women did exhibit a more elevated negative mood state compared to men, regardless of Induction Condition, $F(1, 66) = 10.98$, $p = 0.002$, $\eta_p^2 = 0.14$, although the mean BDI-II score for women was still below the lower threshold for minimal depression (i.e., 13; Beck et al., 1996b). Despite women in the state Rumination condition appearing to exhibit a greater trait tendency towards Brooding on the Ruminative Responses Scale (RRS; Treynor et al., 2003) compared to men in the same condition or women in the Distraction condition, the 2-way interaction of Gender and Induction Condition was not significant ($p = 0.22$). Rather, women's Brooding scores were marginally more elevated than men's, regardless of Induction Condition, $F(1, 66) = 2.90$, $p = 0.09$, $\eta_p^2 = 0.04$. However, the trait tendency towards Reflection, as well as scores on the RRS overall, did not differ as a function of Gender and/or Induction Condition (all ps > 0.13).

Design and Procedure

Overview. The study took place over the course of two days. On the first day, participants were largely run in groups of four to six, but they completed all tasks independently. They first filled out the RRS and BDI-II measures, along with a set of demographic questions. Then they began the general knowledge task, which consisted of three 60-item blocks and used the same stimuli as in Whiteman and Mangels (2016; Study 1), as well as the same titration algorithm to stabilize first-test performance at 35% correct across the entire task. See Figure 1 for a representation of the block structure and experimental design.

Prior to Block 1, all participants were presented with *general task* instructions detailing what a basic trial in the task would look like and how to complete it, and they were briefly reminded of these instructions prior to beginning Blocks 2 and 3. Before receiving these reminder instructions, but after completing Blocks 1 and 2 (i.e., between blocks), participants were also administered *condition-specific* instructions that asked them to use the "break period" to complete a separate but important thought-related exercise. Although participants were not informed of its true purpose, the condition-specific instructions described an exercise participants were to engage in that was intended to place them into either a state of rumination or distraction.

Finally, at the conclusion of each of the three blocks of general knowledge questions, participants were instructed to complete a short survey that queried their subjective experiences in that particular block.

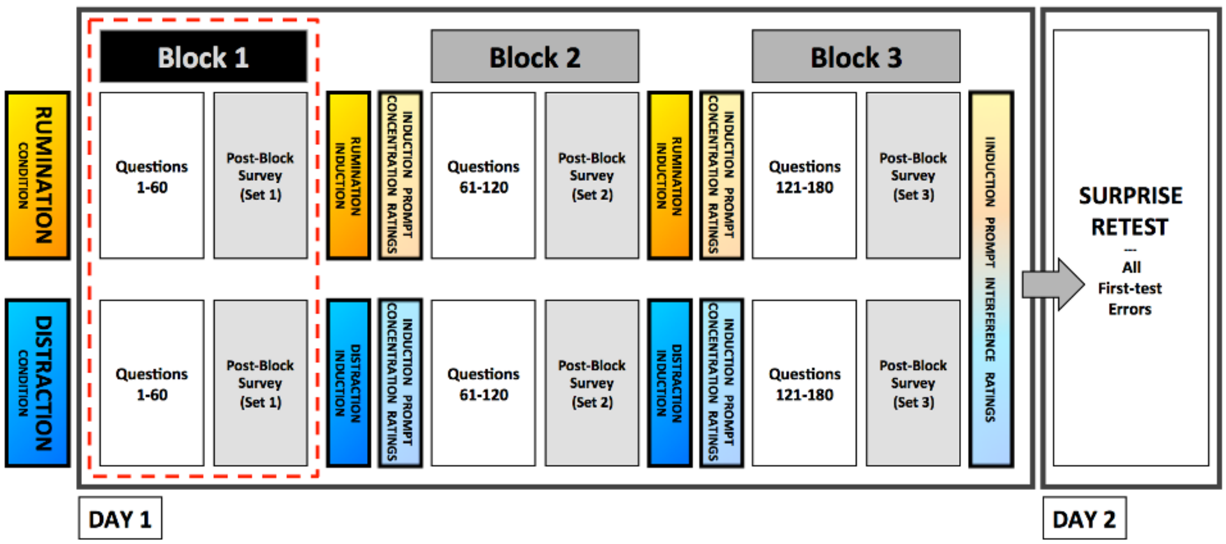

Figure 1. Study 2 Block Structure and Experimental Design. On Day 1, regardless of Induction Condition, Block 1 (surrounded by the red dotted line) served as a preliminary, pre-induction baseline period for memory performance and subjective experiences in the general knowledge task. Each participant then either received the state rumination (indicated by the orange gradient boxes) or state distraction (indicated by the blue gradient boxes) induction manipulation at the outset of Block 2, and then again at the outset of Block 3 in a mixed-measures research design. Induction prompt concentration queries were administered immediately after each of the two state induction procedures, and induction prompt interference queries (i.e., manipulation check queries) were then administered at the end of Block 3. Participants returned on Day 2 for a surprise retest of all first-test errors.

On the second day, 24-48 hours later, participants returned individually to complete another set of general knowledge questions. Although this set consisted of only their incorrect items from day one, they were not told this at either the end of the first-test or at the start of the retest. No induction procedure was administered on the second day of testing.

First Day of Testing.

General task instructions. The general knowledge task was introduced via a *general* instruction set. Briefly, participants were told that they would be completing a large set of questions, and that for each question item, they would have a 3-minute time limit to submit their response, after which they would rate confidence in their response on a 1 (sure wrong) to 7 (sure right) scale. Then they were told that they would receive feedback in two forms: first they would receive indication of whether their response was correct or not, and second they would be shown the correct answer to the question they had just attempted. They were also told that all correct answers were one word only and contained no numbers or symbols.

Condition-specific instructions (Induction). The induction manipulation was introduced via a *condition-specific* instruction set, which began by telling participants that "it can be extremely useful to use the break period between blocks to deliberately focus on, or make sense of, the thoughts or ideas that tend to pop up for students when they are completing the general knowledge questions" (see Appendix A for the full set of condition-specific instructions used in Study 2). Depending on their condition, participants were then presented with 16 of the original 44 state rumination or distraction induction prompts developed previously by Nolen-Hoeksema & Morrow (Nolen-Hoeksema & Morrow, 1993) – a set of eight prompts just before starting Block 2 (i.e., hereafter referred to as the Block 2 Prompt Set) in the general knowledge task, and another set of eight prompts just before Block 3 (i.e., Block 3 Prompt Set; see Appendix B for a full list of rumination and distraction induction prompts used in Study 2)

Regardless of condition, each prompt was presented one at a time for 25 s, and participants were asked to focus their attention and concentration completely on the prompt for as long as it was visible on the screen. Thus, the time devoted to the induction procedure was 4 minutes in each inter-block period, or about 8 minutes in total. Care was taken as best as possible within each condition to match the prompts used in each inter-block induction period based on object of thought (i.e., content) and perceived ease with which they would garner participants' focus. Within each induction period, the prompts were randomly shuffled and presented. Within each condition, the order of the induction prompt sets was counterbalanced. However, despite best efforts, idiosyncratic attrition of participants' data in the current study rendered use of an "order" factor ineffectual during statistical analyses through unstable models due to unequal (and small) numbers of participants in each statistical condition. Therefore order will not be included as a factor in data analysis (see Data Analysis sub-section for further details on the analytical approaches utilized and the factors employed within them).

To serve as a manipulation check, two kinds of queries were administered that measured individuals' subjective experiences with the induction prompts. First, immediately after the presentation of each individual induction prompt, participants were asked to offer a rating on how well they were able to *concentrate* on that prompt's described idea (rumination) or image (distraction) when it was visible on the screen, using a scale of 1 (not well at all) to 9 (extremely well). This kind of query also provided an indirect measure of how successful participants were at following the instruction to focus their attention on the rumination or distraction prompt content. For the second kind of query, at the conclusion of the first-test (i.e., after Block 3), all participants were asked to offer ratings on how frequently thoughts about rumination and distraction prompt content *interfered* with the process of completing the general knowledge questions, using a scale of 1 (never) to 9 (always).

This post-test query about task interference assessed thought intrusions from both *presented* and *novel* prompt types. First, the "presented" type refers to prompts that had actually been used in either condition of the experiment. Indeed, to facilitate better comparison *between* conditions of the interference caused by this presented prompt type, the ratings questions that were administered to the congruent group (e.g., questions regarding the rumination prompts that were actually presented to the state rumination group during the general knowledge task), were *also* shown in this post-test survey to participants in the opposite/incongruent condition (e.g., questions regarding these same rumination prompts were *also* shown to the state distraction group). This rendered sub-classifications of the presented prompt ratings type: "presented-congruent" and "presented-incongruent," depending on whether the post-test question was administered to the congruent or opposite (incongruent) condition, respectively (see further details in the Data Analysis sub-section below). Second, interference ratings questions for the "novel-congruent" prompt type asked participants to rate the perceived interference experienced by content relevant to their condition that had *not* actually been prompted as an object of focus during any induction (See Appendix C for all interference ratings questions for each condition).

Trial Sequence. As shown in Figure 2, for each individual trial in the general knowledge task, participants had a time limit of 3 m to submit their response, after which they rated their response confidence in the same manner as in Whiteman and Mangels (2016; Study 1). Then they were presented with a short blank screen (250 ms), followed by a 1.5s fixation crosshair period. Performance-relevant feedback was then presented for 1.5 s, which consisted of red asterisk and low tone for incorrect feedback and green asterisk and high tone for correct feedback. Then another fixation crosshair was presented for a randomly jittered amount of time (4 to 6 s), prior to presentation of the learning-relevant feedback (i.e., correct answer) for 2 s. The relatively long jittered delay between performance-relevant feedback and learning-relevant feedback was introduced in order to increase the likelihood of generating ruminative thoughts after negative feedback.

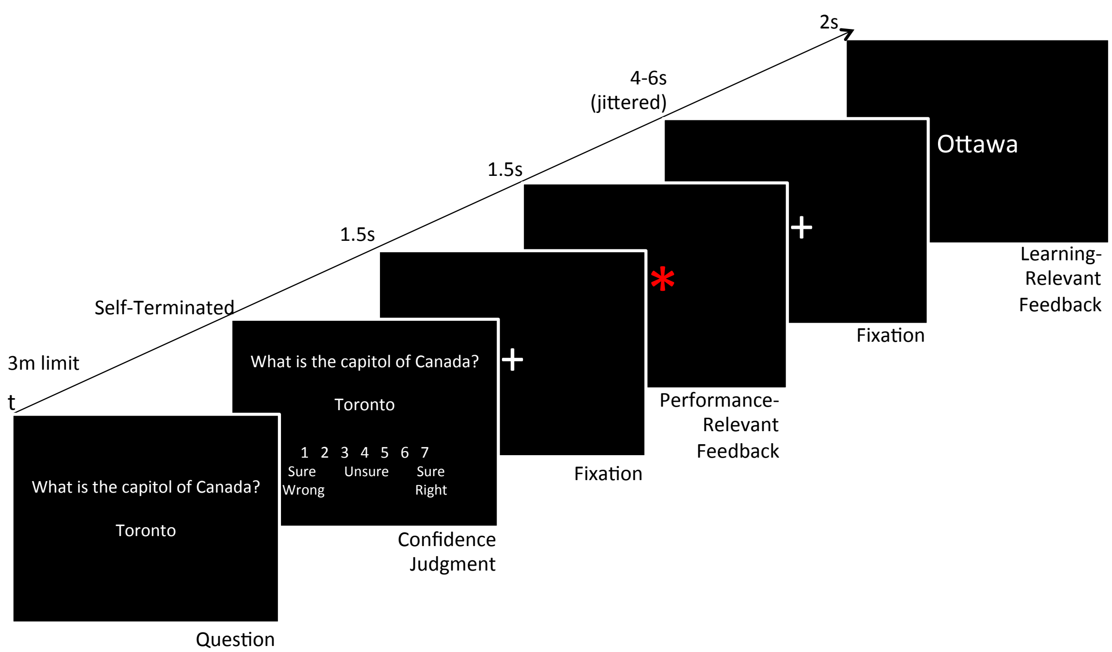

Figure 2. Study 2 First-Test Trial Structure. Example of a trial with an incorrect answer. If the answer had been correct, a green asterisk would have been shown.

Post-Block Surveys. To gain insight into participants' subjective experiences throughout the task, we asked them to answer three short post-block surveys about the thoughts (i.e., recurring negative thoughts – hereafter referred to as RNTs; "How many recurring negative thoughts did you experience in the block of questions you just attempted?") and feelings (i.e., feelings after errors – hereafter referred to as FAEs; "In this block of questions, whenever you made an error, how unpleasant or pleasant did you feel?") they encountered in each block. All questions were rated on a 1-to-9 Likert scale, with 1 reflecting the negative or low end of the subjective experience, 9 reflecting the positive or high end, and 5 indicating an experiential midpoint (*i.e.*, neutrality). At the conclusion of the first day of testing, participants were asked to return within 24-48 h to complete a second set of general knowledge questions.

Second Day of Testing. On the second day, participants were presented with a shortened set of *general* task instructions that described a slightly modified trial structure for the general knowledge questions. Unlike at first-test, the retest feedback combined performance and learning components into a single stimulus to minimize the amount of testing-time for participants on the second day. Specifically, correct responses were presented in green text along with a high tone, and incorrect responses in red text with a low tone. This combined feedback was presented immediately following participants' confidence ratings and lasted for 1 s. No induction manipulation was used during the retest.

All re-queried questions on day two were presented in one large retest block. However, to preserve the baseline and post-induction contexts from day one, and to decrease variability in study-test delay, questions from Block 1 were presented before questions from Block 2, and Block 2 questions were presented before Block 3 questions. Questions within each "block" were randomly shuffled and then presented. Only at the outset of day two were participants informed that they were being retested on a subset of questions they had encountered on day one, without any specific mention that these questions consisted only of first-test items they had answered incorrectly. All participants included in analyses reported being surprised by this retest.

Data analysis

This study focuses on understanding whether individuals induced to experience a state of rumination compared to distraction exhibit differences in measures of memory and subjective experiences in a challenging academic test of verbal general knowledge. It also addresses whether any effects of the induction manipulation may occur differently for men and women as the task progresses, and whether either pre-test levels of depression and/or trait tendencies to ruminate may moderate any of these effects. To test these questions, we conducted a series of customized 2 (Induction Condition) by 2 (Gender) by 3 (Block) mixed-measures Analyses of Covariance (ANCOVAs) on our dependent measures of interest, and also included participants' BDI-II scores and RRS Brooding and Reflection scores as covariates (i.e., predictor variables). As in Whiteman and Mangels (2016; Study 1), parameter estimates (converted to standardized beta coefficients) were rendered for all three covariates, including for all 2-, 3-, and 4-way interaction terms between each of the covariates and the manipulated variables. Interaction terms *between* Brooding, Reflection and BDI-II were not included in the customized ANCOVAs, as the aim of the current study was to determine whether any of these factors (but particularly the BDI-II) served uniquely as moderators (i.e., each one over and above the others).

Given that Block 1 served as a preliminary, pre-induction baseline period, and effects of the manipulation were hypothesized to occur as subjects moved out of this initial block into Blocks 2 and 3 (i.e., after the introduction of the induction), we also computed and analyzed Change scores (see also Whiteman & Mangels, 2016; Study 1). These analyses were especially helpful for unpacking how pre-task depression levels and trait rumination tendencies may have *differentially* predicted the dependent measures of interest as participants moved out of the initial block and into the post-induction blocks (particularly as a function of the Induction Condition). As such, these analyses were only run when necessary, such as when a covariate's rendered parameter estimate during the initial block was in the opposite direction compared to those rendered during post-induction blocks. Change scores were computed by subtracting the values observed for all dependent measures at the initial block from the values observed within each of the two subsequent blocks, thus rendering Change scores for Blocks 1 to 2 and 1 to 3 (hereafter called ΔB1-to-B2 and ΔB1-to-B3, respectively). Thus, the customized general linear model that was used in this case was a 2 (Induction Condition) by 2 (Gender) by 2 (Change) mixed-measures ANCOVA, in which the BDI-II, Brooding, and Reflection measures were again included as covariates and parameter estimates rendered for all 2-, 3- and 4-way interactions. Change scores could be particularly enlightening in situations where there were unexpected groups differences in Block 1, the baseline block, where groups should be equivalent.

These customized ANCOVAs were used to assess general knowledge task memory performance (i.e., first-test performance, followed by retest error correction rates), as well as task-related subjective experiences (i.e., self-reported RNTs and FAEs). Just as in Whiteman and Mangels (2016; Study 1), both retest error correction rates and the subjective experience measures were adjusted to control for the potential confounding influence of first-test accuracy prior to their inclusion in the customized ANCOVAs, whether Block scores or Change scores were used. Also, we structured our presentation of the results to first address any overall effects of Induction Condition, Block and Gender, before turning to any findings that included either mood (BDI-II) and/or trait RRS status (Brooding and Reflection) as moderators.

However, prior to carrying out these general knowledge task-related analyses, we conducted analyses aimed at verifying the sensitivity of the induction manipulation. In particular, we focused first on assessing participants' level of concentration on the induction prompts, and then tested the degree to which state rumination or distraction may have interfered with subjects' perceived level of performance on the general knowledge task. First, for concentration ratings, a 2 (Induction Condition) by 2 (Gender) by 2 (Prompt Set) mixed-measures customized ANCOVA was conducted, in which BDI-II, Brooding, and Reflection measures were again included as covariates, parameter estimates rendered, and all 2-, 3, and 4-way interactions evaluated. Second, for interference ratings, two separate analyses were conducted, each one differentially involving the presented and novel prompt types (See Appendix C).

Regarding this manipulation check on interference ratings, since the goal of the current study was to investigate the effects of an induced state of rumination in particular, only the interference ratings pertaining to rumination prompts were analyzed. One analysis tested whether self-reported interference from rumination was greater in the Rumination condition than in the Distraction condition. To this aim, we analyzed the amount of self-reported interference due to "presented" rumination prompts only, as a function of Induction Condition (i.e., comparing presented-congruent ratings from the state Rumination condition with presented-incongruent ratings from the state Distraction condition) with a 2 (Induction Condition) by 2 (Gender) between-subjects customized ANCOVA (BDI-II, Brooding and Reflection as covariates). Then, to test whether it was specifically the *presented* rumination prompts that actually caused ruminative interference in the Rumination condition or, on the other hand, whether rumination was generally high in that condition overall, we compared interference ratings for the "presented" (congruent) prompt type against interference ratings for the "novel" (congruent) prompt type in the Rumination Condition using a 2 (Gender) by 2 (Prompt Type) mixed-measures ANCOVA, again accounting for BDI-II, Brooding, and Reflection as covariates. An additional rationale for only examining ratings of rumination prompts in both of these analyses is the observation that self-reported interference due to the distraction prompts was at floor regardless of Induction Condition (Rumination condition, presented-incongruent ratings: M = 1.21, SEM = 0.11; Distraction condition, presented-congruent ratings: M = 1.49, SEM = 0.19; Distraction Condition, novel distraction ratings: M = 1.22, SEM = 0.08).

For all analyses, an alpha level of $p \leq 0.05$ was used as criterion for significance, but marginally significant findings ($0.05 < p \leq 0.10$) are also reported, and effect sizes are specified in all cases using the partial eta squared statistic. Where necessary, Greenhouse-Geisser corrections were used for violations of sphericity, and where appropriate, linear trend analyses were conducted for the within-subjects factors of Block or Change to explore how differences in critical measures may have unfolded over time in the task. Any *post hoc* explorations of significant main effects or interactions were carried out using the Holm-Bonferroni procedure for corrections for multiple comparisons (Holm, 1979).

Results

Manipulation Check

Concentration Ratings. As shown in Table 2, participants' concentration ratings were generally at the middle point of the range across Induction Conditions and Prompt Sets, suggesting that the participants allocated attention to the induction content reasonably well during the induction procedure. A main effect of Prompt Set, however, revealed that participants' focus dropped significantly across the two induction periods, regardless of Induction Condition,

$F(1, 54) = 4.02$, $p = 0.05$, $\eta_p^2 = 0.07$, although the ratings for the second set still remained at or above the middle concentration level.

Table 2. Study 2 Concentration on Induction Prompt Content. Concentration ratings are shown as a function of Induction Condition and Gender (including collapsing across women and men [all]), and Prompt Set (including collapsing across the two Prompt Sets [set average]). In this and all other tables, means are adjusted for BDI-II, Brooding, and Reflection covariates, and standard errors of the mean (SEM) are provided in parentheses.

Induction Condition	**Gender**	**Block 2 Prompt Set**	**Block 3 Prompt Set**	**Prompt Set Average**
Rumination				
	All	5.84 (0.25)	5.20 (0.28)	5.52 (0.24)
	Women	5.57 (0.36)	5.06 (0.40)	5.32 (0.36)
	Men	6.11 (0.37)	5.33 (0.40)	5.72 (0.35)
Distraction				
	All	6.64 (0.25)	6.41 (0.28)	6.54 (0.24)
	Women	6.65 (0.37)	6.67 (0.41)	6.66 (0.35)
	Men	6.62 (0.35)	6.16 (0.38)	6.39 (0.33)

Notes: The concentration rating scale ranged from 1 (not well at all) to 9 (extremely well), with 5 indicating a middle point (somewhat well).

Prompt-focused concentration was also slightly better for the distraction prompts compared to the rumination prompts, regardless of Gender and/or Prompt Set, $F(1, 54) = 7.98$, $p < 0.01$, $\eta_p^2 = 0.13$. This is not necessarily surprising given that the rumination prompts were abstract and analytical in nature compared to the distraction prompts, which were intended to focus participants' attention on concrete mental images.

While pre-task levels of depression did not moderate this or any other effect involving the induction (all *p*s > 0.17), Brooding did play a role in predicting concentration on the induction prompts, albeit one that did *not* interact with Induction Condition, but rather Gender only, and this effect was a marginal one, $F(1, 54) = 3.48$, $p = 0.07$, $\eta_p^2 = 0.06$. Surprisingly, Brooding was related to a *higher* level of concentration on all prompt content for men only, $\beta = 0.35$, $t = 1.96$, $p = 0.05$. In sum, although the prompts in the Distraction condition received higher ratings overall, to the extent that Gender and pre-task individual differences interacted to influence ratings, they did so equally across both rumination and distraction groups.

Interference Ratings. As shown in Table 3, all participants reported generally experiencing infrequent rumination-related interference while they were completing the first test, as indicated by low scores on the interference question rating scale (i.e., between "none at all" and "a little"). When comparing mean rumination interference ratings between the Distraction and Rumination conditions (i.e., presented-congruent ratings versus presented-incongruent ratings) no significant differences emerged, either overall or as a function of Gender (all *p*s > 0.15). However, a marginally significant 3-way interaction involving BDI-II, Induction Condition, and Gender, $F(1, 54) = 2.84$, $p = 0.10$, $\eta_p^2 = 0.05$, suggested that pre-task levels of depression could be playing some role in predicting interference ratings. Specifically, in line with earlier predictions, *post hoc* analyses found that for women in the Rumination condition only, the higher their pre-task levels of depression, the higher their frequency of rumination-related interference, $\beta = 0.56$, $t = 2.40$, $p = 0.08$. No relationship between BDI-II and rumination-related interference was found for either gender in the Distraction condition (i.e., all other $p > 0.25$).

Table 3. Study 2 Interference due to Induction Prompt Content. Interference ratings are shown for rumination-related content only, as a function of Induction Condition, Gender (including collapsing across Gender [all]), and Prompt Type (i.e., whether queries were presented or not [novel]). Ratings offered by participants in the state Rumination and Distraction Conditions are referred to as congruent and incongruent, respectively.

Induction Condition	**Gender**	**Presented Prompt Type**	**Novel Prompt Type**
Rumination (congruent)			
	All	2.41 (0.35)	2.41 (0.30)
	Women	2.52 (0.34)	2.55 (0.30)
	Men	2.29 (0.34)	2.26 (0.31)
Distraction (incongruent)			
	All	2.70 (0.35)	-
	Women	2.91 (0.35)	-
	Men	2.52 (0.33)	-

Notes: Ratings reflect how frequently participants thought about the prompts during the general knowledge questions, where the rating scale ranged from 1 (never) to 9 (always), 5 indicating a middle point (sometimes).

We then assessed whether any interference encountered in the Rumination Induction Condition was linked exclusively to the "presented" rumination prompts, or whether other kinds of ruminative thoughts, tapped through "novel" prompts, may have also played a role. A comparison of ratings for presented (congruent) versus novel (congruent) Prompt Types within the Rumination induction condition revealed no differences in frequency of interference, whether overall or as a function of Gender (all ps > 0.28). However, again, we found a marginally significant 3-way interaction involving BDI-II, Prompt Type, and Gender, $F(1, 27) = 3.59$, $p = 0.07$, $\eta_p^2 = 0.12$, that was driven by a positive relationship of pre-task depression with self-reported interference in women only, and only for the rumination prompts that were actually presented; however, this effect did not survive Holm-Bonferroni corrections for multiple comparisons, $\beta = 0.56$, $t = 2.32$, $p = 0.11$ (all other $p > 0.59$).

Taken together, analyses of these ratings do not provide strong evidence that the prompts in the Rumination induction condition were successful in selectively inducing a ruminative state for the participantss in the Rumination condition. Moreover, although all participants regardless of Induction Condition directed a good degree of focus on the induction prompts, concentration was still better for those induced to focus on the concrete distraction prompts compared to those induced to self-reflect on the abstract rumination prompts. In addition, all participants reported experiencing relatively little interference from the rumination prompts during the task, which we will take into consideration when interpreting in the effects of the induction on memory performance. Nonetheless, the one result that was more in line with predictions was the marginal increase in interference due to presented rumination prompt content for women who also exhibited higher pre-task levels of depression. Although marginal, this result nonetheless highlights Gender and BDI-II as being important to consider as moderating factors when we proceed to investigate the relative effects of the rumination induction on memory performance and subjective experiences during the general knowledge task.

Memory Performance

Table 4 shows both the proportions of items initially correct at first-test and the proportions of items initially incorrect at first-test that were later corrected on the subsequent surprise retest. Performance during each of the three 60-item blocks is shown as a function of both Induction Condition and Gender.

Table 4. Study 2 Memory Performance. Proportion correct at first-test and at retest as a function of Induction Condition, Gender, and Block.

Behavior	Induction Condition	Gender	Block 1	Block 2	Block 3
First-Test Accuracy					
	Rumination				
		All	0.35 (0.004)	0.33 (0.009)	0.35 (0.010)
		Women	0.35 (0.006)	0.32 (0.013)	0.35 (0.015)
		Men	0.35 (0.006)	0.35 (0.013)	0.34 (0.015)
	Distraction				
		All	0.35 (0.004)	0.36 (0.009)	0.34 (0.010)
		Women	0.35 (0.006)	0.37 (0.013)	0.34 (0.015)
		Men	0.36 (0.006)	0.35 (0.013)	0.34 (0.014)
Retest Error Correction					
	Rumination				
		All	0.64 (0.023)	0.61 (0.023)	0.57 (0.023)
		Women	0.68 (0.033)	0.65 (0.032)	0.56 (0.034)
		Men	0.61 (0.033)	0.56 (0.033)	0.56 (0.034)
	Distraction				
		All	0.63 (0.023)	0.59 (0.023)	0.57 (0.023)
		Women	0.64 (0.034)	0.60 (0.033)	0.56 (0.034)
		Men	0.62 (0.032)	0.57 (0.031)	0.58 (0.032)

First-test Accuracy. First, we wanted to confirm that groups were well titrated in the initial, pre-induction block. As expected, particularly since we had excluded participants who were outliers in performance during this block in order to establish a stable baseline between and within conditions, a series of one-sample t-tests for each condition (whether separated by or collapsed across Gender) confirmed no significant differences between performance in the initial block and the target proportion of 0.35 correct (i.e., the target titration value; all *p*s > 0.29). When conducting the customized ANCOVA involving the 3-level factor of Block on first-test performance to test the proposed hypotheses, however, there were no main effects or interactions involving Gender, Block, and Induction Condition (all *p*s > 0.14).

Thus, we did not find significant support for the hypothesis that being in a state of rumination would impair initial retrieval of general knowledge during the first-test, although we cannot rule out the possibility that the titration algorithm might have suppressed any weak induction effects. Indeed, scrutiny of the means for all individuals in Table 4 suggests that for women in the Rumination condition, performance in Block 2 decreased numerically from the pre-induction period, whereas performance increased slightly in this block for women in the Distraction condition. Although the 3-way interaction term was non-significant ($p = 0.14$), an exploratory analysis of performance in the task for *women only* revealed a significant Induction Condition by Block effect, $F(2, 54) = 3.66$, $p < 0.05$, $\eta_p^2 = 0.12$. Corrected *post hoc* comparisons revealed Block 2 performance to be significantly lower for women who were induced to ruminate versus those who were induced to distract ($p < 0.05$). No other mean differences in this exploratory analysis survived Holm-Bonferroni corrections for multiple comparisons.

Our statistical model also allowed us to address the additional hypothesis of whether the theoretically-relevant individual differences factor of pre-test mood state (i.e., BDI-II) might have moderated any effects of the induction on first-test performance. However, no interactions concurrently involving BDI-II, Induction Condition, and Block emerged, as would be needed to indicate selective post-induction effects of the instructional manipulation (all *p*s > 0.41). Rather, only two 2-way interactions were found, which subsumed a main effect of BDI-II, $F(1, 54) = 6.29$, $p < 0.05$, $\eta_p^2 = 0.10$. First, subjects' BDI-II scores marginally moderated the effect of the induction manipulation, $F(1, 54) = 3.55$, $p = 0.07$, $\eta_p^2 = 0.06$, and second, the BDI-II predicted performance for all subjects as a function of Block, $F(2, 108) = 3.14$, $p < 0.05$, $\eta_p^2 = 0.06$.

Unpacking the first interaction effect, pre-task depression rates predicted poorer overall first-test performance for individuals in the Rumination condition, $\beta = -0.47$, $t = 3.26$, $p < 0.005$, $\eta_p^2 = 0.15$, but not in the Distraction condition, $\beta = -0.02$, $t = 0.15$, $p = 0.89$, $\eta_p^2 = 0.0003$. While the direction of this effect is in line with our predictions, the lack of a 3-way interaction additionally involving the factor of Block indicates that the predictive value of the BDI-II was not solely confined to the post-induction periods during Blocks 2 and 3. Similarly, when unpacking the second 2-way interaction, pre-task depression levels significantly predicted worse performance for all individuals both pre-induction (Block 1), $\beta = -0.36$, $t = 2.31$, $p < 0.05$, $\eta_p^2 = 0.08$, and post-induction (Block 3), $\beta = -0.35$, $t = 3.15$, $p < 0.01$, $\eta_p^2 = 0.13$, regardless of Induction Condition. These results collectively indicate that pre-test mood state did not play a role in moderating the influence of the induction procedure on memory performance on day one, and instead suggest that any influence of pre-task depression levels (even if more prominent in the Rumination condition) seemed to pre-exist the induction manipulation.

Turning next to the effects of trait rumination, neither Brooding nor Reflection was found to moderate any effect of the induction manipulation on first-test performance (all *p*s > 0.23). However, Brooding did marginally interact with Gender to impact overall accuracy rates on day one, $F(1, 54) = 3.17$, $p = 0.08$, $\eta_p^2 = 0.06$. *Post hoc* comparisons, however, revealed opposite and non-significant relationships for men (negative) and women (positive). There was, however, a marginal main effect of Reflection, $F(1, 54) = 3.01$, $p = 0.09$, $\eta_p^2 = 0.05$, whereby this continuous trait predictor was associated with somewhat increased overall first-test performance ($\beta = 0.28$), regardless of Induction Condition, Gender, or Block, an effect that replicates findings from Whiteman and Mangels (2016; Study 1).

Retest Error Correction. As can be seen in Table 4, retest error correction rates from the initial, pre-induction block (Block 1) appear numerically similar across Induction Condition for all individuals, after which they then seem to drop off rather steadily across the two subsequent post-induction blocks (Blocks 2 and 3). This seeming decline in retest performance was supported by a significant main effect of Block, $F(2, 108) = 7.64$, $p < 0.001$, $\eta_p^2 = 0.12$, characterized by a significant downward linear trend, $F(1, 54) = 15.15$, $p < 0.001$, $\eta_p^2 = 0\ .22$. Contrary to expectation, however, this decline did not differ as a function of Induction Condition, as there was no 2-way interaction between Induction Condition and Block, $F(1, 54) = 0.25$, $p = 0.78$, $\eta_p^2 = 0.01$. Rather, this decline differed marginally as a function of Gender, $F(2, 108) = 2.74$, $p = 0.07$, $\eta_p^2 = 0.05$. *Post hoc* testing of this marginal Block by Gender interaction revealed there to be no retest performance differences in any one block between men and women (all *p*s > 0.75), but instead that among women only, error correction rates from Block 3 were significantly lower than those from Block 1 ($p < 0.05$).

Unlike first-test performance, no effects involving BDI-II emerged in any analyses on retest error correction rates (all *p*s > 0.28). However, in line with predictions that gender and trait rumination might play moderating roles in the influence of the induction manipulation, a significant 4-way interaction emerged that involved the Reflection sub-scale of the RRS, $F(2, 108) = 4.17$, $p < 0.05$, $\eta_p^2 = 0.07$, and this interaction effect subsumed other significant or marginally significant 2-way (Block x Gender; Block x Reflection) or 3-way (Induction Condition x Gender x Reflection) interaction effects.

Unpacking this 4-way interaction, Reflection *negatively* predicted post-induction retest performance, but did so for men only in the Rumination condition (Blocks 2 and 3), and for women only in the Distraction condition (Block 3 only). Although none of these relationships survived Holm-Bonferroni corrections for multiple comparisons, given the large number of comparisons entailed in unpacking this 4-way interaction, we attempted to simplify the model and better control for any baseline (i.e., Block 1) differences by examining Change scores (rather than Block scores). Again, a significant Induction Condition by Gender by Reflection 3-way interaction emerged, $F(1, 54) = 10.16$, $p < 0.005$, $\eta_p^2 = 0.16$, and *post hoc* testing revealed that Reflection predicted a change for the *worse* in retest performance from the pre- to the post-induction period overall (i.e., regardless of the change period), particularly for men in the Rumination condition and for women in the Distraction condition. The latter effect for women survived Holm-Bonferroni corrections, $\beta = -0.72$, $t = 3.05$, $p < 0.05$, $\eta_p^2 = 0.15$.

Trait Brooding also appeared to play a role in predicting error correction rates across blocks of the task as a function of Gender, as evidenced by a significant 3-way interaction that involved only the factors of Block and Gender (i.e., no additional interaction with Induction Condition), $F(2, 108) = 3.71$, $p < 0.05$, $\eta_p^2 = 0.06$. However, all resulting parameter estimates were non-significant. Again turning to Change scores, *post hoc* exploration of a sole, significant two-way interaction between Brooding and Gender, $F(1, 54) = 8.96$, $p = 0.004$, $\eta_p^2 = 0.14$, revealed that Brooding RRS scores predicted marginally *better* error correction rates for men, $\beta = 0.32$, $t = 1.83$, $p = 0.07$, $\eta_p^2 = 0.05$, but did not influence women's error correction scores, $\beta = -0.03$, $t = 1.23$, $p = 0.22$, $\eta_p^2 = 0.02$, regardless of change period and Induction Condition.

Table 5. Study 2 Subjective Experiences. Average self-reported ratings of Recurring Negative Thoughts (RNTs) and Feelings After Errors (FAEs) as a function of Induction Condition, Gender, and Block.

Subjective Experience	**Induction Condition**	**Gender**	**Block 1**	**Block 2**	**Block 3**
RNTs					
	Rumination				
		All	3.37 (0.36)	3.17 (0.40)	3.33 (0.40)
		Women	3.74 (0.52)	3.43 (0.58)	3.47 (0.58)
		Men	2.98 (0.51)	2.92 (0.58)	3.20 (0.58)
	Distraction				
		All	4.21 (0.36)	4.33 (0.40)	4.03 (0.40)
		Women	4.49 (0.53)	4.07 (0.59)	3.82 (0.59)
		Men	3.93 (0.51)	4.59 (0.56)	4.24 (0.56)
FAEs					
	Rumination				
		All	3.99 (0.21)	3.75 (0.26)	3.73 (0.26)
		Women	3.97 (0.31)	3.40 (0.37)	3.32 (0.38)
		Men	4.02 (0.31)	4.11 (0.37)	4.13 (0.38)
	Distraction				
		All	3.58 (0.21)	3.28 (0.26)	3.57 (0.26)
		Women	3.65 (0.31)	3.18 (0.38)	3.52 (0.39)
		Men	3.51 (0.30)	3.39 (0.36)	3.62 (0.37)

Notes: Recurring Negative Thoughts (RNTs) were rated on a scale of 1 (none at all) to 9 (an extreme amount), with 5 representing a moderate amount. Feelings After Errors (FAEs) were rated on a scale of 1 (extremely unpleasant) to 9 (extremely pleasant), with 5 representing neither pleasant nor unpleasant.

Subjective Experiences

Table 5 shows the mean ratings for both recurring negative thoughts (RNTs) and feelings after errors (FAEs) that participants reported experiencing across the task at first-test.

Recurring Negative Thoughts (RNTs). All participants generally reported experiencing between ‘a little’ (i.e., a rating of 3) and ‘a moderate amount’ (i.e., a rating of 5) of RNTs across the task on day one (see Table 5). Contrary to expectation, however, participants in the Distraction group reported significantly more RNTs than the Rumination group, $F(1, 54) = 5.56$, $p < 0.05$, $\eta_p^2 = 0.09$. Nonetheless, this main effect of Induction Condition did not interact with Block, $F(1.69, 91.24) = 2.07$, $\varepsilon = 0.85$, $p = 0.14$, $\eta_p^2 = 0.04$, indicating that the increases in RNTs for the Distraction group were not necessarily tied to introduction of the induction in Block 2. Although assessment of the means in Table 5 might lead to speculation of Gender or Block differences in RNTs, there were no main effects of these factors, nor did Gender or Block interact with each other, or with Induction Condition to show differences in RNTs (all *p*s > 0.29).

Trait Brooding was found to significantly interact with Gender to predict RNTs, $F(1, 54) = 4.50$, $p < 0.05$, $\eta_p^2 = 0.08$. Unlike in Study 1, however, *post hoc* testing revealed that Brooding predicted increased RNTs for men, $\beta = 0.49$, $t = 2.65$, $p < 0.01$, $\eta_p^2 = 0.10$, rather than women, $\beta = -0.14$, $t = 0.69$, $p = 0.49$, $\eta_p^2 < 0.01$. Moreover, these effects did not interact further with Induction Condition, or the combination of Induction Condition and Block (all *p*s > 0.29). No significant effects were found involving trait Reflection (all *p*s > 0.23).

We also found a marginally significant 4-way interaction involving Induction Condition, Block, Gender, and BDI-II, $F(1.69, 91.24) = 2.72$, $\varepsilon = 0.85$, $p = 0.08$, $\eta_p^2 = 0.05$, that subsumed another marginally significant 3-way interaction that excluded Block. However, no *post hoc* comparisons for this 4-way interaction survived corrections for multiple comparisons (all *p*s > 0.13). When exploring these relationships with Change scores, the 4-way interaction of Induction Condition, Change Period, Gender and BDI-II was significant, $F(1, 54) = 5.80$, $p < 0.05$, $\eta_p^2 = 0.10$, but once again, no relationships survived correction for multiple comparisons. Exploration of the additionally mentioned marginal 3-way interaction also rendered no relationships that survived Holm-Bonferroni corrections.

Feelings After Errors (FAEs). Table 5 shows that all participants generally reported feeling ‘somewhat unpleasant’ (i.e., scores between 3 and 4) after making an error in the task on day one. However, these feelings did not differ as a function of Induction Condition, or Induction Condition by Block (all *p*s > 0.29). Nor were there any differences in FAEs between men and women, whether independently or interactively with Induction Condition and/or Block (all *p*s > 0.15).

When considering the pre-task individual differences measures, we did find a significant 2-way interaction between Gender and Brooding on FAEs, $F(1, 54) = 6.97$, $p < 0.01$, $\eta_p^2 = 0.11$. *Post hoc* testing indicated that among men, $\beta = -0.49$, $t = 2.53$, $p < 0.01$, $\eta_p^2 = 0.09$, but not women, $\beta = 0.26$, $t = 1.38$, $p = 0.17$, $\eta_p^2 = 0.03$, Brooding levels predicted more unpleasant FAEs in the entire task, regardless of Induction Condition (or Block). Similar to the RNT effects described above, this finding also provides a partial replication of Whiteman and Mangels (2016; Study 1) in that it highlights how trait Brooding can play a detrimental role in fashioning subjective experiences in the general knowledge task, but again, unlike that previous study, this effect is surprisingly occurring for the opposite gender (i.e., men).

Although we additionally found a marginally significant 4-way interaction involving Induction Condition, Block, Gender and Brooding, $F(1.806, 97.517) = 2.60$, $\varepsilon = 0.90$, $p = 0.09$, $\eta_p^2 = 0.05$, exploration of this interaction did not yield any effects that survived Holm-Bonferroni corrections for multiple comparisons. Similarly, even when exploring a significant 4-way interaction involving Change Period, Induction Condition, Gender and Brooding, $F(1, 54) = 5.19$, $p < 0.05$, $\eta_p^2 = 0.09$, no relationships involving Brooding across Change Period were found to be significant for men and women in any condition (all *p*s > 0.11). No effects involving trait Reflection or BDI-II at all reached significance (all *p*s > 0.11).

Discussion

Overview

Study 2 tested whether being induced into a state of rumination versus distraction during a difficult task of verbal general knowledge would interfere with the encoding of corrective feedback, hindering the ability to use it in remediating first-test errors on a subsequent surprise retest. Ill effects of inducing rumination were predicted to appear only for correction of first-test errors made after the onset of the induction manipulation. However, what was less certain was how these effects would unfold over the post-induction period (i.e., Blocks 2 and 3). Perhaps effects would be most prominent in the initial post-induction block (i.e., Block 2) and then taper off in the later post-induction block (i.e., Block 3), as was predominantly discovered in Whiteman and Mangels (2016; Study 1). Or effects could be evident in the initial post-induction block but become more pronounced in the later post-induction block, as encounters with failure continued to accrue and feelings worsened. Thus, Study 2 aimed to elucidate the extent to which the induction of a ruminative state would produce similar or different effects compared to the effects of trait rumination found in Study 1.

To be able to determine the effects of the state rumination induction *over and above* any effects of trait ruminative tendencies, individual differences in pre-task predilections towards ruminative responsiveness (i.e., RRS scores; Treynor et al., 2003) were captured and accounted for in our statistical modeling. Moreover, our model also accounted for participants' pre-task levels of depression (i.e., BDI-II scores; Beck et al., 1996b), given that Nolen-Hoeksema and Morrow (Nolen-Hoeksema & Morrow, 1993) originally designed their rumination induction prompts to be especially sensitive to those in a depressive mood state. Indeed, the abstract and evaluative self-focused thinking elicited by these prompts has been shown to be particularly costly for those concurrently experiencing depression/dysphoria (for a review see Nolen-Hoeksema et al., 2008). As such, we also hypothesized that participants' BDI-II scores (and/or perhaps their Brooding and Reflection RRS sub-scores) might *moderate* the ill effects of being in a state of rumination. Furthermore, given that a ruminative style of thinking is more prevalent among and costly for women than men (Johnson & Whisman, 2013; Nolen-Hoeksema & Jackson, 2001), we suspected that any adverse effects of the state rumination induction (whether alone or in moderation with pre-task levels of depression and/or trait rumination) might be particularly exacerbated for women. Importantly, however, the statistical modeling employed *also* permitted simultaneously testing whether trait levels of rumination and/or pre-task levels of depression, even in the presence of the state induction manipulations, might *independently* influence behavior, potentially providing some indication of replication of Study 1 in a different context.

Contrary to these predictions, however, we found *no* evidence that the state induction manipulation *independently* influenced retest error correction (i.e., without moderation by mood and/or trait rumination), and although some induction-dependent differences in retest performance were found as a function of Gender *and* trait rumination, surprisingly it was the women who had experienced the *distraction* induction (rather than the rumination induction) who suffered post-induction declines in memory performance, and only as they exhibited increases in the tendency towards trait *Reflection*. Interestingly, this negative relationship between Reflection and error correction was found despite a marginal *positive* effect of trait Reflection on first-test performance for all participants, regardless of Induction Condition, Gender or Block. Finally, no evidence was found (whether independently or interactively with pre-task measures) for the influence of the induction manipulation on self-reported subjective experiences (i.e., RNTs or FAEs) at first-test during the general knowledge task. Yet, an exploratory finding suggested that among women only, induced ruminative thoughts (versus induced distraction) may have played a role in impairing first-test performance, at least during the initial post-induction block (i.e., Block 2). This influence did not extend to the later post-induction block (i.e., Block 3).

Equally surprisingly, pre-task levels of depression did not at all serve as a moderator of the limited amount of manipulation effects, though BDI-II scores alone predicted worse first-test memory performance during the task. These independent depression effects occurred especially among those who had been randomly assigned to the Rumination condition, suggesting group differences that pre-existed the induction manipulation. The prediction that trait Brooding might also predispose participants to more negative feedback evaluations and poorer learning outcomes was only partially supported, and only for *men*. For men, trait Brooding predicted greater emotional responsiveness to the task as a whole, as reflected by increased RNTs and more unpleasant FAEs. But these affective responses did not result in downstream impairments in learning outcomes. Rather, for men only, the Brooding sub-scale of the RRS predicted marginally *greater* improvements in post-induction retest error correction performance from the earlier Block 1 baseline period, as well as marginally *greater* concentration on the induction prompts, regardless of Induction Condition. Interestingly, this suggests that men who were higher in trait Brooding were more cognitively engaged with the task, especially after the onset of the induction, irrespective of state Induction Condition.

In the sections that follow, we will further elaborate on the small set of outcomes that did show sensitivity to the state induction (state induction-dependent effects), followed by those effects that were independent of state and tied to mood (BDI-II), trait rumination and/or Gender (state induction-independent effects). Finally, in light of these limited and somewhat contradictory induction effects, we will conclude our discussion with some possible explanations for the shortcomings of the induction procedure, itself. Indeed, these methodological challenges and limitations foreshadow the motivation for Study 3.

State induction-dependent effects

Induction effects on retest error correction moderated by gender and trait reflection. Somewhat contrary to predictions, women who were induced to experience *distraction* amidst both initial and later induction periods of the general knowledge task suffered greater *declines* in memory performance the *more* they exhibited a trait *reflective* style of rumination. While reflection has for the most part been touted as a relatively adaptive means for processing negative life events and adverse outcomes (Daches, Moor, Winquist, & Gilboa-Schechtman, 2010; Treynor et al., 2003), some studies have nonetheless found this ruminative style to be related to increases in negative thinking (Zetsche & Joormann, 2011) attention to negative events (Whiteman & Mangels, 2016; Whitmer & Banich, 2010). In this sense, it is conceivable that the women in the current sample who self-identified as usually being more *reflective* and were induced into a state of *distraction* in our task, found themselves in a mode of processing incongruent with their trait tendency. It is possible that this incongruency sapped cognitive resources that might have otherwise been devoted to processing information in the general knowledge task useful for remedial behavior. This may have especially been the case for these women given that the "break period" between blocks in the current study was championed as being "useful for processing the kinds of thoughts that students typically report having during tasks such as this one."

Induction effects on first-test accuracy moderated by gender only. Despite the implementation of a titration algorithm to try to stabilize the frequency of errors across blocks and subjects on day one, some of the most compelling effects of the induction manipulation were observed at first-test. Women in the state Rumination condition evidenced poorer performance compared to women in the state Distraction condition, but only during the *initial* post-induction block (i.e., Block 2). This suggests that to the extent that the induction manipulation was sensitive at directing attention either adaptively or maladaptively while in the midst of this goal-directed task on day one, it did so *only immediately* after its onset, and *only* for women. Indeed, this effect did not last into the *later* post-induction block, as scrutiny of mean scores among women in Block 3 shows a return for both induction groups to nearly similar performance around the accuracy rate of 0.35. Although this initial induction-related effect is in line with our predictions, because there were also no concurrent higher-order interactions with trait Brooding or pre-task levels of depression, nor were there any categorical differences in RNTs or FAEs as a function of Induction Condition and Gender, it is not immediately clear that ruminative thoughts, *specifically*, were at the root of this behavioral outcome for women in the Rumination condition.

We therefore searched for some confirmatory evidence elsewhere that the decline in first-test performance for these particular women during this part of the task might be due to a state of ruminative self-focus. We reasoned that if ruminative thinking happened to interfere in any way with memory, this relationship might best be captured by the variability found within the RNTs that were self-reported *during* the task rather than the variability found within trait rumination measures (i.e., Brooding or Reflection RRS sub-scores) acquired *prior to* the task. This led us to conduct a series of correlations where we split by Gender and Induction Condition to explore whether any linear relationships existed between self-reported RNTs and first-test performance within each block.

In these analyses, we focused our attention on women only, and we anticipated seeing a relationship only among those women in the state Rumination condition, especially during the initial post-induction block (i.e., Block 2). As anticipated, for those women being referenced, increased amounts of RNTs were associated with *declines* in first-test performance at this point in the task, $r = -0.46$, $p = 0.05$, and this was not at all the case for women in the Distraction condition, $r = 0.07$, $p = 0.78$. Importantly, no such linear relationships were discovered during either the pre-induction baseline period (i.e., Block 1) or the later post-induction block (i.e., Block 3) for women in either Induction Condition (all ps > 0.11). This suggests that Block 2 declines in memory performance for women in the Rumination (versus Distraction) condition may have been driven by a ruminative self-focus evoked particularly by the initial period of the state rumination induction.

Interestingly, however, for women in the Rumination condition only, increased RNTs during the *pre-induction* period (i.e., Block 1) were *also* negatively associated with performance in the subsequent, initial post-induction period (i.e., Block 2; $r = -0.58$, $p = 0.01$). This suggests that any preliminary RNTs these women had early on about task performance may have *carried over* from the first block and into the second, where they were perhaps exacerbated by the state rumination induction. Thus, the effect of the state rumination induction may have also been compounded by a base level of concern over low task performance that was in the process of developing from the start of the task. Moreover, again for women in the Rumination condition only, poorer task performance during the *initial* post-induction period (i.e., Block 2) was also related to an increase in RNTs in the *later* post-induction period (i.e., Block 3; $r = -0.45$, $p = 0.06$). These effects seemingly reinforce the general claim elsewhere that being in a state of rumination can be a negative cycle, where difficulties maintaining successful goal-directed behavior may continue to beget persistent ruminative thoughts (Nolen-Hoeksema et al., 2008). It is uncertain, however, why this negative cycle did not continue on to interfere with women's performance in the later post-induction period (i.e., Block 3), though one possible explanation for this is general fatigue that may have set in for all participants during the final part of the task. Taken together, these correlational data collectively provide some confirmatory evidence that the women who were induced to ruminate in our task suffered rumination-related deficits in memory performance particularly when that ruminative state was initially induced. Furthermore, these correlation effects seem to partially characterize a story about how the negative relationship between state rumination and goal-directed behavior may be cyclical in nature, and thus insidious, particularly for women in the midst of challenging self-relevant circumstances.

State induction-independent findings

Trait rumination independently predicts subjective experiences and task performance.

Trait Brooding. Somewhat surprisingly, pre-task levels of Brooding did not at all moderate any influence of the induction manipulation. However, independent of the induction manipulation, trait Brooding RRS sub-scores *did* predict a greater amount of RNTs and worse FAEs across the entire task for *men only*. The direction of these effects is in accord with previous findings that Brooding is linked with both increased negative thinking and heightened negative affect (Moberly & Watkins, 2008; Treynor et al., 2003). However, the exclusivity of this association among men in the current sample is uncharacteristic of other work revealing these kinds of relationships and challenges to usually exist more so for women (Nolen-Hoeksema & Jackson, 2001; Nolen-Hoeksema et al., 1999). Perhaps the most counterintuitive Brooding-related finding in the current study, however, was the association of this purported maladaptive ruminative style with a *change for the better* in men's error correction rates from the pre-induction block on through the remainder of the general knowledge task, during both post-induction blocks. These findings are especially striking given that women exhibited significantly higher trait Brooding scores (and higher BDI-II scores) than men in the current sample.

Drawing inferences from other studies about a possible explanation for this striking effect is difficult, particularly because Brooding findings among men elsewhere are sparse. However, insight might be gained by revisiting analyses on the induction prompt concentration ratings in the current study. As rationale, it is conceivable that a link between Brooding and increased concentration on the induction prompts might indicate greater concentration on the general knowledge task, itself. Or perhaps since induction instructions touted focus on the induction prompts as being potentially useful for students in such a challenging task (see Appendix A for condition-specific, induction manipulation instructions), maybe men with a greater tendency to brood used this inter-block task to redirect focus away from their personal concerns and more towards the task itself, in effect facilitating their ability later remediate their errors. In partial support of this, *among men only,* the more they brooded, the *higher* their concentration ratings were on the induction prompts, regardless of the induction condition – and this effect was not present for women. However, men's concentration ratings on the induction prompts were *not* at all related to the change in error correction rates from the pre- to post-induction periods of the task ($r = 0.10$, $p = 0.54$). Thus, it remains unclear exactly why men's Brooding scores were predictive of *greater* post-induction error correction performance in the current study.

Trait Reflection. More in line with general expectations regarding trait rumination, Reflection sub-scores of the RRS predicted a marginal overall increase in first-test accuracy rates for all participants in the current study, in part, replicating behavioral findings from Whiteman and Mangels (2016; Study 1). This effect aligns with the claim that Reflection is adaptive in nature, particularly as it has been characterized as being more deliberate, concrete, and problem-focused, as opposed to passive, abstract, and self-evaluative (Treynor et al., 2003). In the current study, one possible explanation for this positive relationship is that individuals higher in Reflection experienced less interference from self-relevant thoughts in the face of failure (e.g., Daches, Moor, et al., 2010), and this permitted greater focus on accurate initial retrieval of factual information at first-test. However, we would note that Reflection RRS sub-scores did not predict fewer RNTs in the current study, though it did not predict *increased* RNTs either, as it did in Whiteman and Mangels (2016; Study 1).

Pre-task depression independently predicts first-test accuracy. Contrary to expectation, we did not find any conclusive evidence that BDI-II scores *moderated* the influence of the state rumination induction on either subjective experience self-reports (i.e., RNTs or FAEs) or behavioral performance on either day one or day two of the general knowledge task. Pre-task depression *did* predict poorer first-test performance for those participants who were assigned to be in the state rumination induction group, but the lack of a 3-way interaction also involving block indicated that these mood-related challenges in the Rumination condition *pre-existed* the onset of the manipulation. In an attempt to explain why this effect might have occurred in the current study, we looked at how the BDI-II scores for the current sample compared to scores from samples recruited elsewhere in studies also aiming to investigate the effects of a state rumination induction.

In most other studies that used the BDI-II as a measure of depression, participants were recruited based on whether they were depressed or not, and subsequently, they were placed into either a depressed group or a non-depressed group (e.g., Lyubomirsky et al., 2003; Lyubomirsky & Nolen-Hoeksema, 1993, 1995; Lyubomirsky et al., 1999). The mean scores characterizing the depressed group in those studies were substantially higher (e.g., M = 22.04, SD = 5.52; Lyubomirsky et al., 2003) than the overall mean BDI-II score in the current sample, M = 8.80, SD = 4.39. Moreover, the mean scores characterizing the non-depressed group in those studies were very low (e.g., M = 1.43, SD = 1.36; Lyubomirsky et al., 2003). Thus, it could be that the level of pre-task depression exhibited in the current sample was pronounced enough to predict greater challenge with memory during the general knowledge task in the current study, but *not so high* as to predict the kind of challenge that would be exacerbated when being induced to ruminate. The challenges in the current, minimally-to-moderately depressed sample with initial retrieval of factual information on day one were most evident during the initial pre-induction period (Block 1), and also the later post-induction period (Block 3), where BDI-II scores predicted worse retrieval, regardless of Induction Condition or Gender.

Interestingly, women exhibited significantly higher BDI-II scores than men in the current study, regardless of Induction Condition. Thus, in Study 2, entering BDI-II as a predictor variable (i.e., a covariate) in the customized ANCOVA was additionally useful in controlling for this difference, and it permitted testing whether any influence of the induction manipulation may have occurred over and above this inequality in pre-task depression levels between genders. As such, as described in the ‘State induction-dependent findings’ sub-section up above, the observed decline in first-test performance during the initial post-induction block for women experiencing a state of rumination (versus those experiencing a state of distraction) provides the first piece of evidence that we are aware of that this widely used state rumination induction can lead to ill effects *devoid* of any pre-existing mood disturbances (or predilections towards ruminative tendencies).

The lack an interaction effect between pre-task levels of depression and the induction manipulation was somewhat surprising given that at least among women, higher BDI-II scores predicted marginally greater self-reported in-task interference at the hand of ruminative thoughts prompted during the rumination induction, an effect that was not found for women in the state

Distraction condition or for men in the state Rumination condition. Furthermore, the interference self-reported for these women appeared to be specific to rumination-related content that was actually primed via the rumination induction prompts, though this effect did not survive corrections for multiple comparisons. It is worth reminding, however, that these induction prompt interference queries were measured *after* completion of the task on day one (i.e., *not* after each block), and in this sense, these ratings may have been more influenced by hindsight bias or various perceptions or feelings not immediately related to the general knowledge task blocks, themselves. Nonetheless, unexpectedly, the instantiation of the induction manipulation was not necessarily more influential among our mentally healthy sample, who had higher levels of pre-task depression on average than other mentally healthy control groups who also underwent a rumination induction (cf. Lyubomirsky et al., 2003; Nolen-Hoeksema & Morrow, 1993). Indeed, limited additional evidence was found to support the notion that induction manipulation was sensitive enough for evoking a level of ruminative thinking that could hypothetically influence subjective experiences and memory performance in the general knowledge task. We explore the limitations and challenges of the induction manipulation in the next sub-section.

Challenges with the sensitivity of the induction manipulation

The paucity of induction-specific findings, whether independently or in concert with Gender and/or pre-task depression or trait rumination levels, has to be interpreted in light of the seeming lack of sensitivity of the induction manipulation. Indeed, post-task ratings of induction-related ruminative interference were low (i.e., “none at all” to “a little”), regardless of Induction Condition. This casts some doubt that the manipulation was as effective as anticipated at evoking the maladaptive mode of abstract and evaluative ruminative processing that other researchers seem to have induced using this procedure (e.g., Lyubomirsky & Nolen-Hoeksema, 1993, 1995). This issue of minimal sensitivity, however, does not seem to be driven by lack of effort to process the prompts during the induction procedure, as concentration ratings were in the moderate range, suggesting that the students were suitably engaged in this inter-block task. Rumination prompts for those in the Rumination condition did elicit slightly *less* concentration than distraction prompts in the Distraction condition, however. This suggests that focusing on abstract, open-ended, self-relevant prompts may have been more challenging than thinking about mental images of more concrete external events or objects. We offer below, as possible explanations, the current sample's minimal depressive state (cf. Nolen-Hoeksema & Morrow, 1993) and/or the absence of a salient impeded goal state (cf. Roberts et al., 2013) as two possible "contextual" explanations for why the induction manipulation may not have been as effective as predicted at eliciting a temporary ruminative state in the current study.

Of main concern is whether participants were experiencing enough "negative context" during the general knowledge task around which ruminative thoughts could have been induced. Indeed, two of the most prominent models of rumination suggest that there are conditions that need to be present for ruminative thinking to develop and exert its effects. First, Nolen-Hoeksema's Response Styles Theory (Nolen-Hoeksema, 1987) purports that rumination will exert its effects particularly when experienced while concurrently in a state of dysphoria (i.e., in the context of negative mood or clinical manifestations of depression). Second, Martin and Tesser's Control Theory (Martin & Tesser, 1996) forwards the claim that rumination will occur particularly when individuals experience a discrepancy between a desired goal state and their current state of affairs (i.e., in the context of a personally-relevant, on-going or unresolved issue or concern). We speculate below that neither of these contexts may have been present enough for the induction procedure to elicit ample rumination.

Lack of negative affect leaves insufficient context for state rumination effects. When considering the presence of dysphoria as sufficient context for rumination to be induced, of note is that the current study captured both pre-task and in-task measures of participants' affective state in the BDI-II and FAE queries, respectively. Thus, we first made an assessment of how similar participants' BDI-II scores were to those acquired in studies elsewhere that used a similar rumination induction procedure. Given the lack of sensitivity of the induction manipulation it is plausible that participants' pre-task depression rates were not as high as those elsewhere in which the induction manipulation elicited a stronger effect. Indeed, the current sample did not report itself to be as dysphoric as other research samples (e.g., Lyubomirsky et al., 2003; Nolen-Hoeksema & Morrow, 1993). Although the range of BDI-II scores in the current sample overlapped to some extent with others in which state rumination effects were found, many of those studies tested for effects by pre-selecting participants and separating them into depressed and non-depressed groups. However, the current study did not, and instead used BDI-II scores as a continuous predictor, where scores ranged only from zero to 18, compared to larger ranges elsewhere (e.g., Lyubomirsky et al., 1998). Thus, while pre-task depression in the current study *did* impact first-test performance, which shows that at least the general knowledge task, itself, was sensitive to participants' affective state, the lower overall average (and in effect, a smaller range) of pre-task depression in both the rumination and distraction groups could have rendered the induction less effective in the current sample.

Of interest next were participants' FAEs and assessing whether the task *continued* to worsen mood in a way that might render the induction manipulation effectual during the post-induction time frame. Participants in the current task showed somewhat unpleasant FAEs, but contrary to what was expected, these feelings did *not* grow worse from block to block, nor did the level of unpleasantness differ between conditions, nor did BDI-II scores at all predict FAEs in any capacity. Thus, when considering both this lack of change among in-task-related FAEs, as well as the lower overall level of pre-task BDI-II scores in the current sample, it would appear as though the level of negative affect experienced by participants may not have provided a suitable context around which the rumination induction could be the most effective.

Lack of salient goal-state discrepancy leaves insufficient context for state rumination effects. When considering the presence of goal blockage (non-mood-related) as sufficient context for rumination to be induced, performance-related goal-state discrepancies also did not seem to be salient enough for participants to become susceptible to the induction prompts. More specifically, although the titration algorithm in the general knowledge task was found to be successful during the pre-induction period at pushing first-test performance down to an average accuracy rate of 0.35 (i.e., failure), it is possible that this low level of performance was not construed as an indicator that a meaningful, personally-relevant goal was not being met, and therefore the rumination induction could not adequately take effect. Furthermore, if during the rumination induction procedure repeated instances with failure in the general knowledge task did not bring to mind *other* salient, real-world challenges for participants to dwell on (whether on-going and personal academic challenges, or other unresolved issues outside of academics), again, there may not have been an object of thought specific enough upon which the state rumination induction could take hold (cf. Roberts et al., 2013). Finally, since participants were not asked to specifically think about an on-going, unresolved concern of their own prior to experiencing the state induction procedure (and also if poor performance and negative mood did not serve as ample context for rumination to come online), then the induction prompts may have been perceived as being *too* open-ended and unfocused for participants to make sense of. Indeed, given the design of the current study there is no way to know what thought content was the object of participants' focus particularly during the rumination induction procedure. These shortcomings may have led to the greater amount of challenge participants encountered in attempting to concentrate on the rumination prompts in particular.

Nonetheless, we made every effort in Study 2 to ensure that attention was constrained *less* by the task, itself (cf. Whiteman & Mangels, 2016; Study 1), and thus was free to be directed towards other negative contexts, especially those that might be brought on by the induction manipulation (e.g., Hertel, 2004). We attempted to constrain attention less, in part, by jittering the amount of time participants waited for corrective feedback, but *after* participants were informed whether they were accurate or not. This, paired with thinking about abstract, open-ended cues at various points in the task, was intended to keep attention diffuse, and was anticipated to more easily lead to the development of ruminative thoughts during the induction procedure that might interfere with performance. In hindsight, however, it would seem as though without sufficient context in the current study, perhaps the rumination induction prompts, in particular, did not elicit the kind of uncontrollable RNTs that might impair mental efficiency (e.g., Watkins & Baracaia, 2001). Indeed, no differences were found in the amount of RNTs as a function of the induction manipulation.

Conclusions and future directions for Study 3

In conclusion, Study 2 revealed *no* evidence that the state induction manipulation developed by Nolen-Hoeksema and Morrow (Nolen-Hoeksema & Morrow, 1993) *independently* influenced retest error correction (i.e., without moderation by mood and/or trait rumination) in the current open-ended and abstract context. Furthermore, when considering that the influence of the induction procedure depended upon the moderators of Gender and trait rumination (as might be predicted), it was women who had experienced the *distraction* induction (rather than the rumination induction) who suffered post-induction declines in memory performance, and only as they exhibited increases in the tendency towards trait *Reflection*. Given the lack of findings, and the presumed lack of sensitivity of the induction manipulation, the outcome of this study was not as expected. Although a full explanation for the lack of effects remains elusive, we have explored some possible reasons for the shortcomings of the current study.

Moving forward into Study 3, we will again attempt to induce a state of rumination and measure its effects on remedial behavior within the context of our challenging verbal general knowledge task. However, equipped with a good degree of understanding of the shortcomings of Study 2, we acknowledge greater need to provide more negative context around which the rumination induction procedure can take effect. For Study 3, inducing a state of rumination will be informed by a procedure developed by Roberts and colleagues (Roberts et al., 2013), in which participants identify a more meaningful and real-world, on-going concern over which to focus their attention at various time points in a goal-directed task. Thus, Study 3 will attempt to increase the salience of participants' personalized goal-state discrepancies in an effort to measure how rumination may influence learning and rebound from failure.

CHAPTER 5: Study 3

Introduction

Background and rationale

While Study 2 utilized a rumination induction technique rooted in Nolen-Hoeksema's clinical Response Styles Theory (RST; Nolen-Hoeksema, 1987, 1990), Study 3 instead revisits the social-cognitive realm, calling once again upon the control theory account of how a ruminative state develops during goal pursuit (Martin & Tesser, 1989, 1996). Martin and Tesser have argued that when personally salient goals are blocked for an individual, recurrent and repetitive self-focused thought (i.e., a ruminative state) over these issues ensues in service of helping to minimize and resolve these goal-state discrepancies. However, experiencing a ruminative state particularly characterized by brooding over *what* one's unresolved issues are and *why* they continue to happen (rather than reflecting on how to move past them; Treynor et al., 2003), where attention is passive and abstract (rather than deliberate and concrete; Watkins, 2008), may do little to resolve such on-going goal-related concerns, but rather may perpetuate them (Martin & Tesser, 1996). From this point of view, being induced to experience such a brooding-like ruminative state over one's very own unattained goals should capture and sustain attention on these and perhaps other related issues, making it difficult to focus on additional, important tasks also requiring cognitive processing (Watkins & Brown, 2002).

Watkins and Nolen-Hoeksema have corroborated this line of thinking in their habit-goal framework of rumination (Watkins & Nolen-Hoeksema, 2014). They argue that *external* events that are construed as impediments to goal attainment (e.g., being exposed to certain negative environments, locations, and/or behaviors of others), not just *internal* events (e.g., negative affect experienced during bouts of dysphoria or depression), render sufficient context for a ruminative state to develop. In support of this claim, Roberts, Watkins, and Wills (Roberts et al., 2013) found that asking a non-clinical undergraduate sample to dwell on an unresolved goal (i.e., an ongoing, real-world concern of theirs) resulted in more ruminative thoughts about their concern during an unrelated go/no-go task than those who were instructed to focus on a resolved goal, and they also were slower on correct go trials of the task (though they committed *fewer* errors of commission). In addition, trait brooding (but not trait reflection), as measured by scores on the Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 1991), moderated the impact of the goal manipulation on state ruminative responsiveness during the go/no-go task, with higher brooding scores predicting significantly more state rumination, but only for those in the unresolved goal condition.

The research by Roberts et al. (Roberts et al., 2013) informs the current study in a number of ways. First, their work reveals that prompting mentally healthy undergraduates to identify and dwell upon actual unresolved issues in their own lives is a valid means of inducing a state of rumination. Study 3 will therefore make use of a modified version of this manipulation by asking participants to identify and dwell upon an actual, ongoing and unresolved *academic* concern of theirs while they are in the midst of completing our general knowledge task. To the extent that focusing on one unresolved goal in any particularly broad context may bring about additional ruminations over other salient issues (Martin & Tesser, 1996), participants dwelling on their own current, real-world academic challenges may by extension encounter ruminations over their performance in our difficult, academically-relevant task. Second, Roberts and colleagues showed that being prompted to ruminate over an unresolved goal caused slower (yet surprisingly more accurate) responding on a separate cognitive task, providing evidence for carryover effects of rumination. Here, we examine the extent to which this type of induction can produce carryover effects in a task involving a more demanding level of stimulus selection and encoding. Third, these researchers highlighted how trait levels of rumination may moderate the influence of being asked to think about an unresolved, real-world concern. As such, the current study will continue to evaluate and asses how trait Brooding and Reflection RRS sub-scores may moderate the effects of such an induction procedure in our rebound from failure task.

Expressive writing manipulation. A noteworthy aspect of the work by Roberts et al. (Roberts et al., 2013) is that participants first identified and briefly outlined their unresolved or resolved goal aloud to the experimenter, and then they listened to a pre-recorded script delivered over headphones that guided them to think momentarily about (i.e., *internally focus on*) their goal state. The current study will similarly ask participants to initially identify their unresolved academic concerns aloud, but will then prompt individuals to descriptively write about (i.e., *externally narrate*) their concerns, calling upon an adaptation of the methodology used in expressive writing paradigms (e.g., McAdams & McLean, 2013; Pennebaker, 1997). Such narration is important because it offers a more direct means than that used by Roberts and colleagues (or Study 2 of the current research program) for ensuring that participants are actively processing the state induction prompts. In particular, any ruminative thoughts expressed in writing can be quantified and qualified according to whether they are more brooding-like or instead more reflective in nature (Marin & Rotondo, 2017).

In keeping with expressive writing paradigms, we will pit expressive narration of one's personal issues against a non-expressive condition in which individuals offer neutral narrations about how they spend a typical day in their schedule (e.g., Gortner, Rude, & Pennebaker, 2006; Sloan, Marx, Epstein, & Dobbs, 2008). Neutrally writing about a mundane daily routine creates an ideal comparison condition in the current study first because similar to the unresolved goal condition, it can focus attention on the academic domain while aiming to keep focus away from any specific academic *concerns*. Second, it asks for a personal account of one's schedule while minimizing focus on any personal *goal state* that might inadvertently prompt rumination (cf. Roberts et al., 2013). Third, it attempts to equate and therefore control for the autobiographical memory retrieval processes also called upon in the opposite condition.

Interestingly, compared to control conditions, affording individuals an opportunity to externally narrate their personal concerns through expressive writing has revealed *mixed* outcomes for well-being and problem-solving in intervention-based studies (for a review see Frattaroli, 2006). On the one hand, expressive writing can be a helpful, adaptive process, perhaps because instructions invite individuals to "let go and fully explore the deepest thoughts and feelings" about their concern (e.g., Pennebaker, 1997). This, in effect, may promote self-affirmation (e.g., Cohen & Sherman, 2014) through positive self-reflection and constructive meaning-making (Banks & Salmon, 2013), offering writers an opportunity to confront, organize, and insightfully restructure their ongoing problems and issues (Lyubomirsky, Sousa, & Dickerhoof, 2006). In studies that use this kind of prompting, expressive writing can actually *reduce* rumination (Gortner et al., 2006; Sloan et al., 2008) and improve performance on exams (Ramirez & Beilock, 2011). On the other hand, expressive writing can also be maladaptive, particularly when it is characterized more by unconstructive reasoning processes (Banks &

Salmon, 2013), which instead focus writers' attention on negative abstractions of the causes and undesirable consequences of their problems and prime more critical views of the self and fixed views of the situation (Lilgendahl, McLean, & Mansfield, 2013). Not surprisingly, this latter style of expressive writing would seem to exemplify what it means to brood. Importantly, Marin & Rotondo (Marin & Rotondo, 2017) have shown that the extent to which one's expressive writing typifies brooding-like rumination rather than self-reflection is linked with lower self-acceptance and more negative views of the self. Thus, it is conceivable that being prompted to write in such a way about an ongoing and unresolved academic (versus being prompted to write about a typical day in one's schedule) could bring about a brooding-like ruminative state that keeps attention negatively focused on the self and signals of one's failures, ultimately hurting performance in our general knowledge task.

Attention and rumination. In light of the induction procedures selected for the current study, it is important to more carefully consider the underlying mechanisms for how unresolved concerns can lead to ruminative thoughts, and even more importantly, how these thoughts might then influence downstream cognitive processing important for learning. Koster and colleagues (Koster et al., 2011) proposed an "impaired disengagement" hypothesis of rumination suggesting that negatively brooding over stressors that signal goal-state discrepancies impairs the ability to disengage attention from such troubles, at the expense of deploying attention elsewhere. In support of this, empirical evidence reveals that attention can be sustained on self-relevant versus non-self-relevant information not only because ruminating individuals cannot keep from (i.e., *inhibit*) processing information that signals personal goal-state discrepancies (Joormann, 2006), but because they have difficulty with *shifting* focus away from these things (Koster et al., 2011).

Not mutually exclusive with this, Whitmer & Gotlib (2013) proposed an attentional scope model of rumination whereby being in a ruminative state *narrows* attentional focus onto self-relevant information, whether this information is out in the environment or held internally within one's working memory. As shown by Altamirano and colleagues (Altamirano, Miyake, & Whitmer, 2010), this modulation of attention can perhaps help problem solving when a narrow focus is desirable, such as in a goal maintenance task (e.g., modified Stroop task requiring participants to maintain focus on reporting word color over reading word text), but it can hurt performance when more flexible processing is appropriate, such as in a goal shifting task (e.g., letter naming task, where participants must intermittently switch visual attention spatially between lists of letters to be reported).

In the context of the current study, both an attentional scope model and the impaired disengagement hypothesis would predict that for those ruminating over academic concerns, difficulties with feedback-based learning might especially be evident when a reminder of a recent performance failure (i.e., the incorrect response presented back to participants in red) *directly competes for attention* with new information that could be used in the future to correct that error (i.e., learning-relevant information). In this type of competitive feedback situation, these models would predict relatively greater dwell time on the negative performance feedback for those who were in a ruminative state, even though it provides no new information, potentially at the expense of attending to and encoding corrective information that was proximal, but nonetheless spatially separate. Thus, the goal of Study 3 is to use gaze fixation metrics from eye-tracking technology in a competitive attention paradigm to directly examine how a ruminative state influences attention to past outcomes (i.e., negative performance feedback) versus new corrective information (i.e., learning-relevant feedback).

Eye-tracking (gaze fixation) in rumination and depression. One great advantage of using eye tracking technology is that it provides an overt (i.e., direct) and continuous measure of where exactly individuals are looking (i.e., fixating their gaze), and for how long, when two stimuli concurrently vie for attention. Because we are aware of only a few gaze fixation studies involving eye tracking that have been conducted for expressly studying the attentional mechanisms of (trait) rumination among adults (Duque, Sanchez, & Vazquez, 2014; Owens & Gibb, 2017), given the close link between rumination and depressive mood, we additionally reference eye tracking studies of dysphoria and depression to help guide selection of appropriate eye tracking metrics for the current study.

In eye-tracking studies of dysphoria and depression, participants are often shown competing stimuli for an extended period of time (> 3s) during free-viewing tasks that offer little instruction, and biases in attention are measured (for a review see Armstrong & Olatunji, 2012). The vast majority of this research (e.g., Caseras, Garner, Bradley, & Mogg, 2007; Kellough, Beevers, Ellis, & Wells, 2008; Mogg & Bradley, 2005) has consistently shown that either sub-clinical levels of dysphoria or clinical manifestations of depression are associated with a bias to *sustain attention* (i.e., fixate gaze for longer periods of time) onto negative stimuli. Such bias is usually assessed using a 'first fixation duration' metric (i.e., FFD; the amount of time spent maintaining gaze on an area of interest (AOI) the first time it is fixated upon), or a 'total fixation duration' metric (i.e., TFD; the summed amount of time spent fixating an AOI while it is presented on-screen). FFD and TFD contrast with metrics that are instead used to index an *initial orienting* bias, such as the *time taken until* first fixation on a stimulus, or the proportion of times fixating a negative stimulus *first* over a neutral or positive stimulus. These latter metrics are more useful for measuring vigilance for negative stimuli, as is typical of cases in which individuals worry over and subsequently avoid rather than dwell on and ruminate over negative or threatening stimuli (e.g., anxiety; Garner, Mogg, & Bradley, 2006). Indeed, depression and dysphoria appear to have less influence on initial orienting bias than on sustained attentional processes (Gotlib & Joormann, 2010).

In line with the specific hypotheses regarding rumination's effects on attention described above, Duque and colleagues in a free-viewing study (Duque & Vázquez, 2015) found that higher RRS scores predicted a greater negative attentional bias, as measured by TFD (FFD was not assessed), even after controlling for depression. Elsewhere in another similar free-viewing study (Owens & Gibb, 2017), higher trait *Brooding* RRS sub-scores within a mentally healthy adult sample (BDI-II scores of 18 or below) predicted more negative sustained attention using these eye tracking metrics. Taken together, these studies support our choice of measuring FFD and TFD to study the sustained attentional biases we expect to see among those experiencing a state of rumination while they freely view competitive feedback in our academic, incidental learning (i.e., test-feedback-surprise retest) paradigm.

One remaining question, however, is whether the greater sustained attention to negative performance feedback expected for those in a state of rumination versus distraction will make it less likely that nearby *corrective feedback* will be sufficiently encoded for later use in successful remediation of errors. Although a number of studies have relied on the use of various eye tracking metrics to examine memory *retrieval* processes (for a review see Hannula et al., 2010), studies appear to be sparse that have used fixation duration metrics at the time of initial stimulus presentation to assess successful *encoding* as measured by retrieval on a subsequent memory test. To our knowledge, there is only one investigation that measured the relationship between fixation duration and subsequent declarative memory (Pazzaglia, Staub, & Rotello, 2014). That study used three experiments to test whether fixation duration on target word stimuli, either studied in list form in an intentional encoding paradigm (experiments 1 and 2) or read in sentence form in an incidental encoding paradigm (experiment 3), was predictive of later recognition memory for those target words during a test phase, and whether this depended at all on word frequency. In the intentional encoding experiments, longer dwell-time (as indexed by FFD and TFD metrics) predicted greater subsequent recognition, regardless of the frequency of target word stimuli. However, in the incidental encoding paradigm, *neither* FFD *nor* TFD were linked with subsequent memory.

Although the current study investigates incidental learning using a test-feedback-surprise retest paradigm, our competitive feedback stimuli are presented in a form more similar to that of the *intentional* memory task in Pazzaglia and colleagues' work (i.e., words listed on-screen). In addition, unlike their incidental memory task, which presented explicit instructions involving reading comprehension of sentences (in which target words were embedded), our task simply permits a passive *free-viewing* of the feedback stimuli in the absence of any instruction. In this sense, fixation behavior in the current study should also be more like that observed in Pazzaglia and colleagues' intentional memory task, where participants could freely (albeit actively) move their eyes to any word for as long as they wanted, rather than in the incidental memory task, where participants' gaze fixations were likely constrained by the characteristics of reading behavior. Thus, we expect that similar to the intentional memory task findings of Pazzaglia et al. (2014), FFD and TFD gaze fixation metrics may also provide a serviceable index of successful encoding in the current study.

Interestingly, Pazzaglia and colleagues (2014) observed that the FFD values associated with studying behavior in the intentional memory task were longer (460–607 ms) than those observed during reading behavior in the incidental memory task (227–253 ms). They suggested that these longer initial fixations likely reflected more complex encoding processes, whereas the shorter FFDs observed in their incidental memory experiment were more typical of basic lexical processing involved in continuous reading (e.g., E-Z Reader Model; Reichle, Rayner, & Pollatsek, 2003; Staub, White, Drieghe, Hollway, & Rayner, 2010). As such, these longer FFDs might have helped drive the memory relationship they observed in the intentional memory experiments. Unsurprisingly, given the differences in the experimental tasks and instructions, TFD values were also substantially larger in the intentional memory task (1530–2245 ms) than in the incidental memory task (290–421 ms). Thus, for the current study, it is conceivable that variability in the TFD metric, in particular, may be sensitive to the encoding of corrective feedback in our free-viewing task. For FFD, however, the extent to which this metric is also sensitive may depend on whether participants initially fixate the feedback stimuli as if they were aiming to study them, instead of simply read them. In the context of rumination, since attention may be sustained on signals of past failure when ruminating, then compared to those induced to distract, it is possible that less time will be spent encoding learning-relevant feedback, as assessed by TFD and perhaps FFD eye tracking metrics, and as a result error correction may suffer.

Study design and predictions

Study 3 will continue to test whether being induced to ruminate versus distract will impact, either independently or interactively with trait rumination or depression, attention to errors in our general knowledge task and the ability to later correct them on the subsequent surprise retest. The critical elements of the current study, however, are that our induction manipulation will be *academically-relevant* and rooted in *social-cognitive* theory, the implementation of the induction will involve the use of *written narratives* to help ensure both greater engagement with the induction procedure and more objective measurement of its effectiveness, and we will present feedback in a manner that places new, corrective information in *competition* with reminders of the recent mistake. Furthermore, this competitive feedback design lends itself to measurement of overt attention through *gaze fixation eye tracking metrics.* Finally, *only women* undergraduates will be recruited to participate in the current study, given that in Study 2 all induction-dependent effects occurred for women, not men.

We predict that being induced into a state of rumination versus distraction will exert its effects on learning through the modulation of sustained attention and encoding processes during the presentation of competitive feedback in our task. In particular, we expect that compared to being in a state of distraction, those in a ruminative state will exhibit relatively greater dwell time (i.e., longer fixations as measured by FFD and TFD eye tracking metrics) on reminders of performance failure (i.e., negative performance feedback). However, given that during feedback presentation, participants can freely fixate their gaze anywhere on-screen, including blank space, it is not immediately clear whether longer dwell time on negative performance feedback will come at the expense of sufficiently encoding the competing learning-relevant feedback. To the extent that it does, we would anticipate the TFD metric to be the most sensitive at measuring this cost, and predict that for those induced to ruminate versus distract, less total time will be spent looking at this corrective information.

Our assessment of the initial processing (i.e., FFD) of corrective feedback, on the other hand, is more exploratory in nature, as its sensitivity to the aforementioned ‘cost’ likely depends on participants' implicit goals for initially processing this new information. An initial response characterized by rote reading rather than active assessment will likely render shorter FFD measures overall. While it is possible that a negative attentional bias particularly for those in a ruminative state may concurrently render more rote (i.e., quick) processing of corrective feedback at first, therefore leading to shorter FFD measures compared to those in the Distraction condition, it is also possible that *all* participants may rotely process the correct answer the first time they see it, leading to no differences in FFD measures. However, it is also possible that all participants initially focus more *deliberately* on the correct answer word, analogous to the more lengthy initial processing observed overall in the intentional memory experiments of Pazzaglia and colleagues (2014). This, too, might render no differences in FFD measures. Nonetheless, along with more deliberate initial processing might also come more variability in the FFD metric. As such, perhaps those induced to ruminate may be on the shorter end of this variability if they are continuously concerned about their performance and ongoing academic issues, compared to those in the Distraction condition.

To the extent that individuals in the Rumination condition do not sufficiently process learning-relevant feedback, and particularly if attentional biases towards negative performance feedback appear to cost them deeper processing of this corrective information, we anticipate that error correction rates on the surprise retest for this group will suffer compared to those in the distraction group. We also expect that these effects will unfold only after onset of the induction procedure (i.e., in Block 2), and that no group differences in attention to errors, encoding of corrective information, or error correction rates will be present during the pre-induction baseline period (i.e., in Block 1).

The predictions above are based on the assumption that all participants will experience the induction manipulation in the same way. In reality, however, given how personalized the induction procedure is intended to be, there is likely to be variability in the kinds of unresolved concerns individuals in the Rumination condition write about, as well as the perceived intensity of those concerns. Therefore, we also expect that the extent to which the state rumination induction exerts its effects will depend on both the quality and quantity of ruminative thoughts expressed in participants' hand-written narratives. In particular, to the degree that participants exhibit a ruminative brooding style of writing, as indexed by the coding system developed by Marin and Rotondo (Marin & Rotondo, 2017), we expect the aforementioned ill effects of the rumination induction to be more prominent. However, to the degree that participants write in a more adaptive, self-reflective manner, we expect these effects to be attenuated. We also expect that those in the Distraction condition, who will be writing neutrally about a recent day in their academic schedule, will exhibit very little, if any, rumination in their writing, whether in the form of ruminative brooding or self-reflection.

Finally, as in the previous two studies, the current study will acquire both pre-task (RRS) and in-task (RNTs, FAEs) self-report measures of rumination. We expect that the ill effects of being induced into a ruminative state during our challenging test of verbal general knowledge will track in participants' self-reported subjective experiences of RNTs and FAEs throughout the task. In particular, we expect an increased number of RNTs and worse FAEs for those induced to ruminate versus distract. Furthermore, we anticipate that the ill effects of being induced into a ruminative state may be exacerbated by participants' predilection towards the Brooding or Reflective styles of ruminative thinking, as measured by pre-task RRS scores (e.g., Key et al., 2008; Rosenbaum et al., 2017). Specifically, any state-based ill effects observed during the post-induction period may be exacerbated by the trait maladaptive style of Brooding, but attenuated by the trait adaptive style of Reflection. However, trait rumination measures may not only moderate effects of the state induction manipulation, but also predict effects across the whole task. Finally, it is possible that any state rumination and distraction effects may also be shaped by pre-task levels of depression, as measured by the BDI-II (e.g., Lyubomirsky et al., 2003; Lyubomirsky & Nolen-Hoeksema, 1993, 1995).

Method

Participants

Fifty-nine women were recruited from the Baruch College undergraduate population via the institution's online research participation subject pool. This sample of women ranged from 18.0 to 34.2 years of age (*M* = 20.50, *SEM* = 0.40) and self-reported as being native English speakers or fluent by age six. They also reported having normal or corrected-to-normal hearing and vision, with no history of eye disorders (e.g., detached or torn retina, macular degeneration, glaucoma, color blindness). All participants scored 19 or lower (i.e., at or below the cut-off for moderate depression) on the Beck Depression Inventory II (BDI-II; Beck et al., 1996b) in the pre-test survey on the first day of testing. As compensation for their participation, participants received research credit as part of a course requirement (69.5%), or they received cash money at a rate of $10 / h (8.5%), or they received some combination of both credit and money (22.0%). A bonus incentive of $5 or 0.5 h of course credit was offered to all participants who returned for the second day of testing.

Some participants were excluded because critical aspects of their data did not conform to pre-determined standards. One woman terminated her participation in the study after completing only a few trials in the first block of general knowledge questions on day one, citing the task as being too challenging for her to continue on. Another woman finished Block 1 but was unable to complete any trials in Block 2 during the time she had available on the first day of testing. Thus, the data sets for both of these women were excluded because they were incomplete. In addition, another participant's first-test responses in Block 1 were characterized by a disproportionately large amount of spelling (i.e., orthographic) errors (26%), which was confirmed by a boxplot outlier analysis. The higher rate of orthographic errors for this participant raised concern that during trials in which a *non*-spelling (i.e., semantic) error had been committed, both performance- and learning-relevant feedback may have been processed differently compared to all others who committed substantially fewer orthographic errors. Given that this study will focus on correction of semantic errors only, as in the two previous studies, this particular participant was excluded from analyses (see *Behavioral data preparation* portion of the Data analysis sub-section below for additional details on how orthographic errors were processed in the current study). One additional woman evidenced accuracy rates in Block 1 (54%) and Block 2 (63%) that were above 1.5 times the upper interquartile range of scores for the entire sample in those blocks. This cast uncertainty that the task was as challenging for this participant as it was for others (see Materials sub-section below for details on the pool of question and answer stimuli that were used in the current study). Thus, in all, four participants were excluded from analyses, three women from the Distraction condition and one woman from the Rumination condition.

The final sample included 55 participants that were distributed relatively evenly within each Induction Condition (28 state rumination, 27 state distraction). As shown in Table 1, there were no differences between the two induction conditions in pre-task levels of depression as measured by the BDI-II, or in trait levels of rumination as measured by the full RRS, or the Brooding and Reflection sub-scales (all *p*s > 0.26). However, the two groups did differ marginally in their age, $t(53) = 1.93$, $p = 0.06$, and significantly in years of education, $t(53) = 2.38$, $p = 0.02$. Participants in the Rumination condition were marginally older and had been in school longer than those in the Distraction condition.

Table 1. Study 3 Sample Characteristics. Mean scores of pre-test self-report questionnaires and demographics. Standard errors of the mean appear in parentheses in this and all other tables.

	Overall	**Range**	**State Rumination**	**State Distraction**
n	55	—	28	27
Age	20.57 (0.41)	18.03–34.21	21.33 (0.72)	19.77 (0.34)
Years of Education	13.59 (0.16)	12.0–15.67	13.94 (0.22)	13.22 (0.20)
BDI-II	7.47 (0.74)	0–19	6.64 (0.90)	8.33 (1.18)
RRS Total	41.15 (1.44)	22–61	39.57 (2.00)	42.78 (2.06)
Brooding	10.18 (0.49)	5–18	9.71 (0.71)	10.67 (0.67)
Reflection	9.35 (0.45)	5–18	9.46 (0.69)	9.22 (0.59)

Materials

General knowledge stimuli. The acquisition of eye tracking metrics in the current study precluded the use of the algorithm employed previously to individually titrate participants' first-test performance to 0.35 correct. This is because the content and difficulty of the general knowledge questions, as well as the length of each correct answer word, would not be uniform for all participants across the factors of Induction Condition and/or Block, and thus these features of the stimuli might unequally influence gaze fixation duration metrics across these important factors. To forestall these issues, we hand-selected 138 items from the larger, previously-normed pool of 434 general knowledge question and answer stimuli (see www.mangelslab.org/bknorms), and divided them into two bins of 69 items (for use in each block of the general knowledge task). Items in each block were equated on question content and difficulty (with a target accuracy of 0.35) and correct answer word length (6-7 letters on average). To do this we first sorted the full pool of 434 items into three general categories of information topics: science and technology, arts and humanities, history and geography. From each of the three topic categories, we then selected 23 item pairs to populate the two stimulus bins, making an effort to ensure that each item pair was matched as well as possible on the aforementioned characteristics.

Three separate 2 (Stimulus bin) x 3 (Topic category) independent groups ANOVAs then confirmed that there were no differences in question difficulty (all *p*s > 0.40) or in the number of letters (all *p*s > 0.68) or syllables (all *p*s > 0.14) in the correct answer words as a function of Stimulus bin and/or Topic category. In addition, the results of two separate one-sample *t*-tests showed that the average difficulty for all items in each stimulus bin effectively matched the target accuracy rate of 0.35 (all *p*s > 0.88). Thus, the 138 question items selected for use in the current study were anticipated to lead to the same level of challenge as those items that had been encountered by participants in Whiteman and Mangels (2016; Study 1) and Study 2.

Given the pre-selected size parameters of the word feedback in the current study (see *Trial Sequence* sub-section below for further details), the average number of letters found to be present in correct answer word stimuli (Bin 1: *M* = 6.36, *SD* = 1.16; Bin 2: *M* = 6.44, *SD* = 1.31) typified word length shown elsewhere to only require a single fixation for effective lexical processing (Rayner, 1979, 1984). The length for all correct answer words (as well as all possible response words) was pre-set to range from 4 to 9 letters, and in addition, the average number of syllables in the correct answer word was also found to be well matched across bin (Bin 1: $M = 2.46$, $SD = 0.83$; Bin 2: $M = 2.29$, $SD = 0.86$). Finally, all correct answer word stimuli had been rated previously as being familiar to 95% of the Baruch College undergraduate population, thus reducing the likelihood that differences in word fluency would influence gaze fixation behavior (e.g., Gernsbacher, 1984; Gordon, 1985; Rayner & Duffy, 1986; Shatzman & McQueen, 2006). The order of these matched stimulus bins for use in the two separate blocks of questions in our general knowledge task was counterbalanced relatively evenly within each induction condition.

Software and hardware. The general knowledge task was delivered using Presentation software (Neurobehavioral Systems, Inc., Berkeley, CA) and programmed to sync up and interface with Tobii Studio Software (Version 2.3.1; Tobii Technology, Inc., Falls Church VA) in a dual-computer set-up. In the testing booth, the general knowledge stimuli were presented on a 23" widescreen LCD monitor (1920 x 1080 screen resolution; 60 Hz refresh rate) that was part of a Tobii TX300 integrated eye tracker system. Data were pre-processed using Tobii Studio software and then exported and processed further in Matlab (Mathworks, Natick, MA) using an in-house script.

Design and procedure

Overview. The study took place over the course of two days. On day one, participants first filled out the RRS and BDI-II measures, along with a set of demographic questions. They were then escorted to a well-lit room where they were seated comfortably, without a chin rest or head constraints, approximately 60 cm in front of the computer monitor and eye tracker integrated system, and a 9-point calibration procedure was carried out. Participants then began the general knowledge task, which consisted of two 69-item blocks and employed a competitive feedback design that was optimized for eye tracking data collection. (See Figures 1 and 2 down below for a representation of the block and trial structures, respectively.)

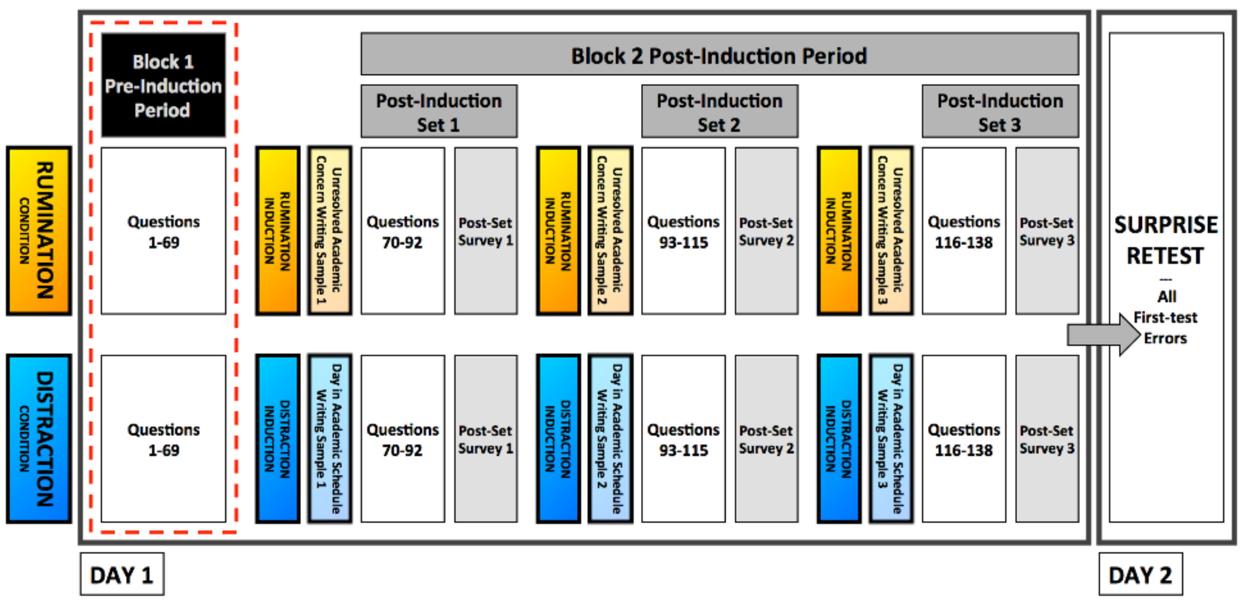

Figure 1. Study 3 Block Structure and Experimental Design. On Day 1, regardless of Induction Condition, Block 1 (surrounded by the red dotted line) served as a preliminary, pre-induction baseline period for memory performance and eye tracking metrics in the general knowledge task. Each participant then either received the state rumination (indicated by the orange gradient boxes) or state distraction (indicated by the blue gradient boxes) induction manipulation at the outset of Block 2, and then again one third and two thirds of the way through this second block in a mixed-measures research design. Induction writing prompts and post-writing queries were administered just before each post-induction set of general knowledge questions, and post-set surveys querying task-related subjective experiences were administered just after each post-induction set of questions. Participants returned on Day 2 for a surprise retest of all first-test errors.

Prior to Block 1, all participants were presented with *general task* instructions detailing the basic structure of a trial and how to complete it, and they were briefly reminded of these instructions prior to beginning Block 2. Before receiving these reminder instructions, but after completing Block 1 (i.e., between blocks), participants were also administered *condition-specific* instructions informing them that they would use this “break period” to begin a separate but important writing-based task. They were also informed that they would revisit this writing-based task again, both one third and two thirds of the way through Block 2. Although participants were not informed of its true purpose, the three-part writing-based task was intended to place them into either a state of rumination or distraction.

Just prior to completing each of the three parts of the writing-based task, participants were additionally given an induction-related *writing prompt* that provided an explicit purpose for the current aspect of the writing task, as well as instructions on how to craft their condition-specific writing sample. Each writing prompt was given on a lined sheet of paper, and subjects were given approximately 3-5 minutes to hand-write their entry, after which the experimenter immediately collected the sample. Participants’ subjective experiences in the induction-related writing-based task were then queried (i.e., three measures taken, each one gathered after each of the three writing samples in Block 2 was completed). Their subjective experiences within Blocks 1 and 2 of the general knowledge task were also queried three times, each assessment coming after participants completed a short 23-item set of general knowledge questions (i.e., one third and two thirds of the way through each block, as well as at the completion of each block).

On day two, 6-8 days later, participants returned to complete another set of general knowledge questions. Although this set consisted of only their incorrect items from day one, they were not told this at either the end of the first test or at the start of the retest. No induction procedure was administered on the second day of testing, nor were any eye-tracking data collected.

First day of testing.

General task instructions. The general knowledge task was introduced via a *general* instruction set. Briefly, participants were told that they would be completing a large set of questions, and that for each question item they would have a 3-minute time limit to submit their response, after which they would rate confidence in their response on a 1 (sure wrong) to 7 (sure right) scale. They were told that all correct answers were one word only, ranging from 4 to 9 letters, and that as such, the computer program would only accept responses in this range. Participants were also told that all correct answers contained no numbers, spaces, or symbols, and that *any amount of misspelling*, even if minor, would result their response being called incorrect. For trials in which participants lacked confidence in their knowledge, they were instructed to refrain from typing gibberish and instead to type their most educated guess, and then to rate their confidence accordingly. Participants were also informed they would be presented with feedback in two forms. First they would be shown an indication of whether their response was correct or not, and second they would be shown a simultaneous presentation of the correct answer to the question they had just attempted along with a re-presentation of the response they had just typed, regardless of whether that response was correct or not.

Condition-specific instructions (Introduction of induction). Just prior to the onset of the induction manipulation in Block 2, a statement was presented to all participants saying:

"Based on your responses so far, you encountered some difficulty answering the first block of questions. Although this difficulty is happening within the context of this research study, perhaps you have encountered difficulties in actual academic situations of your own life. During real-life academic difficulties, many students often report taking the time to…"

At this point, the manipulation was introduced via a *condition-specific* instruction set that prompted participants to identify an object of focus that they would write about in a short additional task.

For the Rumination condition, participants were prompted to "think about their academic difficulties in real life" and to identify an ongoing and unresolved academic concern of theirs that had come about recently and was currently causing them distress.

For the Distraction condition, participants were prompted to "distract themselves from the general knowledge questions or any real-life academic difficulties" by identifying a recent non-emotional day in their academic schedule for which they could remember with good accuracy the events that took place.

To help participants with this process, they were also supplied with two condition-specific, scenario-based examples of suitable objects of focus, described in the instructions as being previously offered by actual participants (see Appendix D for the full set of condition-specific instructions used in Study 3; see also Appendix E for the condition-specific scenario-based examples).

Once participants had identified their object of focus for the writing task, they briefly described it to the experimenter who ensured that the object was suitable for the writing exercise in their condition. If it was not suitable, or if an object of focus could not be identified, participants were redirected with a few verbal prompts until they were successful. Participants were then asked to complete a short, condition-specific *pre-writing* survey that queried the degree of concerned thinking they had recently experienced about their object of focus. The short survey consisted of four items, two examples of which are (with Distraction condition phrasing in parentheses), “How often have you thought about your concern (the day in your schedule) since it first started (happened)?” and “How much was your unresolved issue (the day in your schedule) a concern to you during first block of questions?” For the former ‘frequency of thought’ items, the rating scale ranged from 1 (never) to 9 (all the time), with 5 indicating a middle point (sometimes). For the latter ‘amount of concern’ items, the rating scale ranged from 1 (not at all) to 9 (extremely), with 5 indicating a middle point (somewhat).

Induction-related writing prompts. Next (i.e., prior to starting each of three 23-item sets of questions in Block 2), participants were presented with condition-specific prompts on how to craft their writing samples. For the Rumination condition, we based the writing prompts on three important assumptions of Martin and Tesser’s (1996) Control Theory of rumination. First, given their claim that rumination is born out of goal-state discrepancies that are persistent and revolve around a common instrumental theme, the first prompt asked participants to factually describe with as little emotional expression as possible what their on-going academic concern was and why it seemed to be persisting. Second, given that rumination over unresolved goals can be passive and automatic, the next prompt asked participants to describe the kinds of recurrent and repetitive thoughts that tended to easily come to mind about their ongoing academic concern. Third, given that rumination comes online when the rate of progress towards a goal is not what the individual wants it to be (i.e., slower), the final prompt asked participants to describe the degree of investment of their time and energy that had been expended in vain (i.e., wasted) in attempts to resolve their concern (see Appendix F for exact wording of prompts).

For the Distraction condition, the prompts were fashioned based on 'fact control writing' often used in the expressive writing literature (e.g., Seeley, Yanez, Stanton, & Hoyt, 2017), where participants write a factual account with little to no emotion of a recent day in their schedule. However, the prompts for this condition were also informed, at least in part, again by Martin and Tesser's control theory (Martin & Tesser, 1996). In particular, they have offered that immediate thoughts in the service of attaining a temporary goal (e.g., trying to accurately recall the events of a typical day in one's schedule) are *not* about rumination, though they involve self-focused thinking. Thus, the first prompt asked participants to factually describe the events of a recent, non-emotional day from their academic schedule. The second prompt asked them to describe precisely *when* in the day (i.e., at what exact time) the events they had previously described occurred. Finally, the third prompt asked participants to describe precisely *where* they were (i.e., at what exact spot on or around campus) when the aforementioned events they had described occurred (see Appendix F for exact wording of prompts).

All prompts in each condition were always presented in the order mentioned above (i.e., no counterbalancing was used), given that this particular sequence was deemed ideal for creating a natural and continuous mental thread about one's object of focus that could most easily and fluently be expressed in writing. To further facilitate the continuity of this process, participants' previous writing samples were temporarily re-issued to them prior to completion of a new one. When completing all writing prompts, participants were also asked to constrain their focus on *past-oriented* thinking about their object, rather future-oriented thinking. This was particularly important for the Rumination condition because, although ruminating about past negative events is commonly (and oftentimes, concurrently) associated with concern for the future (Watkins, Grafton, Weinstein, & MacLeod, 2015), such future-oriented, recurrent, and repetitive negative thinking is more often described as being a form of 'worry' than it is a form of rumination (Martin & Tesser, 1996; Watkins, 2008). Indeed, while some research suggests that worry and rumination share a common cognitive mechanism (Krahé, Mathews, Whyte, & Hirsch, 2016), each of these two styles of thinking has been shown to elicit different cognitive and affective consequences (McLaughlin et al., 2007). Because the aim of the current study was to measure the impact of being in a state of rumination, this charge to focus on past-oriented thinking was aimed at curbing participants' level of worry in either condition as much as possible.

After writing for each prompt, participants' were asked to fill out a short *post-writing* survey that queried their subjective experiences while completing that particular writing sample. The items for the survey were selected from the 'experiential self-focus' rumination induction prompts originally developed by Nolen-Hoeksema and colleagues (Nolen-Hoeksema & Morrow, 1993). Adapted for use in survey form, they measured the degree of hopelessness/hopefulness, restlessness/calmness, sadness/happiness, agitation/relaxation, and fatigue/energy that participants felt as they thought and wrote about their condition-specific object of focus. All five queries were rated on a scale that ranged from 1 to 9, with 1 reflecting an extreme amount of the negative self-focus characteristic, 9 reflecting an extreme amount of the positive self-focus characteristic, and 5 indicating a middle, neutral point.

Trial sequence. For all trials in the general knowledge task, a black screen background was used, as in Whiteman and Mangels (2016; Study 1) and Study 2. As shown in Figure 2 for each individual trial, questions were presented in gray font, and participants had a 3-m time limit to submit their response, after which they rated their response confidence also in the same manner as in Studies 1 and 2. Then they were presented with a short blank screen for 250 ms, followed by a 3-s fixation period, consisting of a screen-centered gray circle that subtended 1° of visual angle (VA). Then an initial indicator of participants' performance accuracy was presented for 3 s, also consisting of another centered circle, 1° VA in diameter, where the color red indicated an error response, and the color green a correct response.

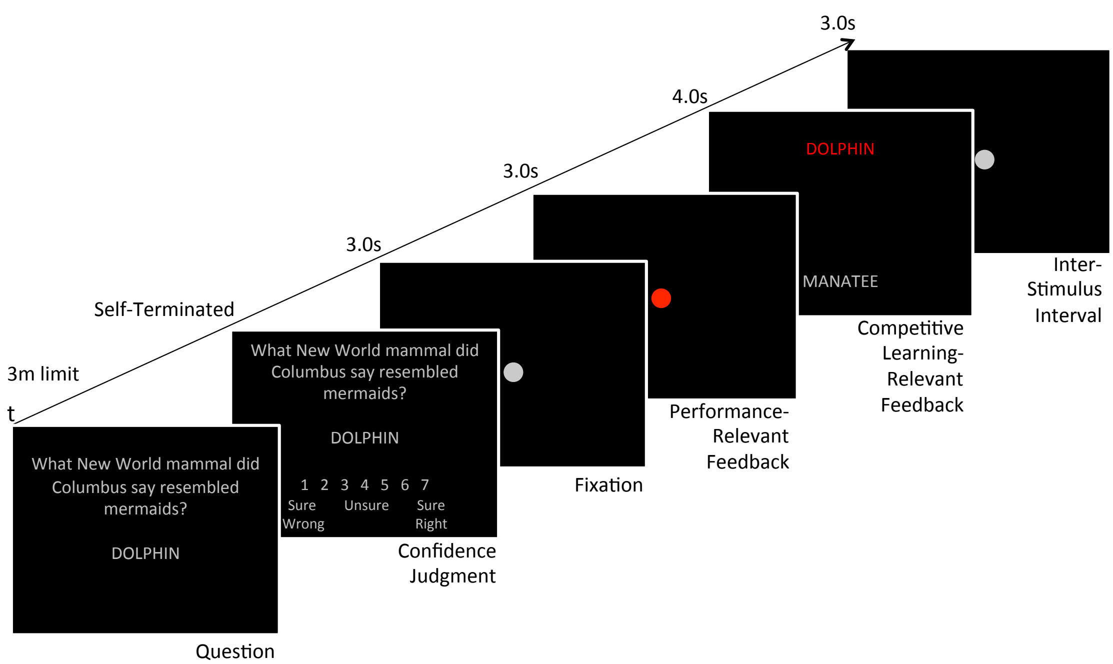

Figure 2. Study 3 First-Test Trial Structure. Example of a trial with an incorrect answer. If the answer had been correct, a green circle and green correct answer would have been shown.

Immediately after, a reminder of performance accuracy (i.e., participants' typed response to the question just attempted) was simultaneously presented along with learning-relevant feedback (i.e., the correct answer to the question just attempted), where the latter feedback type was always presented in gray, but participants' responses were presented in green if correct and in red if incorrect. The two pieces of word feedback, center-justified, were presented in vertical alignment with their centers separated by approximately 19.1 cm, subtending at about 17° VA. Whether learning-relevant feedback appeared on the top of the screen or at bottom on any given trial was pseudorandomly counterbalanced for correct and incorrect trials separately. Each word stimulus was 1.1 cm (~1° VA) tall, and could be as wide as 9.9 cm (i.e., nine letters long, or ~9° VA), but as narrow as about 4.4 cm (i.e., four letters long, or 4° VA). This competitive feedback was presented for 4 s, a duration consistent with other eye tracking studies using a competitive, free-viewing stimulus design like this one (Duque et al., 2014; Kellough et al., 2008; Owens & Gibb, 2017). After offset of the competitive feedback, an inter-stimulus interval ensued, consisting of a 3-s presentation of a screen-centered gray circle, subtending 1° VA.

Post-set surveys. To gain insight into participants' general knowledge task-related subjective experiences, within each one of the two blocks we asked them to answer three short post-set surveys about the thoughts (i.e., recurring negative thoughts – hereafter referred to as RNTs; "How many recurring negative thoughts did you experience in the set of questions you just attempted?") and feelings (i.e., feelings after errors – hereafter referred to as FAEs; "In this set of questions, whenever you made an error, how unpleasant or pleasant did you feel?") they had encountered during the 23-item set they had just finished. All post-set survey questions were rated on a 1-to-9 Likert scale, with 1 reflecting the negative or low end of the subjective experience, 9 reflecting the positive or high end, and 5 indicating an experiential midpoint (*i.e.*, neutrality). At the conclusion of the first day of testing, participants were asked to return within 6 to 8 days to complete a second set of general knowledge questions.

Second day of testing. On the second day, participants were presented with a shortened set of similar *general* task instructions that described a slightly modified trial structure for the general knowledge questions. Unlike first-test, which first issued an index of participants' response accuracy and then presented both the participants' response and the correct answer in a competitive feedback design, the retest feedback combined all of these components into a single stimulus to minimize the amount of testing-time for participants on the second day. Specifically, correct responses were presented in green text and incorrect responses in red text. This combined, single piece of feedback was presented immediately following subjects' confidence ratings and lasted for 1 s. No induction manipulation or eye tracking was used during the retest.

All re-queried questions on day two were presented in one large retest block. However, to preserve the baseline and post-induction contexts from day one, and to decrease variability in study-test delay, questions from Block 1 were presented before questions from Block 2. Questions within each "block" were randomly shuffled and then presented. Only at the outset of day two were participants informed that they were being retested on a subset of questions they had encountered on day one, without any specific mention that these questions consisted only of first-test items they had answered incorrectly. All participants included in analyses reported being surprised by this retest.

Eye tracking recording and data pre-processing

Gaze data were recorded at a sampling rate of 300 Hz. In accord with standard settings used on current Tobii eye trackers, fixations were defined using the Velocity-Threshold

Identification (I-VT) fixation classification algorithm, where a velocity threshold of any directional shift of the eye that was below 30 visual degrees per second across data points was used to operationalize a single fixation. To preserve the continuity of gaze data in momentary instances (i.e., < 75 ms) of signal loss, a gap fill-in interpolation algorithm was applied, and any adjacent fixations found to be within 0.5° VA of one another were merged. Any defined fixation ultimately determined to be shorter than 60 ms in length was re-classified as saccade data. Any trial was excluded from analysis if the summation of available fixation time for that trial was less than 2.67 ms (i.e., two thirds the duration of competitive feedback presentation), or if that time was more than 2 SD below the participant's mean summed-fixation time across all trials (e.g., Chua, Hannula, & Ranganath, 2012).

During data pre-processing, for each trial a static, rectangular-shaped area of interest (AOI) with a width of 14.1 cm (12.5° VA) and a height of 5.6 cm (5° VA) was centered over each of the two pieces of word feedback for the full duration of their presence on-screen (i.e., 4 s, see Figure 3 for a pictorial representation of the AOIs used in the current study). Since any one word stimulus, itself, was 1.1 cm (~1° VA) tall, and could be as wide as 9.9 cm (i.e., nine letters long, or ~9° VA), the overlay of the AOI centrally on top of the longest possible word stimuli (including participants' typed responses) permitted a buffer of additional screen space of 2.1 cm (i.e., ~2° VA) from the outer borders of nine-letter word stimuli out to the edge of the AOI in any direction. These AOIs were used for every trial, regardless of the letter-length of the word stimuli. AOIs with these kinds of parameters have been used elsewhere in other studies investigating visual fixations of word stimuli (Dampuré, Ros, Rouet, & Vibert, 2014).

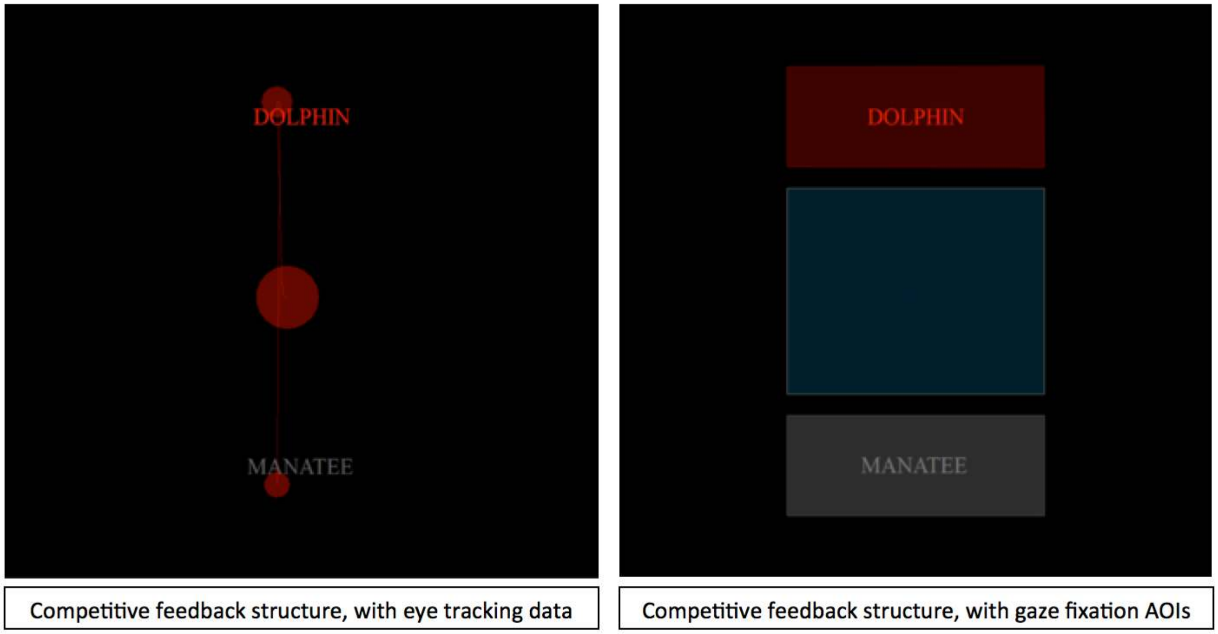

Figure 3. Study 3 Competitive Feedback Structure. Both screens snapshots correspond to the 'Competitive Learning-Relevant Feedback' screen shot depicted in Figure 1 above. For each trial, participants were free to view the competitive feedback for a 4-s period of time. Here on the left, the competitive feedback with negative performance reminder (bottom) and learning-relevant information (top) are shown. A short snippet (< 1 s) of eye tracking data from a single participant is superimposed, with fixations featured as red circles, and saccades as thin red lines. On the right, the areas of interest (AOIs) that were used in generating the First Fixation Duration (FFD) and Total Fixation Duration (TFD) metrics are superimposed over each Feedback Type. The AOI centered between the two feedback AOIs was used as the criterion for determining whether gaze was centered on screen at the onset of the competitive feedback.

Although seemingly conservative, these AOI parameters were also chosen given that during normal reading, the information necessary for making accurate semantic assessments of fixated word stimuli is limited to foveal vision (Rayner, 1979), and central foveal vision can subtend up to 5° VA (Duchowski, 2007). Furthermore, it was deemed important that the AOIs be more inclusive of screen space than not given that in studies assessing the reading of word stimuli, uncertainty of as little as 1° VA in the precision and accuracy of eye tracking data can be problematic for the integrity of eye tracking analyses. In particular, given that Hansen and Ji (Hansen & Ji, 2010) report the error rate for the accuracy of model-based gaze estimation systems like that of the Tobii TX300 to be between 1° and 2° VA, applying such conservative parameters for the two word feedback AOIs in our study likely helped account for any degree of this technical uncertainty, where participants were looking at the word feedback, but this manifested in eye tracking data indicating that participants' gaze was slightly removed from the word stimuli.

Thus, whether participants looked at the two pieces of word feedback on any given trial, and for how long, was defined by assessing the degree of gaze fixation (expressed in ms accrued) that occurred within each of these two AOIs. All relevant details regarding daze fixation metrics are provided further down below in the *Data Analysis* sub-section below, but to briefly preface them here, the measures of gaze fixation generated for use in statistical analyses were First Fixation Duration (FFD), defined as the time in ms spent looking at an AOI the first time it was fixated upon, and Total Fixation Duration (TFD), defined as the overall time in ms, summed across all fixations, spent looking at an AOI. FFD and TFD values were generated for each of the two AOIs in every single trial, after which single-subject averages of each gaze fixation metric were then calculated as a function of trial accuracy, task block, and answer location (i.e., whether the correct answer was presented at the top of the screen or at the bottom).

Data analysis

Overview. We conducted a series of customized 2 (Induction Condition) by 2 (Block) mixed-measures Analyses of Covariance (ANCOVAs) on our memory dependent measures of interest, and also included participants' BDI-II scores and RRS Brooding and Reflection scores as covariates (i.e., predictor variables). Regarding eye tracking analyses, because the current study focuses on gaze fixation and behavioral responses to *negative* feedback presented in a competitive format, all analyses involving eye tracking data were simplified to only include error trials. A similar analysis approach was also used with the electrophysiological measures in Whiteman and Mangels (2016; Study 1). For eye tracking analyses, the customized ANCOVA also included a 2-level within-subjects factor of Feedback Type (i.e., corrective answer word, or reminder of incorrect response). Again in Study 3, parameter estimates (converted to standardized beta coefficients) were rendered for all three covariates, including for all 2- and 3-way interaction terms between each of the covariates and the manipulated variables in the memory performance analyses. In eye tracking analyses, 4-way interaction terms were also included and assessed. Interaction terms *between* Brooding, Reflection and BDI-II were not included in the customized ANCOVAs, as a focus of the current study was to determine whether any of these factors served uniquely as moderators (i.e., each one over and above the others). For each dependent measure, we structured our presentation of the results to first address any overall effects of Induction Condition and Block before turning to any findings that included either trait RRS status (Brooding and Reflection) and/or mood (BDI-II) as moderators.

As in the previous two studies, both retest error correction rates and task-related subjective experience measures were adjusted to control for the potential confounding influence of first-test accuracy prior to their inclusion in the customized ANCOVAs. This adjustment was additionally made to the FFD and TFD eye tracking metrics, as was also done previously with the ERP measures in Whiteman and Mangels (2016; Study 1). We also looked into whether it was necessary to include age as a covariate in our analyses, due to the marginal difference in this participant characteristic between rumination and distraction groups. We considered the measure of 'age' over 'education' here since the former measure was more precisely calculated than the latter (i.e., based on number of days, not semesters, and then converted to years). In relation to our memory and eye tracking dependent measures of interest, age correlated most consistently with first-test accuracy. However, since first-test accuracy was statistically controlled for our error correction and eye tracking analyses, we anticipated very little, if any, influence of age on these main dependent measures of interest. Thus, given this, and because the group difference in age was marginal, we opted not to include participants' age as a covariate in any of our analyses.

Prior to carrying out analyses on the memory and eye tracking dependent measures, we conducted a manipulation check analysis, as well as various analyses assessing participants' induction-related subjective experiences. In the manipulation check analysis, we focused on evaluating participants' writing samples from the induction procedure, analyzing the degree of Ruminative Brooding (RB) and Self-Reflection (SR; e.g., Marin & Rotondo, 2017) that was expressed. For analyses of participants' induction-related subjective experiences, we focused on their *pre-* and *post-writing ratings*, as well as their ratings of RNTs and FAEs. Like the memory and eye tracking analyses, all of these induction-focused analyses also involved the use of customized ANCOVAs in which BDI-II, Brooding, and Reflection measures were again included as covariates, parameter estimates rendered, and all 2- and 3-way interactions evaluated. Unlike those analyses, however, none of these included the factor of Block, given that this induction-focused data was only collected in Block 2 (i.e., during the 'post-induction period') and not in Block 1 (i.e., during the 'pre-induction baseline period'). Nonetheless, given that the induction procedure consisted of three parts, it was necessary in some of these analyses to include a 3-level within-subjects factor of 'Set' or 'Sample'. In the sub-sections that follow, further specifications for these induction-focused analyses are provided, as well as important details regarding data preparation for all measures.

For all analyses, an alpha level of $p \leq 0.05$ was used as criterion for significance, but marginally significant findings ($0.05 < p \leq 0.10$) are also reported, and effect sizes are specified in all cases using the partial eta squared statistic. Where necessary, Greenhouse-Geisser corrections were used for violations of sphericity, and where appropriate, linear trend analyses were conducted for the 3-level within-subjects factors of 'Set' or 'Sample' to explore how differences may have unfolded within the post-induction period of the task. Any *post hoc* explorations of significant main effects or interactions were carried out using the Holm-Bonferroni procedure for corrections for multiple comparisons (Holm, 1979).

Manipulation check. Participants' three induction-related 'Writing Samples' were rated sentence-by-sentence for Ruminative Brooding (RB) and Self-Reflection (SR) 'writing content' according to the coding system of Marin and Rotondo (Marin & Rotondo, 2017). Briefly, RB was any negative statement that described an undesirable outcome/consequence, its cause, or any negative evaluation. SR was any positive or neutral statement that provided an evaluation / explanation about the self, others, or the self-other relationship. Also included were statements that provided constructive or insightful reasoning towards problem-solving or any adaptive action towards resolving one's concerns. Because one sentence could contain more than one statement, each one capturing a *different idea*, it was possible that one sentence could be coded as containing both RB and SR. However, in cases where it was deemed that the participant wrote both RB and SR content about the *same idea* in the same sentence, that sentence was coded as only containing either RB or SR content, based on whichever type was expressed as the concluding remark.

To ensure accurate and consistent adherence to this coding system, the current author and a research assistant independently coded 25% of the 165 (3 writing samples x 55 participants) written narratives, similar what was done in the work of Marin & Rotondo (Marin & Rotondo, 2017). Cohen's Kappa between the two independent coders was 0.740 ($p < 0.05$) for RB and 0.756 ($p < 0.05$) for SR. Any disagreements in codings were resolved through discussion, after which the current author then coded all remaining writing samples. During both reliability and later codings, each rater was blind to Induction Condition and induction-related writing prompt.

Upon the completion of coding, within any single writing sample the number of sentences containing RB and SR content were each then separately summed and divided by the total number of sentences written, thus rendering separate, non-mutually exclusive proportions for each rumination content type in that writing sample. These proportions were then subjected to a customized 2 (Induction condition) x 2 (Writing Content) x 3 (Writing Sample) mixed-measures ANCOVA for evaluation, in which BDI-II, Brooding, and Reflection measures were included as covariates, parameter estimates rendered, and all 2- and 3-way interactions assessed.

Induction-related subjective experiences.

Pre-writing ratings. An internal consistency reliability analysis conducted on the four pre-writing ratings rendered a Cronbach's alpha value (α) of 0.80. Given how consistent these individual items were with one another, we averaged across them, creating a composite score that indexed the 'degree of concerned thought' that participants initially had (i.e., prior to writing) regarding their condition-specific object of focus (i.e., whether their unresolved academic concern for those in the Rumination condition, or a day in their academic schedule for those in the Distraction condition). This individual set of composite scores was then subjected to a univariate ANCOVA involving the factor of Induction Condition and customized with pre-task trait rumination and depression individual differences measures in the aforementioned manner.

Post-writing ratings. High internal consistency was also demonstrated among the five post-writing ratings captured immediately after participants completed each of the three writing samples (Writing Sample 1, $\alpha = 0.87$; Writing Sample 2, $\alpha = 0.92$; Writing Sample 3, $\alpha = 0.94$). Thus, the five items for each sample were averaged into composite scores here, as well, rendering a measure that captured the overall degree of 'experiential self-focus' felt upon completing each writing prompt. Post-writing rating composite scores were then subjected to a 2 (Induction Condition) x 3 (Writing Sample) mixed-measures ANCOVA, also customized with our pre-task individual differences measures in the aforementioned manner.

Post-induction question set ratings. Participants' RNTs and FAEs in Block 2 (i.e., the post-induction period) were subjected to two separate 2 (Induction Condition) x 2 (Post-Induction Rating Set) mixed-measures ANCOVA customized as before for inclusion of pre-task trait rumination and depression measures. Although RNTs and FAEs were also captured in Block 1 (i.e., the pre-induction period), in accord with when the other induction-related subjective experience measures were captured, only RNTs and FAEs captured during the post-induction period were analyzed and reported, thus offering a third index of how the induction influenced participants subjectively.

Behavioral data preparation. As in the previous two studies, we defined learning as the proportion of first-test errors that were later corrected on the surprise retest. However, what differed in Study 3 was what could constitute a first-test error. Previously, errors were only comprised of semantically inaccurate responses (i.e., semantic errors). Furthermore, a degree of leniency was afforded for semantically accurate responses that held minor misspellings (i.e., responses with a 75-99% overlap with the correct answer were programmed to be called accurate during the feedback sequence). In Study 3, however, no such leniency was granted (i.e., to be deemed correct, a response was required to overlap 100% with the correct answer), and thus, in addition to constituting errors through semantic inaccuracies, errors were also constituted through semantically accurate responses that were misspelled to *any* degree (i.e., orthographic errors).

The choice to institute a strict rule for spelling in the current study was driven by the concern that, without this rule, subjects' responses near the borderline of the accuracy judgment threshold (i.e., within ~65-74% overlap between their response and correct answer) might sometimes be called correct when they were semantically inaccurate and at other times be called incorrect when they were semantically accurate. The degree of uncertainty for such discrepancy across subjects (and, critically, across Induction Condition and/or Block) could present variability in subjective experiences with the feedback that might lead to inconsistencies in how participants visually processed this information, regardless of accuracy or error type. Thus, in an effort to eliminate how any such inconsistency would manifest in our eye tracking metrics, we maintained a strict rule for what constituted a general knowledge task error in the current study.

However, because this research program is particularly interested in how rumination may influence the ability to remediate *semantic* errors, we opted to *exclude* from the analysis of memory performance (and eye tracking metrics) any first-test *orthographic* errors (i.e., misspelled but otherwise semantically accurate responses that overlapped orthographically with the correct answer to a degree of 75-99%). Fortunately, the proportion of orthographic errors at first-test was low (Rumination: $M = 0.06$, $SEM = 0.006$; Distraction: $M = 0.06$, $SEM = 0.006$), and a 2-way ANOVA indicated that this proportion did not differ as a function of Induction Condition and/or Block (all ps > 0.11). Thus, because they effectively constituted an in-between state of being semantically accurate, but orthographically inaccurate, and occurred relatively rarely, we opted to exclude these types of errors from both the overall number of trials used to generate first-test accuracy and re-test error correction rates. At retest, however, since no eye tracking data were collected, orthographic errors were counted as accurate responses, as was done in the previous two studies. Thus, with the exclusion of orthographic errors at first-test, but a lenient manner of accounting for this trial type at retest, we aimed to reduce potential noise in eye tracking data due to how misspellings were subjectively experienced, while preserving an operational definition of error correction that was comparable to that of Studies 1 and 2.

Eye tracking data preparation. Prior to conducting the main analyses of interest on FFD and TFD gaze fixation metrics, we carried out several important processing steps to help identify and include only usable eye tracking data in these analyses.

First, in accord with other eye tracking studies (e.g., Chua et al., 2012), a participant's entire data set was deemed unusable if there were fewer than three trials available in critical eye tracking conditions. Given the aforementioned counterbalancing of the location of learning-relevant feedback on the screen, a sufficient number of trials were required for when the correct answer was presented at both the top of the screen and at bottom, and this assessment was made in each block separately and only for error trials resulting in a total of 4 trial conditions (i.e., a 2 [Answer location] by 2 [Block] assessment). Since two participants (one from each induction condition) did not have ample trials in at least one of these four trial conditions, they were removed from any further eye tracking analyses.

With the remaining usable participants, we then assessed the proportion of error trials that were not usable due to eye tracking signal loss, making sure that no critical eye tracking conditions in the study were unequally influenced by this loss (see 'Eye tracking recording and data pre-processing' sub-section above for how signal loss was defined). The proportion of unusable trials due to signal loss was relatively low (Rumination: $M = 0.23$, $SEM = 0.037$; Distraction: $M = 0.22$, $SEM = 0.038$). Moreover, a 2 (Induction Condition) x 2 (Answer Location) x 2 (Block) mixed-measures ANOVA indicated that the proportion unusable trials due to signal loss did not differ across trials where the correct answer word was presented up top or down bottom, whether overall, or as a function of Induction Condition (all *p*s > 0.20). However, a significant Block difference resulted, $F(1, 51) = 4.31$, $p = 0.04$, $\eta_p^2 = 0.08$, whereby more loss was evident in Block 2 ($M = 0.25$, $SEM = 0.030$) compared to Block 1 ($M = 0.21$, $SEM = 0.027$).

Next, we assessed and eliminated from consideration any trials in which participants' eye gaze was not relatively centered on-screen when the competitive feedback stimuli were first presented. Including this contingency was important because if participants happened to initially be fixating either one of the word feedback AOIs at their onset, rather than the center of the screen, this could unduly influence the gaze fixation metrics (particularly FFD) for the competitive feedback stimuli. To identify these trials, participants' gaze was required to be initially located in a region conservatively defined by a screen-centered AOI that was 11.75 cm (10.5° VA) in height and 14.1 cm (12.5° VA) in width (see Figure 3 above). Since the stimulus presented just prior to the onset of the competitive feedback stimuli was, as previously mentioned, a screen-centered circle (subtending 1° VA) that indicated participants' performance accuracy, we anticipated that very few trials would be lost due to a lack of initial central fixation on the competitive feedback stimuli. After identifying and eliminating these trials, again, two additional participants (one from each induction condition) needed to be removed from our main eye tracking analyses for having fewer than the minimum number of trials required (i.e., three) in at least one of the four critical eye tracking conditions (i.e., another 2 (Answer Location) by 2 (Block) assessment).

Following removal of these participants, an assessment of the trials lost due to lack of central fixation revealed that this proportion of loss was also relatively low (Rumination: M = 0.16, SEM = 0.019; Distraction: M = 0.14, SEM = 0.019). Moreover, a 2 (Induction Condition) x 2 (Answer Location) x 2 (Block) mixed-measures ANOVA indicated that the proportion trials lost due to lack of central fixation did not differ across answer location, whether overall, or as a function of Induction Condition (all ps > 0.26). Only a significant Block difference resulted, $F(1, 49) = 11.13$, $p = 0.002$, $\eta_p^2 = 0.19$, whereby more trials were lost in Block 2 (M = 0.18, SEM = 0.017) compared to Block 1 (M = 0.12, SEM = 0.015).

At the conclusion of these data preparation procedures, 51 participants (26 in the Rumination condition, 25 in the Distraction condition) remained whose data was usable for eye tracking analyses. However, prior to conducting the main eye tracking analyses of interest, we aimed to simplify our statistical model even further by testing if we could collapse across both the 2-level factor of 'Answer Location' (i.e., whether the correct answer word was presented at the top of the screen or at bottom) and the additionally required 2-level factor of 'Fixation location' (i.e., whether the measure taken was at the top of the screen or at bottom). Collapsing across these two factors would render a more streamlined analysis that simply assessed fixation durations for the correct answer word (i.e., learning-relevant feedback) and participants' incorrect response (i.e., reminder of negative performance), *regardless of their location on screen*. Importantly, a 2 (Induction Condition) x 2 (Answer Location) x 2 (Block) mixed-measures ANOVA indicated that upon completion of data processing, the proportion of remaining usable eye tracking trials did not differ across answer location, whether overall, or as a function of Induction Condition (all *p*s > 0.26). The only significant term was the main effect of Block, $F(1, 49) = 11.13$, $p = 0.002$, $\eta_p^2 = 0.19$, whereby more usable data was evident in Block 1 ($M = 0.18$, $SEM = 0.017$) compared to Block 2 ($M = 0.12$, $SEM = 0.015$). However, importantly, this Block difference occurred *regardless* of correct answer location and Induction Condition. Thus, we were able to simplify our customized ANCOVA model by collapsing across 'Answer Location' in our main FFD and TFD eye tracking analyses of interest.

Results

Manipulation check

A 2 (Induction Condition) x 2 (Writing Content) x 3 (Writing Sample) mixed-measures ANCOVA, with BDI-II scores and Brooding and Reflection RRS sub-scores included as continuous predictors, was conducted on the amount of ruminative content found in participants' induction procedure writing material. This analysis revealed significant main effects of Induction Condition, $F(1, 47) = 714.32$, $p < 0.001$, $\eta_p^2 = 0.94$, and Writing Content, $F(1, 47) = 27.91$, $p < 0.001$, $\eta_p^2 = 0.37$. First interpreting the main effect of the induction procedure, writing about an unresolved academic concern in the state Rumination condition resulted in ruminative writing content in close to half of the sentences across all writing samples ($M = 0.43$, $SEM = 0.01$), whereas writing about a recent day in one's academic schedule in the Distraction condition resulted in nearly no ruminative writing content ($M = 0.02$, $SEM = 0.01$). Interpreting the second main effect, all participants evidenced more RB in their writing ($M = 0.34$, $SEM = 0.02$) than SR ($M = 0.12$, $SEM = 0.02$), which indicates that to the extent that the writing samples contained any rumination-related content, it was largely characterized by the more maladaptive form of rumination (i.e., RB over SR).

However, these two main effects were qualified by a significant 3-way interaction involving all three categorical factors, Induction Condition, Writing Content, and Writing Set, $F(2, 94) = 3.63$, $p < 0.05$, $\eta_p^2 = 0.07$. This 3-way interaction effect also subsumed several significant 2-way interactions (Induction condition by Writing Content: $F(2, 94) = 29.09$, $p < 0.001$, $\eta_p^2 = 0.38$; Induction Condition by Writing Sample: $F(2, 94) = 3.18$, $p < 0.05$, $\eta_p^2 = 0.06$; Writing Content by Writing Sample: $F(2, 94) = 4.53$, $p = 0.01$, $\eta_p^2 = 0.09$). Here below we unpack the 3-way interaction, applying Holm-Bonferroni corrections for multiple comparisons, and we show that additional critical differences emerged that further validated the effectiveness of the induction manipulation in expected ways.

First, as shown in Figure 4 it was mainly RB Writing content and not SR that was evidenced by those in the Rumination condition. Indeed, within the Rumination condition only, RB content was greater than SR content in Writing Samples 1 ($p < 0.001$) and 2 ($p < 0.001$). However, by Writing Sample 3, RB and SR rates were equal within this particular induction condition ($p = 0.54$), though this was *not* due to a significant decrease in RB here compared to the earlier two writing samples (all *p*s > 0.42), but rather an increase in SR (Sample 1 vs. 3: $p =$

0.003; Sample 2 vs. 3: $p < 0.001$). Second, comparing across conditions, RB writing content was significantly greater for the Rumination condition compared to the Distraction condition in all three of the writing samples (Sample 1: $p < 0.001$; Sample 2: $p < 0.001$; Sample 3: $p < 0.001$). Importantly, however, the low SR rates evidenced by both induction conditions were not statistically different from one another for first two writing samples (all *p*s > 0.53). It was not until Writing Sample 3 that those in the Rumination condition demonstrated an increase in SR that was statistically greater than that demonstrated by the Distraction condition ($p = 0.001$).

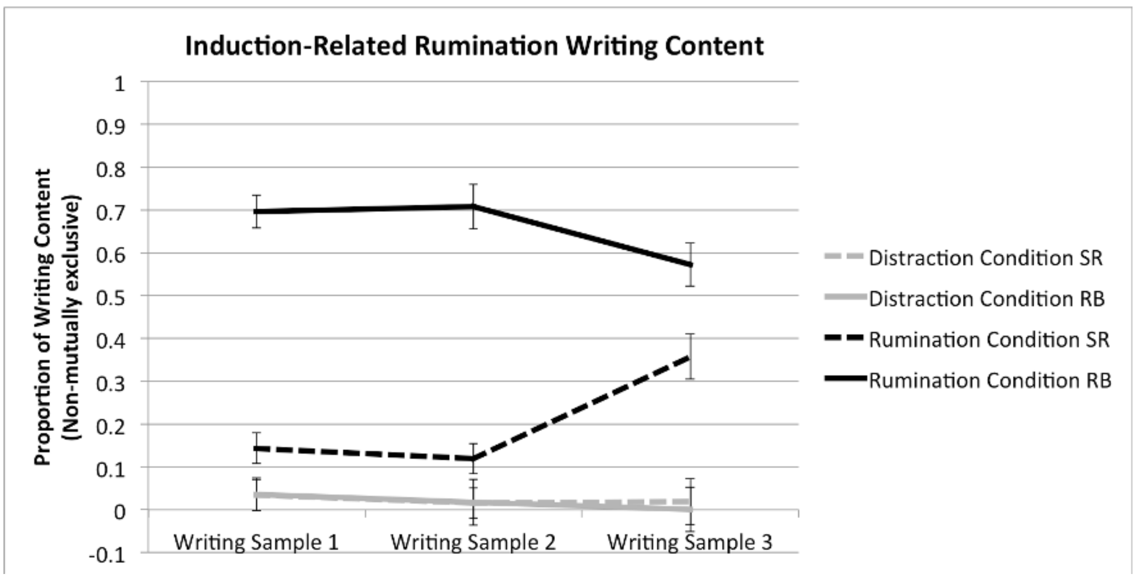

Figure 4. Study 3 Induction-Related Rumination Writing Content. The proportion of ruminative writing content (Y-Axis), whether in Ruminative Brooding (RB; solid lines) or Self-Reflection (SR; dotted lines) forms, is plotted as a function of Induction Condition (Distraction in gray; Rumination in black) across each of the three Writing Samples during the post-induction period.

Taken together, these findings largely support the conclusion that the induction manipulation effectively led only those in the Rumination condition to express statements more consistent with being in a state of rumination. Furthermore, the kind of rumination expressed was characterized by ruminative brooding, a style commonly reported as being maladaptive for cognition and behavior. To the extent that any writing content characterized self-reflection was present for the Rumination condition, it did not come online until later in the induction procedure (though this was not entirely unexpected; e.g., Marin & Rotondo, 2015), and it was not necessarily at the expense of the amount of writing content that was characterized by ruminative brooding in this final writing sample. Thus, for participants in the Rumination versus Distraction condition, their expressiveness of rumination through writing makes it likely that these ideas were semantically primed prior to engagement with the general knowledge task.

Next turning to evaluate the role that pre-task trait rumination and mood state measures may have played in the expression of rumination in hand-written content during the induction manipulation, we first observed an overall main effect of trait Brooding, $F(1, 47) = 9.65$, $p < 0.005$, $\eta_p^2 = 0.17$. *Post hoc* assessment of the associated parameter estimate revealed this maladaptive trait ruminative style to be predictive of greater overall ruminative expressiveness (i.e., regardless of RB or SR types) for all individuals across the entire induction procedure. No other effects involving trait Brooding approached significance (all ps > 0.34).

For trait Reflection, on the other hand, interestingly, we found *no* overall main effect on rumination expression ($p = 0.67$). Rather, a significant 3-way interaction involving trait Reflection, Induction Condition, and Writing Sample resulted, $F(2, 94) = 4.27$, $p < 0.05$, $\eta_p^2 = 0.08$. *Post hoc* testing revealed that among the Rumination condition only, like trait Brooding, trait Reflection appeared to predict a marginally greater amount of overall ruminative content in the *initial* writing sample, but this effect did not survive Holm-Bonferroni corrections for multiple comparisons ($p = 0.44$). However, by the third and *final* writing sample, trait Reflection was associated with a *significantly reduced* amount of ruminative expression, regardless of the type, $\beta = -0.58$, $t = 3.88$, $p < 0.005$, $\eta_p^2 = 0.24$. There was no relationship between trait Reflection and expression of rumination in the middle writing sample, ($p = 0.90$), nor were there any significant relationships involving trait Reflection found among the Distraction condition (all *p*s > 0.31).

We also found a marginally significant 3-way interaction involving pre-task mood (i.e., BDI-II scores), Induction Condition, and Writing Sample, $F(2, 94) = 2.55$, $p = 0.08$, $\eta_p^2 = 0.05$, and this effect subsumed two marginally significant 2-way interactions involving BDI-II and Writing Sample, $F(2, 94) = 2.55$, $p = 0.08$, $\eta_p^2 = 0.05$, and BDI-II and Induction Condition, $F(1, 47) = 2.75$, $p = 0.10$, $\eta_p^2 = 0.06$. While unpacking the 3-way interaction (as well as the 2-way interaction involving BDI-II and Writing Sample) revealed no predictive effects that survived Holm-Bonferroni corrections for multiple comparisons (all *p*s > 0.12), exploration of the 2-way interaction involving BDI-II and Induction Condition revealed that among the *Distraction* condition only, pre-task depressive mood state was associated with marginally *less* expression of rumination across all written narratives $\beta = -0.45$, $t = 1.97$, $p = 0.06$, $\eta_p^2 = 0.08$.

Having evaluated the *expression* of rumination in written narrative form, we next address participants' subjective experiences with the induction manipulation in service of providing insight into the extent to which they were experiencing a *state* of rumination during various parts of the experiment.

Induction-related subjective experiences

We analyzed several self-report measures that helped provide an understanding of how the induction procedure influenced participants' subjective experiences throughout Block 2 of the general knowledge task (i.e., during the post-induction period). We first report findings from an analysis on participants' pre-writing ratings that measured the degree of concerned thought over their condition-specific object of focus prior to writing about it. Next, we report findings from an analysis on participants' post-writing ratings that measured their of experiential self-focus they were feeling immediately after completing each of the three writing samples. Finally, we report findings from an analysis on participants' ratings of RNTs and FAEs experienced during each of the three induction-dependent sets of general knowledge questions in Block 2.

Pre-writing ratings. A univariate ANCOVA that included the factor of Induction Condition, as well as BDI-II scores and Brooding and Reflection RRS sub-scores as predictors, was conducted on the composite score for pre-writing ratings. A significant main effect of Induction Condition, $F(1, 47) = 53.72$, $p < 0.001$, $\eta_p^2 = 0.53$, indicated a greater degree of concerned thought among those in the Rumination condition compared to the Distraction condition. In particular, participants in the Rumination group reported a degree of thinking about their recent academic issue that was 'somewhat' concerning ($M = 5.24$, $SEM = 0.26$), whereas those in the Distraction group reported having only 'a little' concerned thought over the recent day in their academic schedule ($M = 2.54$, $SEM = 0.26$). This suggests that compared to those in the Distraction condition, participants in the Rumination condition had successfully identified an object of focus that was likely to elicit a greater amount of ruminative self-focus as they moved forward into the writing portion of the induction procedure. Neither BDI-II nor RRS sub-scores predicted any of these ratings, whether overall or via interaction with the Induction Condition factor (all ps > 0.38).

Post-writing ratings. A 2 (Induction Condition) x 3 (Writing Sample) mixed-measures ANCOVA that included BDI-II and Brooding and Reflection RRS predictor variables was conducted on the amount of experiential self-focus participants reported feeling following completion of the writing prompts. A significant 2-way interaction effect between Induction Condition and Writing Sample resulted, $F(1.69, 79.32) = 7.79$, $\varepsilon = 0.84$, $p < 0.005$, $\eta_p^2 = 0.14$, which subsumed a significant main effect of Induction Condition, $F(1, 47) = 8.47$, $p < 0.01$, $\eta_p^2 = 0.15$. Holm-Bonferroni-corrected *post hoc* tests of the 2-way interaction revealed that it was after the first writing sample only that the Rumination group evidenced significantly more negative self-focus than the Distraction group. This was confirmed by exploration of a significant 2-way linear trend effect involving Induction Condition and Writing Sample, $F(1, 47) = 9.87$, $p < 0.005$, $\eta_p^2 = 0.17$, whereby those induced to ruminate reported experiencing self-focus that was 'somewhat negative' at first ($M = 4.01$, $SEM = 0.26$) but then trended upward towards being more neutral (i.e., a rating of 5), whereas those induced to distract reported self-focus that was 'somewhat positive' at first ($M = 5.60$, $SEM = 0.26$) but then trended downward towards neutrality. In line with expectations, these findings indicate that the induction procedure was experienced more negatively by those induced to ruminate versus distract, though this subjective difference was most prominent earlier on in the post-induction period.

Turning to the possible influence of trait rumination and pre-task levels of depression, a 3-way interaction involving Induction Condition, Writing Sample, and the continuous predictor of Brooding resulted that was right at the threshold of the conventional level of significance, $F(1.69, 79.32) = 3.30$, $\varepsilon = 0.84$, $p = 0.05$, $\eta_p^2 = 0.07$. Although this effect indicated that the differential influence of the state induction procedure on experiential self-focus across the post-induction period needed to be considered in light of this maladaptive style of trait rumination, *post hoc* testing revealed no significant relationships within either Induction Condition for any particular Writing Sample (all *p*s > 0.21). A significant 2-way interaction effect involving trait *Reflection* and Writing Sample also emerged, $F(1.57, 79.32) = 5.71$, $\varepsilon = 0.84$, $p = 0.007$, $\eta_p^2 = 0.11$, but again, no parameter estimates were significant (all *p*s > 0.14). Finally, no effects involving pre-task BDI-II levels were significant (all *p*s > 0.55).

Induction-dependent recurring negative thoughts and feelings after errors. Table 2 shows the mean ratings of recurring negative thoughts (RNTs) and feelings after errors (FAEs) that participants reported experiencing during the post-induction period (i.e., Block 2) of the general knowledge task on day one.

Table 2. Induction-Dependent Subjective Experiences. Ratings of task-related Recurring Negative Thoughts (RNTs) and Feelings After Errors (FAEs), as a function of Induction Condition and Post-induction Rating Set. In this and all other tables, means are adjusted for BDI-II, Brooding, and Reflection covariates, and standard errors of the mean (SEM) are provided in parentheses.

Subjective Experience	Induction Condition	Post-Induction Set 1	Post-Induction Set 2	Post-Induction Set 3
RNTs				
	Rumination	2.90 (0.36)	2.81 (0.38)	2.76 (0.37)
	Distraction	3.63 (0.35)	3.37 (0.38)	3.23 (0.37)
FAEs				
	Rumination	4.20 (0.23)	3.91 (0.27)	3.92 (0.23)
	Distraction	3.78 (0.23)	3.54 (0.27)	3.95 (0.23)

Notes: Recurring Negative Thoughts (RNTs) were rated on a scale of 1 (none at all) to 9 (an extreme amount), with 5 representing a moderate amount. Feelings After Errors (FAEs) were rated on a scale of 1 (extremely unpleasant) to 9 (extremely pleasant), with 5 representing neither pleasant nor unpleasant.

Recurring negative thoughts (RNTs). All participants reported experiencing generally 'little' RNTs (i.e., a rating of 3) across the post-induction period on day one (see Table 2). Despite the appearance that it was the *Distraction* group who evidenced more RNTs overall than the Rumination group, a 2 (Induction Condition) x 3 (Post-Induction Rating Set) mixed-measures ANCOVA that included BDI-II and Brooding and Reflection RRS predictors rendered no main effect of Induction Condition ($p = 0.20$). Nor was there a main effect of Post-Induction Rating Set or an interaction between these two factors (all ps > 0.50).

When considering pre-task individual differences measures, however, a significant Induction Condition by Brooding interaction effect emerged, $F(1, 47) = 7.08$, $p = 0.01$, $\eta_p^2 = 0.13$, indicating that the state induction manipulation only exerted its influence on RNTs in moderation with this trait maladaptive form of rumination. Although Brooding predicted more RNTs, it did so somewhat surprisingly for the *Distraction* group only, $\beta = 0.52$, $t = 2.41$, $p < 0.05$, $\eta_p^2 < 0.11$, whereas in the Rumination group a negative but non-significant parameter estimate resulted, ($p = 0.20$). No effects involving trait Reflection or BDI-II depression scores on RNTs emerged (all ps > 0.17). Thus, although we continued to find some support, as in Studies 1 and 2, for a link between Brooding and increased RNTs in our task, unlike in Study 2, where the induction manipulation did not moderate the influence of Brooding, here in the current study, it did. Interestingly, however, it was in the Distraction condition, where very little, if any, rumination had been expressed during the induction writing procedure, that Brooding was predictive of increased RNTs throughout the post-induction period of the task.

Feelings After Errors (FAEs). Table 2 also shows that in likeness with the ratings provided in Study 2, all participants generally reported feeling 'somewhat unpleasant' (i.e., ratings primarily between 3 and 4) after making an error during the post-induction period of the task. Also similar to Study 2, however, these feelings did not differ as a function of Induction Condition or Post-Induction Rating Set, nor did they differ by way of an interaction between these two factors (all *p*s > 0.24).

Turning again to the pre-task individual differences measures, we found no evidence that that the state induction manipulation exerted its influence on FAEs in moderation with either trait rumination or depression (all *p*s > 0.15). Instead, however, we found that regardless of Induction Condition or Post-Induction Rating Set, a significant overall main effect pre-task depression, $F(1, 47) = 4.44$, $p < 0.05$, $\eta_p^2 = 0.09$, as well as a marginally significant overall main effect of trait Brooding emerged on FAEs, $F(1, 47) = 3.40$, $p = 0.07$, $\eta_p^2 = 0.07$. *Post hoc* testing surprisingly indicated that pre-task depression levels predicted more neutral feelings (i.e., *less* unpleasant feelings) for all participants during the post-induction period, $\beta = 0.32$, $t = 2.02$, $p < 0.05$, $\eta_p^2 = 0.07$. However, more in line with general expectations, Brooding levels predicted marginally *more* unpleasant FAEs for everyone in Block 2 of the task, $\beta = -0.28$, $t = 1.76$, $p = 0.07$, $\eta_p^2 = 0.06$. This latter finding is in line with replication of Whiteman and Mangels (2016; Study 1) in that it highlights how trait Brooding can fashion subjective experiences detrimentally in our general knowledge task. However, since this effect did not occur interactively with Induction Condition (nor indeed was there *any* effect of Induction Condition), this means that FAEs were *not* at all fashioned by expressiveness of rumination through writing during the state induction procedure.

Eye tracking metrics

Durations from the gaze fixation metrics of interest (FFD and TFD), indexing participants' looking time on the competitive feedback in the general knowledge task, are shown in Table 3 as a function of Feedback Type, Induction Condition, and Block (i.e., induction period).

Table 3. Study 3 Gaze Fixation Durations in Seconds.

Metric	**Induction Condition**	**Pre-induction period**	**Post-induction period**
FFD			
Correct Answer			
	Rumination	0.310 (0.024)	0.301 (0.028)
	Distraction	0.265 (0.024)	0.356 (0.029)
Incorrect Response			
	Rumination	0.185 (0.012)	0.207 (0.011)
	Distraction	0.201 (0.012)	0.199 (0.011)
TFD			
Correct Answer			
	Rumination	1.778 (0.073)	1.656 (0.082)
	Distraction	1.775 (0.075)	1.752 (0.084)
Incorrect Response			
	Rumination	0.846 (0.051)	0.868 (0.052)
	Distraction	0.838 (0.053)	0.804 (0.053)

First Fixation Duration (FFD). A 2 (Induction Condition) x 2 (Feedback Type) x 2 (Block) mixed-measures ANCOVA that also included BDI-II as well as Brooding and Reflection RRS predictors was conducted on participants' feedback FFDs. Interestingly, all participants'

FFDs on the correct answer word were longer (*M* = 0.308, *SEM* = 0.017) than they were on reminders about their incorrect response (*M* = 0.198, *SEM* = 0.007), a relatively large difference that can be seen in the top half of Table 3 and is supported by a significant main effect of Feedback Type, $F(1, 43) = 49.26$, $p < 0.001$, $\eta_p^2 = 0.53$. Furthermore, a significant main effect of Block, $F(1, 43) = 6.68$, $p = 0.01$, $\eta_p^2 = 0.13$, revealed that all FFDs in the post-induction period were longer *M* = 0.240, *SEM* = 0.010) than those evidenced in the pre-induction period (*M* = 0.266, *SEM* = 0.012). No overall difference in FFDs emerged as a function of Induction Condition, $F(1, 43) = 0.05$, $p = 0.81$, $\eta_p^2 < 0.01$.

However, the two significant main effects of Feedback Type and Block were qualified by a significant 3-way interaction involving these two factors *and* Induction Condition, $F(1, 43) = 12.31$, $p = 0.001$, $\eta_p^2 = 0.22$, and this 3-way interaction subsumed two marginally significant 2-way interactions (Feedback Type by Block: $F(1, 43) = 3.15$, $p = 0.08$, $\eta_p^2 = 0.07$; Induction Condition by Block: $F(1, 43) = 3.50$, $p = 0.07$, $\eta_p^2 = 0.08$). To unpack the significant 3-way interaction, we opted to use a simple effects approach, splitting by Feedback Type, especially given the large overall effect on FFDs observed between the incorrect response and the correct answer feedback types, as well as the *a priori* rationales independently offered for how being in a state of rumination might particularly impact one's overt attention to and encoding of each distinct piece of feedback. Thus, we ran two separate 2-way mixed-measures ANCOVAs, one for FFDs on the correct answer, and the other for FFDs on the incorrect response, and each analysis included Induction Condition and Block as factors, as well as the pre-task individual differences measures of trait rumination and depression.

First, when assessing FFDs on the incorrect response feedback type, only a marginally significant 2-way interaction between Induction Condition and Block resulted, $F(1, 43) = 2.89$, *p*

$= 0.10$, $\eta_p^2 = 0.06$, initially revealing an effect within the Rumination condition only ($p < 0.05$) that was in accord with predictions, though this effect did not survive Holm-Bonferroni corrections for multiple comparisons. In particular, for those induced to ruminate, FFDs on reminders of recent performance failures were (numerically) longer during the post-induction period (i.e., Block 2) than they were during the pre-induction baseline period (i.e., Block 1). This same block-based comparison within the Distraction condition did not reach significance during *post hoc* testing, nor did either of the condition-based comparisons within each block (all *p*s > 0.33).

Next, when assessing FFDs on the correct answer, a main effect of Block resulted, $F(1, 43) = 5.74$, $p < 0.05$, $\eta_p^2 = 0.12$, which indicated that compared to the pre-induction baseline block, all participants evidenced longer FFDs on this new corrective information during the post-induction block. However, this effect was qualified by a significant Induction Condition by Block interaction, $F(1, 43) = 8.30$, $p < 0.01$, $\eta_p^2 = 0.16$, indicating that this post-induction increase in initial looking time may have been evidenced by one particular induction group. Indeed, among only those induced into a state of *distraction*, FFDs on the correct answer were significantly longer during the post-induction period than they were during the pre-induction period ($p < 0.005$). This same block-based comparison within the Rumination condition was not significant, nor was either of the condition-based comparisons within each block (all *p*s > 0.18). Although we did not observe a *shortening* of FFDs on corrective feedback among those induced to ruminate, we would note that their *lack of an increase* in FFDs here still aligns with the general expectation that expressing rumination over an unresolved academic concern would be problematic for attending to and processing corrective feedback in our task, *particularly as* *compared to* being distracted by non-expressively and factually writing about the neutral events of one's school day.

Finally, turning back to the original, overall FFD analysis to evaluate the possible influence of pre-task indivdidual differences measures, we observed a marginally significant main effecct of trait Brooding on FFDs, $F(1, 43) = 3.83$, $p = 0.06$, $\eta_p^2 = 0.08$. *Post hoc* examination of parameter estimates indicated that regardless of Induction Condition, Feedback Type or Block, and over and above any influence of pre-task depression or trait levels of Reflection, Brooding predicted marginally longer FFDs on the feedback stimuli, $\beta = 0.31$, $t = 1.89$, $p = 0.07$, $\eta_p^2 = 0.07$. The Brooding factor did not interact with any additional factors (all ps > 0.13), nor were there any additional effects involving Reflection sub-scores of the RRS or BDI-II scores, whether independently or interactively with other factors (all ps > 0.11).

Total Fixation Duration (TFD). Another 2 (Induction Condition) x 2 (Feedback Type) x 2 (Block) mixed-measures ANCOVA, including BDI-II as well as Brooding and Reflection RRS predictors, was conducted on participants' feedback TFDs. Similar to findings with the FFD metric, a significant main effect of Feedback Type, $F(1, 43) = 185.32$, $p < 0.001$, $\eta_p^2 = 0.81$, indicated that all participants' TFDs on the correct answer feedback were much longer ($M = 1.740$, $SEM = 0.053$) than their TFDs on reminders about their incorrect response ($M = 0.839$, $SEM = 0.035$). This more than two-fold overall difference in looking time can be seen in the bottom half of Table 3. In addition, a significant main effect of Block also resulted, $F(1, 43) = 6.05$, $p < 0.05$, $\eta_p^2 = 0.12$, but unlike findings with the FFD metric, all TFDs observed in the post-induction period were *shorter* ($M = 1.270$, $SEM = 0.033$) than those seen in the pre-induction period (*M* = 1.309, *SEM* = 0.029). There was no overall difference in TFDs between Rumination and Distraction groups, $F(1, 43) < 0.01$, $p = 0.93$, $\eta_p^2 < 0.01$.

Unlike the findings for FFD, however, the 3-way interaction involving Feedback Type, Block, and Induction Condition was non-significant for TFD, $F(1, 43) = 2.06$, $p = 0.16$, $\eta_p^2 = 0.05$. Despite this unexpected null effect, once more we split by Feedback Type in a simple effects approach as we had done with the FFD metric and explored individual mean comparisons as a function of Induction Condition and Block. Again, this was especially important given the separate *a priori* predictions made for each piece of feedback, as well as our concern that the massive mean difference in TFD between correct answer word and incorrect response feedback types may have masked more subtle, higher-order effects also involving Induction Condition and Block.

First, when assessing TFDs on the incorrect response feedback type, no main effects of Block or Induction Condition emerged (all *p*s > 0.61), nor was there a 2-way interaction effect between these two variables ($p = 0.23$). Nonetheless, we persued exploration of the planned comparisons, but these also revealed no Induction condition TFD differences within either Block 1 or Block 2, nor were there any Block differences within either the Rumination condition or Distraction condition (all *p*s > 0.31).

Next, when assessing TFDs on the correct answer, only a marginally significant main effect of Block emerged $F(1, 43) = 3.72$, $p = 0.06$, $\eta_p^2 = 0.08$, and an assessment of means indicated that compared to the pre-induction baseline block, all participants evidenced shorter TFDs on this new corrective information during the post-induction block. Although the interaction term involving Block and Induction Condition was not significant ($p = 0.20$), again we pursued exploration of planned comparisons. This time, one significant comparison emerged, though this effect was reduced to being marginally significant after applying Holm-Bonferroni corrections. In particular, among only those induced into a state of *rumination*, TFDs on the correct answer were marginally shorter during the post-induction period than they were during the pre-induction period (p = 0.10). This same block-based comparison within the Distraction condition was not significant, nor was either of the condition-based comparisons within each block (all ps > 0.42). Thus, in line with our predictions, we found some evidence that particularly being induced to experience rumination (and not distraction) could somewhat reduce sustained attention to corrective information in our task.

Finally, turning back to the original, overall TFD analysis to evaluate the possible influence of pre-task indivdidual differences measures, we observed a significant 3-way interaction involving Feedback Type, Block and trait Brooding, $F(1, 43) = 7.89$, $p < 0.01$, $\eta_p^2 =$ 0.16, which subsumed both a main effect of Brooding, $F(1, 43) = 6.08$, $p < 0.05$, $\eta_p^2 = 0.12$, and a 2-way interaction involving Feedback Type and Brooding, $F(1, 43) = 5.92$, $p < 0.05$, $\eta_p^2 =$ 0.12. Unpacking the 3-way interaction, within the pre-induction baseline period only (i.e., Block 1), Brooding surprisingly predicted significantly longer TFDs on the *correct answer* feedback type, regardless of Induction Condition, $\beta = 0.50$, $t = 3.40$, $p < 0.005$, $\eta_p^2 = 0.20$. No parameter estimates involving the relationship of Brooding with TFDs on reminders of participants' incorrect responses in either Block 1 or Block 2 were significant (all ps > 0.27).

We also observed a significant 3-way interaction involving Feedback Type, Block and trait Reflection, $F(1, 43) = 4.37$, $p < 0.05$, $\eta_p^2 = 0.09$. *Post hoc* examination of parameter estimates again revealed an effect involving the correct answer feedback type within the pre-induction baseline period only (i.e., Block 1). However, this particular trait style of ruminative responsiveness surprisingly predicted significantly *shorter* TFDs to this novel corrective information for all participants, β = -0.41, t = 2.89, p < 0.05, η_p^2 = 0.15. No parameter estimates involving the relationship of Reflection with TFDs on reminders of participants' incorrect responses in either Block 1 or Block 2 were significant (all ps > 0.39).

Last, we also observed a marginally significant 3-way interaction involving pre-task BDI-II scores and the Induction Condition and Block factors, $F(1, 43) = 2.87$, $p = 0.10$, $\eta_p^2 = 0.06$. However, *post hoc* assessment of this mood-related effect revealed no significant parameter estimates (all ps > 0.26).

Memory Performance

Table 4 shows both the proportions of items initially correct at first-test and the proportions of items initially incorrect at first-test that were later corrected on the subsequent surprise retest. Performance during each of the two 69-item blocks (i.e., during both the pre- and post-induction periods) is shown as a function of Induction Condition.

Table 4. Study 3 Memory Performance. Proportion correct at first-test and at retest as a function of Induction Condition and Block.

Behavior	**Induction Condition**	**Pre-induction period**	**Post-induction period**
First-Test Accuracy			
	Rumination	0.29 (0.019)	0.30 (0.018)
	Distraction	0.33 (0.020)	0.32 (0.018)
Retest Error Correction			
	Rumination	0.38 (0.021)	0.37 (0.019)
	Distraction	0.43 (0.022)	0.37 (0.019)

First-test Accuracy. First, we wanted to assess whether first-test performance during the initial, pre-induction baseline period differed from the accuracy rate of 35% correct that was targeted. A pair of one-sample *t*-tests, one for each condition, revealed that participants demonstrated performance in the initial block that was worse than the targeted rate, an effect was significant for the Rumination condition, $t(27) = 2.72$, $p = 0.01$, and marginal for the Distraction condition, $t(26) = 1.70$, $p = 0.10$. This reduced first-test performance was not entirely unexpected, however, given that behavioral data preparation required removal of orthographic errors from analysis, and these were trials that in the previous two studies would have been counted as being correct. Accordingly, it was deemed that this overall lower rate was acceptable, as it was comprised of an amount of errors that, on average, was still comparable to that of the previous two studies.

We then submitted first-test accuracy rates to our customized ANCOVA involving Induction Condition and Block, as well as our three pre-task individual differences measures. No main effect of Block emerged, nor was there an interaction between Block and Induction Condition (all *p*s > 0.81), indicating that the aforementioned accuracy rates demonstrated in Block 1 did not change for worse (or for better) with the onset of rumination induction procedure in Block 2. There was also no overall main effect of Induction Condition ($p = 0.25$).

Moving on to investigate the role of our pre-task individual differences measures, first a significant 3-way interaction involving Induction Condition, Block, and Brooding, $F(1, 47) = 4.91$, $p < 0.05$, $\eta_p^2 = 0.10$, indicated that the state induction manipulation appeared to moderate the influence of this maladaptive ruminative style on first-test performance. Examination of parameter estimates initially revealed that Brooding predicted marginally worse first-test performance after onset of the induction manipulation, but only for those in the *Distraction* condition, however, this effect did not survive Holm-Bonferroni corrections for multiple comparisons ($p = 0.24$). No relationships involving trait Reflection were significant (all *p*s > 0.19).

Next, a 3-way interaction involving Induction Condition, Block, and participants' BDI-II scores also emerged that was right at the cusp of the conventional level of significance, $F(1, 47) = 4.06$, $p = 0.05$, $\eta_p^2 = 0.08$. This time, the source of the effect appeared to occur in only the *Rumination* condition, where increased rates of pre-task depression seemed to predict marginally worse performance during the post-induction period, though, once again, this effect did not survive Holm-Bonferroni corrections ($p = 0.40$).

Finally, given that we were previously required to exclude four participants in our eye tracking analyses, we additionally assessed whether any changes in the aforementioned first-test performance effects resulted when using this slightly smaller 'eye tracking' sample. When re-running our customized ANCOVA, the patterns we had observed in the larger 'behavioral' sample did not change, and no new effects emerged.

Retest Error Correction. As can be seen in the lower half of Table 4 during the pre-induction period only, retest error correction rates appeared to be numerically larger for the Distraction condition compared to the Rumination condition. During the post-induction period, however, rates appeared similar across conditions, and the occurrence of this similarity appeared to be driven by the Distraction condition, whose rates seemed to drop off to meet that of the Rumination condition in Block 2. Although this pattern suggested existence of an interaction effect, the 2-way interaction term involving Induction Condition and Block in our customized ANCOVA fell short of the threshold for marginal significance, $F(1, 47) = 2.52$, $p = 0.12$, $\eta_p^2 =$

0.05. However, a significant main effect of Block resulted, $F(1, 47) = 6.24$, $p < 0.05$, $\eta_p^2 = 0.12$, which indicated that regardless of Induction Condition, error correction rates for *all* participants declined from the pre-induction to post-induction period. There was no main effect of Induction Condition on retest error correction rates, $F(1, 47) = 0.68$, $p = 0.42$, $\eta_p^2 = 0.01$. Thus, contrary to predictions, we found no evidence that being induced to ruminate versus distract led to a decline in the ability remediate errors in our challenging general knowledge task.

When turning to assess the possible influence of our pre-task individual differences measures, we also found no evidence of any predictive relationships of trait Brooding or trait Reflection on retest error correction rates, whether independently or interactively with the induction manipulation (all ps > 0.12). Furthermore, we found no involvement whatsoever of participants' pre-task levels of depression (all ps > 0.24).

Next, we again assessed whether any of these results at all differed when using the slightly smaller 'eye tracking' sample. Once more, no effects emerged that involved any of the pre-task individual differences measures (all ps > 0.11). This time, however, when re-running our customized ANCOVA, the aforementioned non-significant 2-way interaction term involving Induction Condition and Block was marginally significant, $F(1, 47) = 3.02$, $p = 0.09$, $\eta_p^2 = 0.07$, and this interaction effect subsumed a significant main effect of Block, $F(1, 47) = 5.74$, $p < 0.05$, $\eta_p^2 = 0.12$. Unpacking the 2-way interaction, we found neither one of the group-based comparisons within Block 1 or Block 2 to reach significance (all ps > 0.14). Rather, one of the block-based comparisons *was* significant, particularly for the Distraction condition ($p = 0.02$) and not the Rumination condition ($p = 0.64$), indicating a drop in error correction rates from the pre-induction to post-induction period. Thus, albeit contrary to expectation, among this smaller sample we found evidence of a decline in retest performance following the onset of the induction procedure that was particularly driven by those who were induced to distract themselves during our challenging task of verbal general knowledge.

Correlations between eye tracking metrics and error correction rates

Although we found little evidence in Study 3 that error correction rates were influenced by the induction procedure (and no support for the prediction that being induced to *ruminate* about unresolved academic concerns versus being distracted from them would be *detrimental* for learning and rebounding from failure), we did find some evidence that participants' attention to the competitive feedback, as measured by the gaze fixation metrics of interest, was modulated by the manipulation to some degree and in expected ways. Thus, to assess any whether any variability in participants' overt attention was at all linked with their retest performance, we also carried out a series of zero-order correlations between fixation times on the competitive feedback stimuli (one set involving FFD and another set involving TFD) and participants' error correction rates. To do this, we evaluated correlations occurring only within a single block, looking first at relationships involving the correct answer feedback type, and second at relationships involving the incorrect response feedback type. Correlation analyses were also run both collapsed across and splitting by the factor of Induction Condition.

Contrary to our expectations, we found no evidence that FFDs on the correct answer word in a given block was linked with remedial behavior from that block, whether for all participants (all ps > 0.45), or for participants only within the Rumination (all ps > 0.27) or Distraction conditions (all ps > 0.27). Similarly, there was no association in either block between FFDs on participants' incorrect response and their error correction rates, whether for all individuals (all *p*s > 0.13), or for those in the Rumination (all *p*s > 0.14) or Distraction conditions (all *p*s > 0.50).

Turning to the TFD metric, again, there were no relationships observed between this measure of total looking time on the corrective feedback and participants' error correction rates, whether overall (all *p*s > 0.70), or split by Induction Condition (Rumination: $p > 0.69$; Distraction: $p > 0.47$). Nor was there any association found between TFDs on reminders of the incorrect response and error correction, whether overall (all *p*s > 0.47), or for the Rumination (all *p*s > 0.34) or Distraction groups (all *p*s > 0.37). Thus, in sum, we found no support that gaze fixation on either of piece of the competitive feedback stimuli was linked with rebounding from failure.

Discussion

Overview

Using a modified version of our general knowledge test-feedback-retest design, Study 3 tested whether women who were induced to ruminate versus distract would sustain greater attention to errors, as measured by gaze fixation duration, at the expense of encoding concurrently-presented corrective information. We proposed that any such costs of attending to corrective information would then hinder their ability to remediate those errors on a delayed surprise retest. In order to induce rumination or distraction effectively, we adopted a procedure that involved completing hand-written narratives contextualized to be academically-relevant and thus, relatively easy for participants to link to their feelings in the general knowledge retrieval task. Participants in the Rumination condition, who were prompted to write about an on-going academic concern of theirs, were expected to express more ruminative brooding (but not necessarily more self-reflection; cf. Marin & Rotondo, 2017) in their writing samples than participants in the Distraction condition, who were prompted to write about a recent, neutral day in their academic schedule. The induction of ruminative brooding, in turn, was expected to lead to more negative subjective experiences during the general knowledge task, as well as more downstream ill effects on feedback processing, as measured by greater first fixation and total fixation on their incorrect response rather than the correct answer, which would ultimately interfere with the ability to learn and rebound from failure.

We found relatively good support for the general effectiveness of the induction manipulation. First, compared to the Distraction group, the Rumination group reported initially identifying an object of focus for the induction-related writing procedure that provoked more concerning thoughts. Subsequently, during the induction procedure itself, only the Rumination group was found to express the intended maladaptive form of rumination (i.e., ruminative brooding) in all of their writing samples, despite eventually also expressing an equal amount of the more adaptive style of self-reflection in the third and final writing sample; the Distraction group, expressed little, if any, rumination of either type in any of their writing samples. Furthermore, the condition-specific writing prompts were found to lead those in the Rumination condition to report greater amounts of negative experiential self-focus compared to those in the Distraction condition, though this effect was primarily observed after completion of the initial writing sample. Surprisingly, however, the induction manipulation did not at all influence participants' subjective experiences of Recurring Negative Thoughts (RNTs) or their Feelings after Errors (FAEs) *during* the general knowledge task. Despite this latter null effect, the results mentioned here generally support the conclusion that compared to participants in the Distraction group, those in the Rumination group were induced to experience a cognitive state consistent with a brooding ruminative style, although this particular state was perhaps strongest and most salient during the earlier aspect of the post-induction period of the general knowledge task.

To measure sustained attention to the two pieces of feedback that were simultaneously vying for participants' focus on every trial throughout the task (i.e., the correct answer to the question just attempted, as well as a reminder of the response just submitted), Study 3 also made use of eye tracking metrics. In particular, we captured participants' initial focus of attention on each feedback type, as measured with the First Fixation Duration (FFD) metric, and overall dwell time on this information, as measured with Total Fixation Duration (TFD). Focusing on error trials only, we expected that those induced to ruminate would exhibit greater sustained attention than those induced to distract on the reminder of their incorrect response, as evidenced by longer TFDs (and perhaps FFDs), but exhibit shorter dwell times on the correct answer, and these effects were expected to come online only after onset of the induction manipulation (i.e., during the post-induction period in Block 2). Contrary to predictions, however, we found no group differences in either initial or overall fixation times on reminders of negative performance. However, more in line with our expectations, we did observe changes *within each condition* in how participants processed the *correct answer* between the pre-induction and post-induction blocks. In particular, in Block 2 compared to Block 1, participants in the Distraction condition evidenced longer FFDs on this novel corrective feedback, while participants in the Rumination condition evidenced shorter TFDs on this information.

To the extent that we observed differential modulation of feedback processing between the Rumination and Distraction conditions, we predicted that this would have maladaptive downstream consequences for remedial behavior, particularly for those participants induced to ruminate. Scrutiny of correlations between the eye tracking metrics and error correction rates turned up no significant linear relationships, however. Thus, it is not surprising that, despite condition-specific variability in the time spent dwelling on the correct answer (or incorrect response) feedback, looking for longer (or for shorter) at this information did not necessarily facilitate remedial behavior. Indeed, we observed no detrimental induction-related decrease in error correction from the pre- to post-induction period for those in the Rumination condition. Rather, there was some evidence from the smaller eye-tracking sample of a Block 2 decline in error correction in the Distraction condition. Specifically, error correction rates for the Distraction group dropped down from Block 1 to Block 2 to match that of the ruminators in the latter half of the task. In the Rumination group, correction rates were stable from Block 1 to Block 2. Additional details and further explanation for the various condition-specific (and null-effect) eye tracking and memory performance findings are offered in the sub-sections that follow.

Finally, we predicted that pre-task levels of trait Brooding and/or Reflection (and perhaps pre-task mood levels) might play a role in how sensitive participants would be to the induction manipulation. Consequently, we also expected that these trait styles might *interact* with the state induction manipulation to help shape how it would influence attention to competitive feedback stimuli and retest memory performance in the general knowledge task. However, we also anticipated that these two distinct forms of trait rumination could influence gaze fixation and memory performance measures *independent* of the state induction manipulation. Perhaps not surprisingly, Brooding RRS scores predicted increased expression of rumination in writing across the induction procedure, regardless of Induction Condition, and this maladaptive trait style was also subsequently associated with worse FAEs for all participants during the post-induction period of the general knowledge task. Brooding also predicted increased RNTs in Block 2, though this was surprisingly only observed in the Distraction condition. Despite these findings, however, Brooding did not at all predict error correction, and interestingly, it was associated with *increased* fixation times on the correct answer feedback stimuli for all participants.

Unlike trait Brooding, which was associated mostly with induction-independent effects, the effects associated with trait Reflection, on the other hand, though fewer in number, were only induction-dependent. Reflection RRS scores interestingly predicted *reduced* expression of rumination during the induction procedure, but only during the last writing sample, and only for those who were induced into a state of rumination. This more adaptive style of trait rumination, however, was not associated with any changes in task-related subjective experiences, as Brooding was, though Reflection was also associated with *reduced* TFDs on the correct answer during the pre-induction baseline block. Trait Reflection did not at all predict remedial behavior whether interactively with or independently of the state induction manipulation.

Finally, pre-task depression levels, as measured by the BDI-II, did not at all exacerbate (or moderate in any fashion) any influence of being induced to ruminate during the general knowledge task in Study 3. Rather, we found some evidence that for individuals arriving to the task in more of a negative mood state, being induced to *distract* led to a *reduced* expression of rumination during the induction procedure. BDI-II scores were also predictive of more *neutral* FAEs during the post-induction period of the general knowledge task. Despite these interesting findings, pre-task depression levels did not at all predict gaze fixation durations or error correction rates, whether interactively with or independently of the state induction manipulation.

The induction manipulation evokes a cognitive state consistent with brooding rumination

Guided by Martin and Tesser's control theory account of rumination (Martin & Tesser, 1996), and drawing from the induction manipulation of Roberts, Watkins and Wills (Roberts et al., 2013), cuing participants' actual ongoing and unresolved academic concerns in the current study appeared to serve as an effective means for inducing a cognitive state consistent with a maladaptive form of rumination. The success of the manipulation may be attributed in large part to participants' completion of hand-written narratives, which likely afforded them some degree of *deliberate disclosure* (e.g., Pennebaker, 1997) about their on-going concern or recent day in their schedule. We were then able to apply a detailed coding scheme developed by Marin and Rotondo (Marin & Rotondo, 2017) for assessing the expression of ruminative brooding or self-reflection in such kinds of narratives. Interestingly, although Marin and Rotondo's study examined writing about a recent, stressful experience over a longer longitudinal, 3-day study (participants wrote once each day for 15 minutes) their pattern of results was similar to that found in the present study, where all writing took place on the same day. Specifically, they found that their participants maintained a relatively high amount of focus on the causes of their issue and other related negative evaluations (i.e., ruminative brooding) across the 3 writing samples, and a higher degree of expression of this maladaptive form of rumination was associated with more negative self-focus and lower self-acceptance. Similarly, we found that being prompted to focus on an unresolved academic concern in a manner consistent with ruminative brooding led to more negative experiential self-focus, especially immediately after onset of the induction manipulation. Nonetheless, it did not appear to influence subjective experiences downstream during the general knowledge task (i.e., RNTs and FAEs).

Marin and Rotondo (Marin & Rotondo, 2017) also found that by the third writing sample, all participants evidenced an increased degree of positive evaluation about their circumstances (i.e., self-reflection), and similar findings were observed in our study as well. According to their impression, self-reflection is a proactive, dynamic process, which is an interpretation in accord with one of the earliest descriptions of this particular ruminative sub-type (e.g., Treynor et al., 2003). Thus, in our study, while heightened expressiveness of ruminative brooding persisted across all three induction-related writing samples, it is likely that by time the third and final opportunity arose for participants to express their thoughts about their object of focus, they felt the urge to try to move into a more deliberate and positive way of appraising their on-going, unresolved concern.

Being induced to ruminate does not sustain overt attention to errors

Despite the effectiveness of the academically-relevant induction procedure, we did not find that being induced to ruminate versus distract increased attention to reminders about one's errors in the general knowledge task, at least not as indexed by overt measures of attention in participants' initial or total fixation durations. Although we initially observed an *increase* in FFDs on the incorrect response feedback type among only those induced to ruminate as they moved from the pre- to post-induction period, we would note that this predicted effect did not survive corrections for multiple comparisons. Indeed, FFDs on reminders of recent performance failures were, in both induction conditions, characterized by a (brief) length more consistent with basic lexical processing (Reichle et al., 2003; Staub et al., 2010) than the complex processing that might underlie deeper encoding of, and therefore greater subsequent memory for, this information (over the corrective information that was also competing for participants' attention).

Such null effects with both FFD and TFD metrics run in *contrast* to both impaired disengagement (Koster et al., 2011) and attentional scope accounts of rumination (Whitmer & Gotlib, 2013). However, it is worth noting that the experimental designs that have previously tested and supported both of those models have primarily utilized relatively basic tasks, of which free-viewing of negative, self-relevant stimuli was a part (e.g., passive viewing of emotional faces with no explicit task-based instruction (Duque & Vázquez, 2015; Owens & Gibb, 2017); passive viewing of emotional or self-focused words in a simple target discrimination task (Grol, Hertel, Koster, & De Raedt, 2015; Southworth, Grafton, MacLeod, & Watkins, 2017). In contrast with those basic tasks, in our more complex general knowledge task, participants' free-viewing of the competitive feedback stimuli could have been more *active* in nature, as they had an opportunity to process feedback stimuli in service of either updating their already existing knowledge or encoding new information. Thus, given the nature of our task, coupled with the lengthy presentation of the competitive feedback stimuli, perhaps disengaging overt attention from negative performance feedback was not as difficult as would be predicted by the impaired disengagement hypothesis and attentional scope model. In partial support of this, in Study 3 we found that across the task as a whole, all participants devoted *less than half as much time* to looking at their errors than they did fixating the novel corrective information that was presented, and the onset of the induction manipulation did not influence this. Perhaps, in the future, shortening the length of presentation of the feedback stimuli, or removing the accuracy feedback (i.e., the initial red or green circle indicating participants' accuracy) would change the sensitivity of our general knowledge task to such predictions.

Finally, we would also note that a few researchers have highlighted rumination as a factor that may additionally be involved in the development of *anxiety*, not just depression (McLaughlin & Nolen-Hoeksema, 2011). As such, it is possible that an account of attention more consistent with a vigilance-avoidance model could have better predicted how those induced to ruminate versus distract in our task might have overtly processed reminders of recent performance failures. The eye tracking metrics used to index vigilance are typically those associated with initial orienting bias, such as time taken until first fixation on a stimulus, or the proportion of times fixating a negative stimulus first over a neutral or positive stimulus (Armstrong & Olatunji, 2012). However, we opted for the FFD and TFD metrics over these initial orienting metrics since most studies of rumination predominantly link it with depression and challenges, in particular, with disengaging sustained attention from negative, self-relevant stimuli (for a review see Whitmer & Gotlib, 2013).

Being induced to ruminate impacts overt attention to corrective feedback, but not error correction

Despite finding no link between state rumination and an increase in sustained attention to reminders of negative performance, being induced to ruminate did lead to a *decreased* overall amount of looking time at the correct answer feedback type, as measured with the TFD metric. While we have found little research elsewhere that speaks to the relationship between looking time on verbal information and the successful encoding of that information, in one study, longer TFDs on listed words during intentional studying were associated with greater memory for those words (Pazzaglia et al., 2014). Thus, based on that study, it is possible that participants in the Rumination condition were less intentional about processing the novel corrective feedback they were fixating upon. Nonetheless, along with this lack of intention, we would have expected an accompanying decrement in the correction of first-test errors from the post-induction period of the task. However, shorter TFDs was not necessarily characteristic of shallower encoding of corrective feedback, as we found no difference in error correction rates between the pre- and post-induction periods for those induced to ruminate. Indeed correlations between fixation durations (whether for FFD or TFD) on either feedback type turned up no relationships with error correction rates.

It is important to add that the TFD (and FFD) metrics in the current study were calculated by averaging across *all errors* in any given block, rather than back-sorting these trials based on whether or not participants later remembered or forgot that information on the surprise retest (i.e., a difference due to memory, or 'Dm' analysis; Paller & Wagner, 2002). This choice to not run Dm analyses was made in order to forestall issues with reduced power due to low trial counts. Had there been ample trials for such analyses, it is possible that items later forgotten might have elicited significantly shorter total (and/or initial) looking times at the corrective feedback than items later remembered. Such DM effects, which could also be assessed for the *incorrect response* feedback type in our competitive feedback design, might have been more pronounced for those induced to ruminate versus distract.

Interestingly, the work by Pazzaglia and colleagues (Pazzaglia et al., 2014) also found memory benefits associated with *the FFD* metric, with longer initial fixations *also* leading to better memory. In our study, increased FFDs on the corrective feedback from the pre- to post-induction periods were evidenced by the *Distraction* group, suggesting that they should have experienced a memory benefit. On the contrary, however, they evidenced a *decrement* in error correction from Block 1 to Block 2. Again, though, in the absence of any significant correlations between gaze fixation metrics and memory performance, and without sufficient trials for a Dm analysis, being able to offer a plausible explanation that links these two opposing effects is difficult. One possibility is that inducing a state of distraction by prompting participants' focus towards a mundane day in their academic schedules, though eliciting very little ruminative thinking, might have *promoted* some degree of general mind wandering during the task. Interestingly, in one eye tracking study that assessed the characteristics of mindless reading, mind wandering was associated with increased FFDs on words in a reading passage (Reichle, Reineberg, & Schooler, 2010). Thus, perhaps such mind wandering in our task for those induced to distract could have interfered with encoding of corrective feedback, causing error correction to suffer.

Trait Brooding and Reflection act independently of the induction manipulation on gaze fixations

Consistent with previous work identifying the trait Brooding and Reflection styles of rumination as being maladaptive and adaptive, respectively, for one's affective and cognitive state (Treynor et al., 2003), we found that higher Brooding RRS sub-scores were related to a greater overall amount of ruminative expression in participants' written narratives during the induction procedure, regardless of condition, whereas Reflection (particularly for individuals induced to ruminate) reduced this expression. The tendency to Brood was also predictive of increased FAEs and RNTs during the task, but interestingly, this latter effect occurred for those induced to distract.

Despite these relatively intuitive relationships with the state induction-related measures, we found that trait Brooding and Reflection also acted *independently* of the induction manipulation on participants' on gaze fixations during the general knowledge task, but in opposing and initially counterintuitive ways. In particular, for all individuals, while Brooding predicted *increased* pre-induction TFDs (and task-wide FFDs) on corrective feedback, Reflection predicted *decreased* pre-induction TFDs on this information. It is difficult to speculate on whether these surprising findings were adaptive or not, given that there were no predictive relationships between trait ruminative tendencies and error correction, nor any correlations between gaze fixation metrics and remedial behavior. Nonetheless, it is at least interesting to note that these two distinct forms of rumination predicted different visual behavior in our task. Perhaps it is possible that those with a predilection towards Brooding, given their longer FFDs and TFDs on the learning-relevant feedback were concurrently experiencing a degree of mindless reading as they were viewing this corrective information (e.g., Reichle et al., 2010). On the other hand, perhaps those with a predisposition towards Reflection, given their shorter TFDs on the corrective feedback, simply chose to look elsewhere on-screen as they continued to ponder this novel information. Whatever the reason for these interesting opposing effects, we would nonetheless note that the influence of trait rumination (and pre-task mood state) was, unexpectedly, in no way interactive with the state induction procedure on our dependent measures of interest.

CHAPTER 6: General Discussion

Overview

This research program was dedicated to investigating whether and how the recurrent and repetitive style of thinking known as rumination might influence attention to errors in an academically-relevant general knowledge task, as well as the ability to learn from corrective feedback in order to rebound from these errors on a later retest. Across three studies, we examined the role of trait tendencies to ruminate on the cognitive and affective processes involved in learning and rebounding from failure, first in isolation (Study 1) and then in terms of their interactions with experimental manipulations of a ruminative state (Studies 2 & 3). Here, we offer collective conclusions from these three studies, beginning with a sub-section that addresses the influence of rumination on error-related attentional processes during the general knowledge task. We then follow with sub-sections regarding the impact of rumination on physiological processes associated with encoding of corrective feedback, as well as with behavioral measures of first-test performance and error correction. Within each of these sub-sections, we also comment on any similarities or differences in the roles of trait and state rumination, as well as any salient gender differences. Finally, within all sub-sections we remark on how our findings fit in with, extend, or even contradict, existing theories on rumination. Finally, we offer thoughts on the practical relevance of this research.

Rumination sustains internal (but not external) focus of attention in response to errors during feedback-based learning

As anticipated, we found evidence that rumination could heighten and sustain attention to errors in a challenging academic task in which participants receive repeated negative performance feedback. Interestingly, the best evidence for this was found with selected event-related potentials (ERPs), which serve as *covert* measures of sustained attention, rather than with gaze fixation metrics, which serve measures of *overt* sustained attention. Specifically, in Study 1, the Late Positive Potential (LPP), a putative ERP index of internal motivated focus on a visually evocative stimulus (Foti & Hajcak, 2008; Schupp, Junghofer, Weike, & Hamm, 2004), showed less attenuation to negative performance feedback across the general knowledge task for women exhibiting higher degrees of the trait ruminative Brooding style. On the other hand, in the women-only sample in Study 3, neither of the two eye-tracking metrics of visual fixation on externally-presented reminders about performance failures was modulated by either trait *or* state rumination. Interestingly, in *both* Studies 1 and 3, women's trait Brooding levels predicted increased task-related recurring negative thoughts and worse feelings after errors, suggesting that an inward negative self-focus was present in *both* samples for women with greater Brooding tendencies. However, to the extent such self-focus directed attention more inward than outward, this modulation was captured more by the LPP than gaze fixation, respectively. Thus, in a difficult academic context in which failures accrue, rumination may heighten and sustain attention to internal representations of the self-relevance of these failures, and potentially the feelings associated with them, even if visual gaze is not necessarily maintained towards signals of failure, at least when novel task-relevant information is also competing for attention.

To help contextualize the effects trait rumination on the LPP measures covert attention, we would also note that in Study 1 we found no influence of trait rumination on the earlier Feedback-related negativity (FRN), an ERP waveform studied extensively with respect to error feedback processing, but shown to index a more *reflexive orienting of attention* to outcomes that are worse than expected, rather than sustained focus (Simons, 2010). Given that the LPP occurs later than the FRN, and that the LPP can continue to be modulated by appraisals of externally-presented emotional stimuli *even after their offset* (Hajcak & Olvet, 2008), it would appear that these trait Brooding effects are indeed better explained by internal representations of the meaning of the negative feedback rather than by an alerting reaction to externally-driven stimulus onset. Although trait Brooding *did* sustain the *early* LPP, which indexes more *passive, bottom-up* internal representations of arousing stimuli, rather than those more deliberate and top-down, as reflected in the late LPP (Codispoti et al., 2007), this early effect was also found to be related to *trait Reflection* among women. Interestingly, it was not until the later LPP where we observed the more expected opposing effects between these two distinct forms of trait rumination. In this latter period of the LPP, thought to be more influenced by top-down goals and expectations, Brooding continued to sustain internal motivated attention to failures for women, but for *all* individuals, Reflection attenuated it.

In contrast to our present findings, researchers testing both the impaired disengagement hypothesis and the attentional scope model have found rumination to result in increased gaze fixation on negative stimuli, however the stimuli used in those studies were mainly pictures of emotional faces (Duque et al., 2014; Owens & Gibb, 2017) or negative, self-relevant words (Fang, Sanchez, & Koster, 2017; Grol et al., 2015). Although in our eye tracking study participants' incorrect response was presented in red, a color that some studies have been shown to be implicitly arousing and negative (Elliot, Maier, Binser, Friedman, & Pekrun, 2009; Elliot, Maier, Moller, Friedman, & Meinhardt, 2007), the words themselves were not negative or self-relevant. Rather, the semantic information provided by this feedback was neutral, and it was the internal construal of the meaning of this feedback in reference to performance goals that was likely to vary as a function of rumination, something that may not necessarily be captured by gaze fixation. Gaze fixation metrics can only speak to where and how long the eyes dwell on the screen, but do not necessarily speak to what individuals are focusing on internally. Although general models of eye movements and attention are often based on the principle that where one is looking is what one is thinking about (e.g., Just & Carpenter, 1976), it is quite possible that at any given moment, the object(s) of internal and external focus can be different (Hunt & Kingstone, 2003), such as has been shown in the eye tracking patterns of individuals who are mind wandering (Reichle et al., 2010).

In summary, our results indicate that during feedback-based learning, rumination seems more likely to modulate one's internal, inward focus of attention, regardless of where the eyes are looking. Interestingly, the relationship between Brooding and greater sustained attention to negative outcomes was strongest in women, whereas the effects of Reflection were observed for men as well. This extends our understanding of the well-known gender differences in rumination (Nolen-Hoeksema & Jackson, 2001) by showing that maladaptive forms of recurrent self-focused thinking may particularly evident for women's down-stream cognitive processing during goal-directed behavior. The positive impact of Reflection in both genders also extends the growing, yet limited, body of research showing that Reflection's ability to reduce negative affect in the long-term (i.e., Treynor et al., 2003) can be found even in modulation of affective responses in the short term. Finally, the finding that rumination may modulate covert, but not overt attention to negatively construed information, particularly in a more common, everyday setting with non-depressed individuals, rather than in a clinical context, is a novel addition to the existing models of attention in rumination (cf. Koster et al., 2011; Whitmer & Gotlib, 2013).

Rumination attenuates overt (but not necessarily covert) attention to corrective information during feedback-based learning

In the eye tracking study (Study 3), we found that being induced to ruminate led to a *decreased* overall amount of looking time at the *correct answer* feedback type, as measured with the Total Fixation Duration (TFD) metric. Since all participants were unaware that they would later be retested on all their first-test errors in this incidental encoding task, this decrease in overall gaze duration could be explained by a general reduction in intrinsic curiosity about the correct answer and a disinterest in integrating this information into their existing knowledge base (cf. Kang et al., 2009). Indeed, some related work in a peripheral research domain used gaze fixation to index motivation towards attainment of a personally-relevant goal (Light & Isaacowitz, 2006), and found that individuals looked less at a goal-related stimulus if they believed the goal reflected by that stimulus was unattainable. Thus, for those induced to ruminate in the face of repeated failure, such a lack of intrinsic interest could have been fueled by the perception that an effort to update knowledge might prove fruitless, and therefore the greater motivation was to minimize focus on the 'sting' of the correct answer. Interestingly, in partial support of this interpretation, we found that being induced to *distract* from any ruminative thoughts or on-going concerns led to an *increased* initial gaze towards corrective feedback, as indexed by the First Fixation Duration (FFD) metric, though this effect was not found for overall TFDs.

Somewhat surprisingly, however, we found that *trait* Brooding *increased* overall looking time on the correct answer feedback as measured by the TFD metric. Thus, while a temporary *state* of brooding may be associated with less intentional engagement with this information, habitual brooding may result in attempts at *greater engagement* with assessing the problem at hand. However, because the negative thought patterns of women who brood are primarily passive and abstract in nature, rather than concrete and constructive (Treynor et al., 2003; Watkins, 2008, 2011), perhaps this increased focus on the correct answer was more shallow and superficial than it was deep and meaningful. Indeed, based on characterizations of those who brood (for a review see Nolen-Hoeksema et al., 2008), it is easy to imagine that this maladaptive response style might capture individuals' gaze as they self-critically think: 'Why didn't I put *that* answer!?'.

These opposing effects of state and trait Brooding are additionally striking given that trait *Reflection* in Study 3 was linked with a *reduction* in overt attention to corrective feedback as measured by the TFD metric. Again, seemingly counterintuitive at first (especially given that state Brooding also was associated with reduced TFDs), if we reference the general characteristics of those exhibiting trait Reflection versus trait Brooding we find that this more adaptive ruminative tendency is often epitomized by the desire to 'take space' from one's issues in order to self-reflect proactively about them rather than to remain in the midst of them and passively dwell on them (Treynor et al., 2003). Such a positive characteristic could have manifested for these women in looking elsewhere on-screen (i.e., blank space, center of the screen in active preparation of the next question) once they recognized the value of the corrective feedback in the context of their error.

These findings indicating that state and trait rumination can lead to opposite effects is especially surprising given recent hypotheses by leading rumination researchers of the potential developmental link between state and trait forms rumination. These developmental explanations detail that over time, negative internal or external contexts (e.g., depressive mood, undesirable environments), when repeatedly becoming paired with ruminative thinking brought about by goal-state discrepancies, can eventually bring about reflexive ruminative responsiveness, even in the *absence* of goal-state discrepancies, thus become a trait cognitive style. Since such pairing is implicit, the belief is that while ruminative responsiveness can become much more automatic and habitual, the effects on cognition and emotion will otherwise be *similar and even perhaps more pronounced* than those resulting from temporary state of rumination. Furthermore, we would add that research elsewhere has shown that trait rumination can *exacerbate* the ill effects of state rumination, rather than result in opposing effects (Key et al., 2008; Rosenbaum et al., 2017).

In Study 3, however, not only did we not observe interactive effects on overt attention between trait and state rumination, but surprisingly, the trait rumination effects on *all* participants' overall amount of looking time at the correct answer (i.e., TFDs) *subsided* in the post-induction block, which is where the state brooding effects subsequently unfolded. Although proponents of trait rumination as a mental habit offer that ruminative tendencies can be triggered regardless of current situational demands or attempts to rely on other thought processes in service of facilitating adaptive, goal-directed behavior (Hertel, 2004; Martin & Tesser, 1996; Nolen-Hoeksema et al., 2008; Watkins, 2008), one possible explanation for the cessation of trait influence on correct answer TFDs during the post-induction block is that effortful attempts to complete object-oriented written narratives may have constrained participants' focus onto salient events of their recent past in a way that temporarily overrode trait tendencies for sustaining attention to this kind of information. Interestingly, more consistent effects of trait tendencies were found across the entire task when examining *initial* processing (i.e., first fixation duration (FFD) metric) of corrective feedback, and this effect was found for all participants regardless of Induction Condition. Thus, it appears that even if *prolonged* processing dissipated at the hand of the induction task, this maladaptive trait tendency was still linked with an *initial urge* to dwell more and this persisted regardless of variations in study context (i.e., onset of the induction).

Finally, we contrast these effects of rumination on *overt* attention to the corrective feedback to the findings of Study 1 in which we used ERPs as our index for the processing of learning-relevant feedback. In that initial study, we found no evidence that rumination influenced encoding processes during first-test, at least as measured by the Learning Error-Related Negativity (LERN), an ERP waveform that has consistently predicted successful learning in this paradigm (Butterfield & Mangels, 2003; Mangels, Hoxha, Lane, Jarvis, & Downey, 2018; Mangels, Rodriguez, Ochakovskaya, & Guerra-Carrillo, 2017), and even sensitivity to state (Mangels et al., 2017) and trait personality differences (Mangels et al., 2006; Mangels et al., 2018). However, the LERN measured in Study 1 only assessed the electrophysiological processes occurring within a brief period (1 s) after feedback onset, while the eye tracking metrics in Study 3 found differences on the order of time-frames that extended well beyond this short duration (i.e., inclusive of 4 s of possible processing time). Thus, in the ERP study, it is not outside the realm of possibility that rumination may have influenced further downstream neural processing (temporally) at these scalp sites, or at electrode sites (spatially) that were not the focus of measurement in Study 1. Finally, it is also possible that while overt attention was modulated by rumination, the processes critical for successful encoding of the correct answer was simply not directly modulated by this recurrent and repetitive manner of thinking. We will address this in terms of the effect of rumination of error correction in the following section.

In summary, our findings reveal that during opportunities to encode corrective information that could remediate errors in general knowledge, the effects of rumination seem to be more evident in measures of overt attention (i.e., gaze fixation) than in measures sensitive to the internal focus of attention (i.e., ERPs). While *trait* Brooding was associated with *increased* fixation on corrective information, perhaps characterizing a passive and superficial viewing, a *state* of rumination that was brooding-like *decreased* overall external focus on this information, perhaps caused by a general lack of interest in updating one's own existing knowledge when experiencing this state. However, trait Reflection also reduced overall gaze on corrective feedback (at least before the onset of the induction procedure). If we interpret this effect within the common view that this trait sub-type is more adaptive in nature, perhaps this decrease was an attempt to proactively and deeply process this information by moving the gaze to another area on the screen or even closing the eyes to facilitate internal direction of thought. While such interpretations draw from previous research that characterizes these different sub-types of trait rumination (for a review see Nolen-Hoeksema et al., 2008), our findings are nonetheless difficult to immediately reconcile with relatively nascent efforts to understand the developmental link between habitual trait rumination and more momentary forms of state rumination (cf. Watkins & Nolen-Hoeksema, 2014). It may be that when a transient state of rumination elicited by goal-discrepant events transitions to a trait ruminative habit, externally directed attention processes induced by a state (and captured by gaze fixation measures) become fully internalized and are no longer stimulus- or event-dependent, and being more internally-focused, reverse in their pattern of behavior in terms of external metrics.

Brooding and Reflective Rumination exert different effects on memory as a function of task demands, gender, and state manipulations

Brooding rumination effects

Despite finding that, for women, trait Brooding predicted a sustained inward focus of attention in response to errors in our task, especially across blocks, and that Brooding in both trait and state forms exerted effects (although in the opposite direction) on the amount of time they spent overtly looking at corrective feedback, we found no support that this style of rumination hindered (or facilitated) women's (or men's) ability to remediate their errors. These null effects run in contrast to the prediction that this passive and abstract form of rumination would be detrimental particularly for women in an academically-relevant task in which failures accrue, but attention must adequately be focused on corrective feedback in order for them to learn and rebound from this failure. We are quick to mention, however, that since Brooding rumination did often increase women's recurring negative thoughts, worsen their feelings after errors, and modulate their attention in our rebound from failure task, maintaining engagement in this challenging academic environment may have consumed more precious cognitive resources for women who brooded compared to others who did not. Future work should consider whether this maladaptive form of rumination might impair learning in challenging academic settings where failure occurs, but corrective feedback is more complex and multifaceted and therefore requires more cognitive resources to effectively process (e.g., math problem solving; cf. Mangels et al., 2012).

Surprisingly, the only evidence for a link between Brooding rumination and error correction was the *positive* relationship we observed involving the *trait* measure of Brooding among men only in Study 2. Although contrary to expectations, this finding is interesting because it is one that occurred only after the onset of the induction procedure and regardless of Induction Condition (i.e., equally whether induced to ruminate or distract). Because of the generality of the finding to both induction conditions, this finding suggests that when men who tend to brood are in the midst of academic difficulties in which negative feedback is repeatedly received must be benefitting from a feature that is common to both induction conditions. Thus, we offer the possibility that installing intentional break periods for them that involve either mental imagery or the deliberate processing of their feelings may *increase concentration*, and this may facilitate their ability to re-engage with learning opportunities in a more effective manner in the face of future instances with failure. These benefits to learning were coupled with *increased* recurring negative thoughts about task performance and worse feelings after errors as the task progressed, interpretation of which is additionally complicated by the findings of opposite trait brooding effects on men's feelings after errors in Study 1, and no link there with remedial behavior. Though it may currently be difficult to reconcile these various effects, and they bear replication, we would at least begin to point out that in this research program, trait rumination, as measured by the Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 1991) seems to characterize drastically different experiences for men and women during feedback-based learning.

Finally, it is interesting to note that although we did not find rumination-related deficits in error *correction* in this research program, we did find compelling evidence in Studies 1 and 2 that rumination, particularly when in a maladaptive brooding-like form, and particularly among women, was associated with *poorer initial retrieval* of fact-based information during *first-test*. In Study 1, this effect was found with *trait* Brooding. In Study 2, it was women who were induced into a temporary *state* of brooding, particularly one that was prompted to be *open-ended, passive*, and *abstract* in nature, who suffered disruption of retrieval processes, perhaps because their recollection of task-relevant facts was too over-general (Watkins & Teasdale, 2001; Watkins, Teasdale, & Williams, 2000). Although it is not immediately evident whether these state effects were driven by the ill influence of being in a state of rumination or the benefit of being in a state of distraction (or some combination of both), we would at least note that among women who were in the *Rumination condition only*, first-test performance decrements were associated with *increases* in in-task recurring negative thoughts (RNTs). This link may partially characterize an account of how the negative relationship between state brooding and goal-directed behavior may be deleterious for women's general knowledge retrieval. When confronted with academic challenge, the kinds of memories that they may retrieve may be more abstract and about personal issues than they are concrete and about the task or assignment at hand. As such, it may be useful, as some research involving the use of mindfulness meditation for reducing rumination would suggest (Deyo, Wilson, Ong, & Koopman, 2009; Jain et al., 2007; Teasdale et al., 2000), for some women to adopt concrete mental exercises to temporarily distract themselves from their difficulties and perhaps resituate their thinking on task-related demands.

In conclusion, while Brooding did not adversely impact the ability to encode and use corrective information to remediate errors, some support was found among men only that interrupting sustained task performance with meaningful breaks that prime concentration might *facilitate* the ability to remediate errors for these high-Brooding men (cf. Lyubomirsky et al., 2003). Women's memory performance was not entirely exempt of any influence from Brooding rumination, however. For them, Brooding was associated with *deficits in initial retrieval* of fact-based information, perhaps because abstract and over-general thinking interfered with an effective search through memory. Negative effects on error correction might have been more evident if the encoding-task required more integrative, cognitively demanding processes. Nonetheless, not only do these findings corroborate the general impression that rumination is particularly detrimental for women (Nolen-Hoeksema & Jackson, 2001), but they extend this long-held understanding by showing that in the face of academic challenge, brooding rumination may modulate separable memory processes differently for women and men.

Reflection rumination effects

When there was no manipulation of ruminative state (i.e., Study 1), both *men and women* who demonstrated a greater trait tendency to exhibit *Reflection* also showed an *improved* ability to rebound from failure. This benefit was found despite finding that greater Reflection was also associated with an increased amount of recurring negative thoughts self-reported during the initial general knowledge task. These findings corroborate previously established impressions that, although habitually ruminating in this way may momentarily accentuate negative thoughts and feelings, this particular style of recurrent thinking, which is more concrete and deliberate than Brooding, may also be more adaptive in the long-run for cognition and affect (Treynor et al., 2003; Watkins & Moulds, 2005; Watkins, 2008). Here, for the first time, to our knowledge, we show that these impressions extend from a primarily clinical setting to an applied and common real-world setting — learning in response to feedback during repeated academic challenges — and can be observed even in a non-depressed sample.

Interestingly, however, we did *not* observe these beneficial effects in Studies 2 or 3. Rather, we found some evidence in Study 2 that an incongruity between the trait tendency to Reflect and an instructional context designed to distract from internal task-relevant thoughts (i.e., Distraction condition) may have disrupted error correction. Here, women with a greater tendency to reflect suffered *declines* in remedial behavior as they moved from the pre-induction baseline block into the post-induction period designed to *distract* from any ongoing concerns. While being induced to experience a temporary state of distraction has repeatedly been shown to reduce the ill effects of being in a momentary state of rumination (for a review see Nolen-Hoeksema et al., 2008), this may apply more to the Brooding style of rumination. For those who have a stronger Reflective style of rumination, the incongruous nature of being directed to focus on unrelated mental images of objects and places when one would rather engage in goal-directed thinking could have more negative downstream effects, particularly on problem solving. Furthermore, we speculate that in Study 2, this incongruity may have also caused frustration, additionally sapping cognitive resources that might have otherwise been devoted to processing corrective information in the general knowledge task that was useful for remedial behavior. Additionally, it is notable that in Study 3, where neither positive nor negative trait effects of Reflection were observed, the manipulation to induce a Brooding-like state also appeared to be more effective (at least compared to Study 2), suggesting that trait Reflection effects may be more easily sidelined in the context of a strong state of Brooding. Indeed, greater vulnerability to the cognitive and/or affective demands of the environment may be one reason why Reflection effects are often less consistent across the literature (see Nolen-Hoeksema et al., 2008).

Finally, returning to the influence of the reflective form of rumination on the retrieval of general knowledge at *first-test*, we largely found benefits of this more proactive manner of recurrent and repetitive thinking. While in Study 1, these benefits were apparent for women only, in Study 2, Reflection predicted an increase in first-test accuracy for both men and women participants. Although these benefits were not replicated in Study 3, we cannot rule out the possibility that the increased effectiveness of the state Brooding manipulation or differences in study design (fewer blocks, different feedback structure) may be responsible. Nonetheless, taken as a whole, these positive findings on first-test retrieval generally highlight the value of exhibiting this trait ruminative tendency over a more passive and abstract brooding form of rumination in the midst of academic challenge, where being able to accurately recall information from memory in precise detail is critical. When considering these effects along with those on error correction, we can conclude that during feedback-based learning, the tendency to reflect is much more useful than not, perhaps because it promotes proactive engagement with concrete and deliberate means for working through academic challenges (cf. Ciarocco et al., 2010). Moreover, such benefits may particularly manifest for women when the environment they are in affords the opportunity to express this self-reflective style.

Conclusions

During feedback-based learning in a challenging academic context where failures accrue, but attention must be given to corrective feedback for successful remedial behavior, we have shown that rumination modulates internal focus of attention in response to errors, regardless of how the eyes overtly process error-related feedback. While maladaptive brooding sustained inward focus, particularly among women, the more adaptive reflection style *attenuated* it for both women *and* men. Interestingly, women's trait brooding, while not necessarily linked with covert ERP measures of successful encoding, *was* linked with *increased* gaze (that was perhaps passive and superficial) on corrective feedback, though being in a temporary *state* of brooding *decreased* their interest in looking at this useful feedback. These findings add to the literature detailing rumination's relationship with cognition and emotion, because while current models have sought to especially characterize rumination in the context of the onset and maintenance of depression, they have not yet adequately done so in a manner that comparatively addresses modulations of both covert and overt forms of attention to negatively-valenced stimuli. These models have also not yet begun to address such comparisons among mentally healthy individuals within applied settings in which rumination is likely to occur, which is somewhat surprising given how common a style of thinking rumination has been purported to be. The current findings begin to shed light on how rumination, and in particular, its maladaptive form of Brooding, may differentially modulate covert and overt attention processes, especially for women, in a challenging academic environment. These effects hold implications for how educational services might be developed to better fit the needs of students who, when facing significant academic difficulties, may internalize their issues and not be able to externally focus their attention deeply enough on resources that would help them be successful in reaching their academic goals.

Surprisingly, in the current research program Brooding rumination did not impair women's ability to correct their errors in this challenging academic context, though across two of three studies it *did* impair their ability to retrieve general knowledge at first-test. Despite these ill effects of this maladaptive style of rumination on retrieval processes, in these same two studies, women exhibiting the more adaptive style of Reflection also experienced *enhanced* memory for general knowledge at first-test, an effect that was also present for men in Study 2. Reflection also predicted *increased error correction* for *all* individuals in Study 1. These positive effects of Reflection, though generally in accord with previously established impressions of the adaptive nature of this ruminative sub-type, *extend* the current understanding by revealing that in an academically challenging environment in which rumination is likely to occur, this concrete and deliberate recurrent style of thinking (as opposed to Brooding rumination) may be useful for promoting more *task-focused* and *goal-directed* behaviors. The proactive nature of such a style of thinking not only has positive implications for academic success, but also for the mental health of the common undergraduate, especially for women, who may regularly experience a flurry of negative thoughts and feelings in the midst of academic challenges. Future work could address means for developing counseling resources at academic institutions that would help students particularly identify the nature of their ruminative tendencies and offer strategies on how to minimize passive Brooding, but promote active Reflection.

Finally, although some theoretical and empirical accounts suggest that the effects of being induced to temporarily ruminate may be exacerbated for those who habitually express ruminative responsiveness, rarely did we see additive or even interactive effects between trait and state rumination. The one exception being in Study 2 where women who were induced to experience a distractive state suffered greater *declines* in error correction the more they endorsed a trait tendency to Reflect. Although paradoxical to the aforementioned *benefits* of the Reflective style, these effects highlight the complexities of this ruminative style, and along with other findings, suggest its relationship to behavioral outcomes are more likely to be influenced by external learning environments. With respect to a *challenging* academic context, in particular, these effects from Study 2 imply that educators might do best to offer their students options in the classroom for helping to create learning environments that students feel they will be best suited for and that minimize the chances of invoking unwanted ruminative or other maladaptive mental states.

In conclusion, the findings from this research program add to the growing dialogue on how the recurrent and repetitive style of thinking known as rumination might not only influence cognition and emotion, but also goal-directed behavior. Future work should continue to address how ruminative thinking may impact goal-directed behaviors in challenging academic settings, where rumination may abound, especially for women. The continuation of this discussion through scientific inquiry is especially important given the prevalence of rumination as a style of thinking among both mentally healthy and clinical populations alike. Such research could inform the development of strategies and resources that would be helpful for students to minimize unwanted or maladaptive ruminative thoughts, and instead promote proactive forms of self-reflection that would facilitate learning.

APPENDIX A

Study 2: *Condition-Specific Instructions*

Rumination Condition:

The next block of questions will begin shortly…

First, however, we have another important task for you to do. In a demanding experiment such as this, it can be extremely useful to use a "break period" like the one you are in now to deliberately focus on, or make sense of, the different kinds of thoughts or ideas that tend to pop up when completing the general knowledge questions.

Here, we are going to display some ideas on the computer screen, some of which students have often reported thinking about when answering the general knowledge questions. Other ideas are ones which students report just generally thinking about as undergraduates.

Your task is to listen to each idea as it is read aloud to you, and focus your attention and concentration on *thinking about each idea* for as long as it appears on the screen. The ideas will be presented one at a time, each for 25 seconds.

Immediately afterward, you will be asked to rate how well you were able to concentrate on that idea on a 9-point scale. Some ideas will be easier to concentrate on than others – please use the whole scale. At the end of the experiment, you will also be asked some additional questions about these ideas.

Distraction Condition:

The next block of questions will begin shortly…

First, however, we have another important task for you to do. In a demanding experiment such as this, it can be extremely useful to use a "break period" like the one you are in now to deliberately focus on, or make sense of, the different kinds of thoughts or ideas that tend to pop up when completing the general knowledge questions.

Here, we are going to display some ideas on the computer screen, some of which describe images that students have often reported thinking about when answering the general knowledge questions. Other ideas will describe images that students report just generally thinking about as undergraduates.

Your task is to listen to each idea as it is read aloud to you, and focus your attention and concentration on *thinking about a mental image of each description* for as long as the idea appears on the screen. The ideas will be presented one at a time for 25 seconds each.

Immediately afterward, you will be asked to rate how well you were able to concentrate on that mental image on a 9-point scale. Some images will be easier to concentrate on than others – please use the whole scale. At the end of the experiment, you will also be asked some additional questions about these images.

APPENDIX B

Study 2: *State Induction Prompts*

Rumination Condition:

Prompt Set 1
Think about the possible consequences of the way you feel.
Think about trying to understand who you are.
Think about the degree of control you feel right now.
Think about why you turned out this way.
Think about how different / similar you are to other people.
Think about the degree of restlessness / calmness you feel.
Think about the long-term goals you have set.
Think about the kind of student you are and wish you were.

Prompt Set 2
Think about trying to understand your feelings.
Think about the kind of person you think you should be.
Think about the level of motivation you feel right now.
Think about what people notice about your personality.
Think about how slow / quick your thinking is right now.
Think about how hopeless / hopeful you are feeling.
Think about whether you are fulfilled.
Think about the expectations your family has for you.

Distraction Condition:

Prompt Set 1
Think about a row of shampoo bottles on display.
Think about the baggage claim area at the airport.
Think about the shape of a large black umbrella.
Think about the structure of the Eiffel Tower.
Think about a double-decker bus driving down a street.
Think about the way the ocean looks at sunset.
Think about two birds sitting on a tree branch.
Think about a clown putting on his or her make-up.

Prompt Set 2
Think about a gas station on the side of a highway.
Think about a train stopped at a station.
Think about raindrops sliding down a windowpane.
Think about the structure of a high-rise office building.
Think about a truckload of watermelons on a dirt road.
Think about the movement of an electric fan on a warm day.
Think about a group of polar bears fishing in a stream.
Think about and concentrate on the expression on the face of the Mona Lisa.

APPENDIX C

Study 2: *Induction-Related Interference Ratings Questions*

All interference ratings questions began with:
When you were doing the general knowledge questions, how frequently did you think about…

Rumination Condition:

Presented-Congruent Questions
…the possible consequences of the way you felt?
…why you have turned out this way?
…how hopeless / hopeful you were feeling?
…the expectations your family has for you?
…trying to understand your feelings?
…how restless / calm you were feeling?
…what people notice about your personality?
…the kind of student you are and wish you were?

Novel-Congruent Questions
…the things that are most important in your life?
…why you react the way you do?
…what you feel about your friendships?
…how passive or active you felt?

Presented-Incongruent Questions
…a train stopped at a station?
…the shape of a large black umbrella?
…a double-decker bus driving down a street?
…a group of polar bears fishing in a stream?

Distraction Condition:

Presented-Congruent Questions
…a train stopped at a station?
…the shape of a large black umbrella?
…a double-decker bus driving down a street?
…a group of polar bears fishing in a stream?
…the baggage claim area at the airport?
…raindrops sliding down a windowpane?
… a truckload of watermelons on a dirt road?
…two birds sitting on a tree branch?

Novel-Congruent Questions
…a full moon on a clear night?
…the pattern of an oriental rug?
…the shape of a baseball glove?
…a freshly painted door?

Presented-Incongruent Questions
…the possible consequences of the way you felt?
…why you have turned out this way?
…how hopeless / hopeful you were feeling?
…the expectations your family has for you?

*RED text – rumination-related queries that were presented to both conditions post-test
*BLUE text – distraction-related queries that were presented to both conditions post-test

APPENDIX D

Study 3: *Condition-Specific Instructions*

Rumination Condition:

Based on your responses so far, you encountered some difficulty answering the first block of questions. Although this difficulty is happening within the context of this research study, perhaps you have encountered difficulties in actual academic situations of your own life. During real-life academic difficulties, many students often report taking the time to think about the causes and meaning of their difficulties. Please take a moment to pause from the general knowledge questions to complete this second task that involves thinking about your academic difficulties in real life…

In this task, we want you to take some time to identify *a real, on-going, and unresolved academic concern in your own life* that has entered your mind once or twice, or maybe more, causing you to feel distressed across the past few weeks. If you cannot identify an academic concern from the past few weeks, it's okay to identify one that started at some point during this semester, academic session, or school year. Still, it's important that your concern is one that *remains unresolved and has entered your mind a lot, causing you distress across this particular period of time*.

Please hit the *Enter* key to continue…

Distraction Condition:

Based on your responses so far, you encountered some difficulty answering the first block of questions. Although this difficulty is happening within the context of this research study, perhaps you have encountered difficulties in actual academic situations of your own life. During real-life academic difficulties, many students often report taking the time to distract themselves from thinking about their difficulties. Please take a moment to complete this second task as a distraction from the general knowledge questions or any real- life academic difficulties you may be thinking about…

In this task, we want you to take some time to think about your academic schedule at Baruch College and identify a day across the past few weeks for which you can *remember with good accuracy what sorts of things you did while you were here on campus*. If no particular day stands out to you as memorable, just think back to a day for which you can remember what classes you attended, what friends you met up with between classes, what food you ate for lunch, and so on. Whatever day you choose, it's important that the day be one for which *you can remember with good accuracy what sorts of events took place for you while you were at Baruch*.

Please hit the *Enter* key to continue…

APPENDIX E

Study 3: *Condition-Specific Examples*

Rumination Condition:

Take a look at the following example of an unresolved academic concern that one participant gave permission for us to show you…

> *I'm enrolled in this course for my major right now where the material that's been covered across the past few weeks has been really difficult for me to understand. I've repeatedly performed below my expectations on quizzes and assignments, and recently at night as I've tried to fall asleep I've found myself continuously wondering why this is happening to me, and why no one else seems to have the problems I'm having. What's worse is that the exam grade I just got back was one of the lowest in the class, and since I spent more time studying than ever before, I'm now completely frustrated and pretty much can't stop thinking about it.*

Or consider this example of an unresolved concern that another participant gave permission for us to show you…

> *Across the past few weeks I've become preoccupied with what the students in this one class think of me. I've been part of a study group with some of them before, but recently I noticed that they formed a new study group without me. Across the past few class periods, I've caught myself mind- wandering about whether I know as much as they do. I decided a few days ago to ask if I could join them, but they basically just continued to give me the cold shoulder. Now since asking them, I've been feeling totally unappreciated and very concerned that my contributions don't measure up to their standards. It's been hard for me to keep the negative thoughts about it all from cycling over and over in my head.*

Distraction Condition:

Take a look at the following example of a day at Baruch that one participant gave permission for us to show you…

> *Mondays are my longest day at Baruch since I have three classes that day. Psychology is first, and then later in the day I have my Accounting and Management classes, back to back. I'm choosing this past Monday to write about because in the morning I remember picking up some coffee with a friend at Starbucks before heading up to Psychology. Then in Psychology I remember we went over a huge exam that the professor handed back to us. Later I met a friend outside and we went to Bagel Express. In the afternoon, I had my Accounting class, and the professor let us out a little early. After my Management class later on I studied in the library for a few hours with three of my friends before getting on the subway to go home for the night.*

Or consider this example of a day that another participant gave permission for us to show you…

Last Wednesday kind of stands out in my mind as being easy to remember. I got to Baruch earlier than usual that day since the subways were running smoothly. That gave me some extra time to finish my homework for my afternoon Math class. Psychology was my first class of the day though, and after that a bunch of us went out to get pizza at a place on 3rd Ave that I had never been to before. After lunch I went to Math class, and then I always have some free time before Finance starts. But that day, I remember I got a text from my study group for my Psychology class, so I used my free time to meet up with them that day. After Finance, I went to the gym, and then went home.

APPENDIX F

Study 3: *Induction-Related Writing Prompts*

Rumination Condition:

PROMPT 1: Now that you have identified your own unresolved academic concern, please take a few more moments to write your concern down on the lines below. Please refer to the tips below that will help guide you through this process. Please write about your concern as honestly and accurately as possible. When you are finished, please alert the experimenter. (See the attached pages again for student examples.)

Guidelines:
1. Use as much space as you need – your entry can be as long as the examples presented on the screen.
2. Avoid worrying about spelling or grammar; but please write legibly / clearly.
3. Avoid expressing too many personal feelings or emotions you may have about your concern.
4. Rather, as honestly and accurately as you can, provide a description of the concern itself.
5. You have plenty of time – the experimenter will check in with you in 3-5 minutes to see if you're done.

PROMPT 2: In a few short sentences, given what you wrote about earlier, describe what sorts of RECURRING or REPEATED thoughts tend to pop into your head when your unresolved academic concern comes to mind. If you don't usually experience any recurring or repeated thoughts, simply describe *the thoughts that most easily come to mind* about your unresolved concern.

For Example:
If you wrote earlier about currently doing poorly in a course for your major despite all your effort, you might say: "I can't stop thinking about why this is happening to me." Or "I often wonder 'What's the matter with me?'" And so on. Please write about all of the COMMON or RECURRING thoughts you tend to have as honestly and accurately as you can.

PROMPT 3: In a few short sentences, describe the AMOUNT OF TIME AND ENERGY you have invested in trying to resolve your on-going academic concern. Given that your concern is still unresolved, *what is your immediate reaction* to the amount of time and energy you have spent trying to resolve it?

For example:
If you wrote earlier about currently doing poorly in a course for your major despite all your effort, you might say: "I didn't spend as much time studying as I needed to – and now that mistake has come back to haunt me." Or "Even after all my effort, I still can't see a light at the end of the tunnel – this is really frustrating." And so on. Please write your actual thoughts about YOUR TIME AND EFFORT as honestly and accurately as you can.

Distraction Condition:

PROMPT 1: Now that you have identified a day from your own academic schedule at Baruch College, please take a few more moments to write down what you did while you were here on campus on the lines below. Please refer to the tips below that will help guide you through this process. Please write about your schedule as honestly and accurately as possible. When you are finished, please alert the experimenter. (See the attached pages again for student examples.)

Guidelines:

1. Use as much space as you need – your entry can be as long as the student examples provided here.
2. Avoid worrying about spelling or grammar; but please write legibly / clearly.
3. Avoid expressing personal feelings or emotions you may have about your schedule.
4. Rather, as honestly and accurately as you can, provide a description of the day you chose.
5. You have plenty of time – the experimenter will check in with you in 3-5 minutes to see if you're done.

PROMPT 2: In a few short sentences, given what you wrote about earlier, describe the details of WHEN these events of your day occurred. That is, starting with the first event of the day that you mentioned and ending with the last, specify as precisely as possible *what time each event occurred and how long it lasted.*

For Example:
If you previously wrote about what classes you had and the lunch you ate, you might now say: "My first class started at 10:20 and ended early at 1:05. Then I ate lunch from 1:15 to 1:50." And so on. Please write about WHEN THINGS HAPPENED as precisely as possible.

PROMPT 3: In a few short sentences, please write specific details about WHERE on campus (or around campus) the events you wrote about before took place. That is, starting with the first event of the day that you mentioned and ending with the last, specify as precisely as possible *the location where each event occurred*.

For Example:
If you wrote about what classes you had and the lunch you ate, you might say: "My first class was in the huge lecture hall on the 4th floor of the Vertical Campus. For lunch, we went to the cafeteria on the 1st floor and sat at one of the tables' right outside the registers." And so on. Please write about WHERE YOU WERE as precisely as possible.

References

Aldao, A., & Nolen-Hoeksema, S. (2010). Specificity of cognitive emotion regulation strategies: A transdiagnostic examination. *Behaviour Research and Therapy, 48*(10), 974-983.

Altamirano, L. J., Miyake, A., & Whitmer, A. J. (2010). When mental inflexibility facilitates executive control: beneficial side effects of ruminative tendencies on goal maintenance. *Psychological Science, 21*(10), 1377-1382. doi: 10.1177/0956797610381505

Armstrong, T., & Olatunji, B. O. (2012). Eye tracking of attention in the affective disorders: A meta-analytic review and synthesis. *Clinical Psychology Review, 32*(8), 704-723.

Bandura, S. A. (1993). Perceived Self-Efficacy in cognitive Development and Functioning. *Educational Psychologist, 28*(2), 117-148.

Banks, M. V., & Salmon, K. (2013). Reasoning about the self in positive and negative ways: Relationship to psychological functioning in young adulthood. *Memory, 21*(1), 10-26.

Beck, A. T., & Beck, R. W. (1972). Screening depressed patients in family practice: A rapid technic. *Postgraduate Medicine, 52*(6), 81-85.

Beck, A. T., Steer, R. A., & Brown, G. (1996a). *Manual for Beck Depression Inventory II (BDI-II)*. San Antonio, TX: Psychology Corporation.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996b). *Manual for the Beck Depression Inventory* (2 ed.). San Antonio, TX: The Psychological Association.

Beilock, S. L., Rydell, R. J., & McConnell, A. R. (2007). Stereotype threat and working memory: mechanisms, alleviation, and spillover. *Journal of Experimental Psychology: General, 136*(2), 256-276. doi: 10.1037/0096-3445.136.2.256

Berman, M. G., Peltier, S., Nee, D. E., Kross, E., Deldin, P. J., & Jonides, J. (2010). Depression, rumination and the default mode network. *Social Cognitive and Affective Neuroscience, 6*(5), 548-555. doi: 10.1093/scan/nsq080

Bernblum, R., & Mor, N. (2010). Rumination and emotion-related biases in refreshing information. *Emotion, 10*(3), 423-432. doi: 10.1037/a0018427

Binder, J. R., Desai, R. H., Graves, W. W., & Conant, L. L. (2009). Where is the semantic system? A critical review and meta-analysis of 120 functional neuroimaging studies. *Cerebral Cortex, 19*(12), 2767-2796. doi: 10.1093/cercor/bhp055

Borkovec, T. D., Hazlett-Stevens, H., & Diaz, M. L. (1999). The role of positive beliefs about worry in generalized anxiety disorder and its treatment. *Clinical Psychology & Psychotherapy, 6*(2), 126-138. doi: 10.1002/(SICI)1099-0879(199905)6:2<126::AID-CPP193>3.0.CO;2-M

Borkovec, T. D., Robinson, E., Pruzinsky, T., & DePree, J. A. (1983). Preliminary exploration of worry: Some characteristics and processes. *Behaviour Research and Therapy, 21*(1), 9-16.

Butterfield, B., & Mangels, J. A. (2003). Neural correlates of error detection and correction in a semantic retrieval task. *Cognitive Brain Research, 17*(3), 793-817.

Caseras, X., Garner, M., Bradley, B. P., & Mogg, K. (2007). Biases in visual orienting to negative and positive scenes in dysphoria: An eye movement study. *Journal of Abnormal Psychology, 116*(3), 491-497.

Chua, E. F., Hannula, D. E., & Ranganath, C. (2012). Distinguishing highly confident accurate and inaccurate memory: Insights about relevant and irrelevant influences on memory confidence. *Memory, 20*(1), 48-62.

Ciarocco, N. J., Vohs, K. D., & Baumeister, R. F. (2010). Some good news about rumination: Task-focused thinking after failure facilitates performance improvement. *Journal of Social and Clinical Psychology, 29*(10), 1057-1073. doi: 10.1521/jscp.2010.29.10.1057

Codispoti, M., Ferrari, V., & Bradley, M. M. (2007). Repetition and event-related potentials: distinguishing early and late processes in affective picture perception. *Journal of Cognitive Neuroscience, 19*(4), 577-586. doi: 10.1162/jocn.2007.19.4.577

Cohen, G. L., & Sherman, D. K. (2014). The psychology of change: Self-affirmation and social psychological intervention. *Annual Review of Psychology, 65*, 333-371.

Cooney, R. E., Joormann, J., Eugène, F., Dennis, E. L., & Gotlib, I. H. (2010). Neural correlates of rumination in depression. *Cognitive, Affective, & Behavioral Neuroscience, 10*(4), 470-478.

Cuthbert, B. N., Schupp, H. T., Bradley, M. M., Birbaumer, N., & Lang, P. J. (2000). Brain potentials in affective picture processing: covariation with autonomic arousal and affective report. *Biological Psychology, 52*(2), 95-111.

Daches, S., Mor, N., Winquist, J., & Gilboa-Schechtman, E. (2010). Brooding and attentional control in processing self-relevant information: Evidence from a modified Garner task. *Cognition & Emotion, 24*(5), 876-885. doi:10.1080/02699930902954825

Dampuré, J., Ros, C., Rouet, J.-F., & Vibert, N. (2014). Task-dependent sensitisation of perceptual and semantic processing during visual search for words. *Journal of Cognitive Psychology, 26*(5), 530-549.

Davis, R. N., & Nolen-Hoeksema, S. (2000). Cognitive inflexibility among ruminators and nonruminators. *Cognitive Therapy and Research, 24*(6), 699-711.

De Lissnyder, E., Derakshan, N., De Raedt, R., & Koster, E. H. (2011). Depressive symptoms and attentional control in a mixed antisaccade task: Specific effects of rumination. *Cognition & Emotion, 25*, 886-897. doi: 10.1080/02699931.2010.514711

De Lissnyder, E., Koster, E. H., Derakshan, N., & De Raedt, R. (2010). The association between depressive symptoms and executive control impariments in response to emotional and non-emotional information. *Cognition & Emotion, 24*, 264-280. doi: 10.1080/02699930903378354

De Lissnyder, E., Koster, E. H., Goubert, L., Onraedt, T., Vanderhasselt, M. A., & De Raedt, R. (2012). Cognitive control moderates the association between stress and rumination. *Journal of Behavior Therapy and Experimental Psychiatry, 43*(1), 519-525. doi: 10.1016/j.jbtep.2011.07.004

Deyo, M., Wilson, K. A., Ong, J., & Koopman, C. (2009). Mindfulness and rumination: does mindfulness training lead to reductions in the ruminative thinking associated with depression? *EXPLORE: The Journal of Science and Healing, 5*(5), 265-271.

Dolan, R. J. (2002). Emotion, cognition, and behavior. *Science, 298*(5596), 1191-1194. doi: 10.1126/science.1076358

Donaldson, C., Lam, D., & Mathews, A. (2007). Rumination and attention in major depression. *Behaviour Research and Therapy, 45*(11), 2664-2678. doi: 10.1016/j.brat.2007.07.002

Duchowski, A. T. (2007). *Eye tracking methodology: Theory and practice.* London, UK: Springer-Verlag.

Duckworth, A. L., Peterson, C., Matthews, M. D., Kelly, D. R. (2007). Grit: Perseverence and passion for long-term goals. *Personality Processes and Individual Differences, 92*(6), 1087-1101.

Duque, A., Sanchez, A., & Vazquez, C. (2014). Gaze-fixation and pupil dilation in the processing of emotional faces: The role of rumination. *Cognition & Emotion, 28*(8), 1347-1366.

Duque, A., & Vázquez, C. (2015). Double attention bias for positive and negative emotional faces in clinical depression: Evidence from an eye-tracking study. *Journal of Behavior Therapy and Experimental Psychiatry, 46*, 107-114.

Elliot, A. J., Maier, M. A., Binser, M. J., Friedman, R., & Pekrun, R. (2009). The effect of red on avoidance behavior in achievement contexts. *Personality and Social Psychology Bulletin, 35*(3), 365-375.

Elliot, A. J., Maier, M. A., Moller, A. C., Friedman, R., & Meinhardt, J. (2007). Color and psychological functioning: The effect of red on performance attainment. *Journal of Experimental Psychology: General, 136*(1), 154-168.

Fang, L., Sanchez, A., & Koster, E. H. W. (2017). Testing the attentional scope model of rumination: An eye-tracking study using the moving window paradigm. *Biological Psychology, 123*, 278-285.

Foti, D., & Hajcak, G. (2008). Deconstructing reappraisal: descriptions preceding arousing pictures modulate the subsequent neural response. *Journal of Cognitive Neuroscience, 20*(6), 977-988. doi: 10.1162/jocn.2008.20066

Frattaroli, J. (2006). Experimental disclosure and its moderators: a meta-analysis. *Psychological Bulletin, 132*(6), 823-865.

Frijda, N. H. (1988). The laws of emotion. *American Psychologist, 43*(5), 349-358.

Garner, M., Mogg, K., & Bradley, B. P. (2006). Orienting and maintenance of gaze to facial expressions in social anxiety. *Journal of Abnormal Psychology, 115*(4), 760-770.

Gernsbacher, M. A. (1984). Resolving 20 years of inconsistent interactions between lexical familiarity and orthography, concreteness, and polysemy. *Journal of Experimental Psychology: General, 113*(2), 256-281.

Gordon, B. (1985). Subjective frequency and the lexical decision latency function: Implications for mechanisms of lexical access. *Journal of Memory and Language, 24*(6), 631-645.

Gortner, E.-M., Rude, S. S., & Pennebaker, J. W. (2006). Benefits of expressive writing in lowering rumination and depressive symptoms. *Behavior Therapy, 37*(3), 292-303.

Gotlib, I. H., & Joormann, J. (2010). Cognition and depression: current status and future directions. *Annual Review of Clinical Psychology, 6*, 285-312.

Greicius, M. D., Krasnow, B., Reiss, A. L., & Menon, V. (2003). Functional connectivity in the resting brain: a network analysis of the default mode hypothesis. *Proceedings of the National Academy of Sciences of the United States of America, 100*(1), 253-258. doi: 10.1073/pnas.0135058100

Grol, M., Hertel, P. T., Koster, E. H. W., & De Raedt, R. (2015). The effects of rumination induction on attentional breadth for self-related information. *Clinical Psychological Science, 3*(4), 607-618.

Hajcak, G., Dunning, J. P., & Foti, D. (2009). Motivated and controlled attention to emotion: time-course of the late positive potential. *Clinical Neurophysiology, 120*(3), 505-510. doi: 10.1016/j.clinph.2008.11.028

Hajcak, G., MacNamara, A., & Olvet, D. M. (2010). Event-related potentials, emotion, and emotion regulation: an integrative review. *Developmental Neuropsychology, 35*(2), 129-155. doi: 10.1080/87565640903526504

Hajcak, G., Moser, J. S., Holroyd, C. B., & Simons, R. F. (2006). The feedback-related negativity reflects the binary evaluation of good versus bad outcomes. *Biological Psychology, 71*(2), 148-154. doi: 10.1016/j.biopsycho.2005.04.001

Hajcak, G., Moser, J. S., & Simons, R. F. (2006). Attending to affect: appraisal strategies modulate the electrocortical response to arousing pictures. *Emotion, 6*(3), 517-522. doi: 10.1037/1528-3542.6.3.517

Hajcak, G., & Olvet, D. M. (2008). The persistence of attention to emotion: brain potentials during and after picture presentation. *Emotion, 8*(2), 250-255. doi: 10.1037/1528-3542.8.2.250

Hamilton, J. P., Furman, D. J., Chang, C., Thomason, M. E., Dennis, E., & Gotlib, I. H. (2011). Default-mode and task-positive network activity in major depressive disorder: implications for adaptive and maladaptive rumination. *Biological Psychiatry, 70*(4), 327-333.

Hannula, D. E., Althoff, R. R., Warren, D. E., Riggs, L., Cohen, N. J., & Ryan, J. D. (2010). Worth a glance: using eye movements to investigate the cognitive neuroscience of memory. *Frontiers in Human Neuroscience, 8*(4), 166-182.

Hansen, D. W., & Ji, Q. (2010). In the eye of the beholder: A survey of models for eyes and gaze. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 32*(3), 478-500.

Hertel, P. (2004). Memory for Emotional and Nonemotional Events in Depression: A Question of Habit? In D. Reisberg & P. Hertel (Eds.) *Series in affective science. Memory and Emotion* (pp. 186-216) New York, NY, US: Oxford University Press.

Hertel, P. T., Benbow, A. A., & Geraerts, E. (2012). Brooding deficits in memory: Focusing attention improves subsequent recall. *Cognition & Emotion, 26*(8), 1516-1525.

Holm, S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics*, *6*(2), 65-70.

Holroyd, C. B., & Coles, M. G. (2002). The neural basis of human error processing: reinforcement learning, dopamine, and the error-related negativity. *Psychological Review, 109*(4), 679-709.

Holroyd, C. B., Pakzad-Vaezi, K. L., & Krigolson, O. E. (2008). The feedback correct-related positivity: Sensitivity of the event-related brain potential to unexpected positive feedback. *Psychophysiology, 45*(5), 688-697.

Hunt, A. R., & Kingstone, A. (2003). Covert and overt voluntary attention: linked or independent? *Cognitive Brain Research, 18*(1), 102-105.

Jain, S., Shapiro, S. L., Swanick, S., Roesch, S. C., Mills, P. J., Bell, I., & Schwartz, G. E. R. (2007). A randomized controlled trial of mindfulness meditation versus relaxation training: effects on distress, positive states of mind, rumination, and distraction. *Annals of Behavioral Medicine, 33*(1), 11-21.

Johnson, D. P., & Whisman, M. A. (2013). Gender differences in rumination: A meta-analysis. *Personality and Individual Differences, 55*(4), 367-374. doi: 10.1016/j.paid.2013.03.019

Johnson, M. K., Nolen-Hoeksema, S., Mitchell, K. J., & Levin, Y. (2009). Medial cortex activity, self-reflection and depression. *Social Cognitive and Affective Neuroscience, 4*(4), 313-327.

Johnson, M. K., Raye, C. L., Mitchell, K. J., Touryan, S. R., Greene, E. J., & Nolen-Hoeksema, S. (2006). Dissociating medial frontal and posterior cingulate activity during self-reflection. *Social Cognitive and Affective Neuroscience, 1*(1), 56-64.

Johnson, R., Jr., Nessler, D., & Friedman, D. (2013). Temporally specific divided attention tasks in young adults reveal the temporal dynamics of episodic encoding failures in elderly adults. *Psychology and Aging, 28*(2), 443-456. doi: 10.1037/a0030967

Joormann, J. (2006). Differential effects of rumination and dysphoria on the inhibition of irrelevant emotional material: Evidence from a negative priming task. *Cognitive Therapy and Research, 30*(2), 149-160.

Just, M. A., & Carpenter, P. A. (1976). Eye fixations and cognitive processes. *Cognitive Psychology, 8*(4), 441-480.

Kang, M. J., Hsu, M., Krajbich, I. M., Loewenstein, G., McClure, S. M., Wang, J. T.-y., & Camerer, C. F. (2009). The wick in the candle of learning: Epistemic curiosity activates reward circuitry and enhances memory. *Psychological Science, 20*(8), 963-973.

Kellough, J. L., Beevers, C. G., Ellis, A. J., & Wells, T. T. (2008). Time course of selective attention in clinically depressed young adults: An eye tracking study. *Behaviour Research and Therapy, 46*(11), 1238-1243.

Key, B. L., Campbell, T. S., Bacon, S. L., & Gerin, W. (2008). The influence of trait and state rumination on cardiovascular recovery from a negative emotional stressor. *Journal of Behavioral Medicine, 31*(3), 237-248.

Kluger, A. N., & DeNisi, A. (1996). The effects of feedback interventions on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory. *Psychological Bulletin, 119*(2), 254-284.

Koster, E. H., De Lissnyder, E., Derakshan, N., & De Raedt, R. (2011). Understanding depressive rumination from a cognitive science perspective: the impaired disengagement hypothesis. *Clinical Psychology Review, 31*(1), 138-145. doi: 10.1016/j.cpr.2010.08.005

Krahé, C., Mathews, A., Whyte, J., & Hirsch, C. R. (2016). Cognitive bias modification for interpretation with and without prior repetitive negative thinking to reduce worry and rumination in generalised anxiety disorder and depression: protocol for a multisession experimental study with an active control condition. *BMJ open, 6*(12), e013404.

Kutas, M., & Federmeier, K. D. (2000). Electrophysiology reveals semantic memory use in language comprehension. *Trends in Cognitive Sciences, 4*(12), 463-470.

Lassiter, G. D., Pezzo, M. V., & Apple, K. J. (1993). The Transmitter-Persistence Effect: A Confounded Discovery? *Psychological Science, 4*(3), 208-210.

Levens, S. M., Muhtadie, L., & Gotlib, I. H. (2009). Rumination and impaired resource allocation in depression. *Journal of Abnormal Psychology, 118*(4), 757-766.

Light, J., & Isaacowitz, D. (2006). The effect of developmental regulation on visual attention: The example of the" biological clock". *Cognition & Emotion, 20*(5), 623-645.

Lilgendahl, J. P., McLean, K. C., & Mansfield, C. D. (2013). When is meaning making unhealthy for the self? The roles of neuroticism, implicit theories, and memory telling in trauma and transgression memories. *Memory, 21*(1), 79-96.

Lyubomirsky, S., Caldwell, N. D., & Nolen-Hoeksema, S. (1998). Effects of ruminative and distracting responses to depressed mood on retrieval of autobiographical memories. *Journal of Personality and Social Psychology, 75*(1), 166-177.

Lyubomirsky, S., Kasri, F., & Zehm, K. (2003). Dysphoric rumination impairs concentration on academic tasks. *Cognitive Therapy and Research, 27*(3), 309-330.

Lyubomirsky, S., & Nolen-Hoeksema, S. (1993). Self-perpetuating properties of dysphoric rumination. *Journal of Personality and Social Psychology, 65*(2), 339-349.

Lyubomirsky, S., & Nolen-Hoeksema, S. (1995). Effects of self-focused rumination on negative thinking and interpersonal problem solving. *Journal of Personality and Social Psychology, 69*(1), 176-190.

Lyubomirsky, S., Sousa, L., & Dickerhoof, R. (2006). The costs and benefits of writing, talking, and thinking about life's triumphs and defeats. *Journal of Personality and Social Psychology, 90*(4), 692-708.

Lyubomirsky, S., Tucker, K. L., Caldwell, N. D., & Berg, K. (1999). Why ruminators are poor problem solvers: Clues from the phenomenology of dysphoric rumination. *Journal of Personality and Social Psychology, 77*(5), 1041-1060.

Maloney, E. A., & Beilock, S. L. (2012). Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in Cognitive Sciences, 16*(8), 404-406.

Mangels, J. A., Butterfield, B., Lamb, J., Good, C., & Dweck, C. S. (2006). Why do beliefs about intelligence influence learning success? A social cognitive neuroscience model. *Social Cognitive and Affective Neuroscience, 1*(2), 75-86. doi: 10.1093/scan/nsl013

Mangels, J. A., Good, C., Whiteman, R. C., Maniscalco, B., & Dweck, C. S. (2012). Emotion blocks the path to learning under stereotype threat. *Social Cognitive and Affective Neuroscience, 7*(2), 230-241. doi: 10.1093/scan/nsq100

Mangels, J. A., Hoxha, O., Lane, S. P., Jarvis, S. N., & Downey, G. (2018). Evidence that disrupted orienting to evaluative social feedback undermines error correction in rejection sensitive women. *Social Neuroscience, 13*(4), 451-470.

Mangels, J. A., Picton, T. W., & Craik, F. I. (2001). Attention and successful episodic encoding: an event-related potential study. *Cognitive Brain Research, 11*(1), 77-95.

Mangels, J. A., Rodriguez, S., Ochakovskaya, Y., & Guerra-Carrillo, B. (2017). Achievement goal task framing and fit with personal goals modulate the neurocognitive response to corrective feedback. *AERA Open, 3*(3), 2332858417720875.

Marco-Pallares, J., Kramer, U. M., Strehl, S., Schroder, A., & Munte, T. F. (2010). When decisions of others matter to me: an electrophysiological analysis. *BMC Neurosci, 11*, 86. doi: 10.1186/1471-2202-11-86

Marin, K. A., & Rotondo, E. K. (2017). Rumination and self-reflection in stress narratives and relations to psychological functioning. *Memory, 25*(1), 44-56.

Martin, L., & Tesser, A. (1989). Toward a motivational and structural theory of ruminative thought. In J. S. Uleman, Bargh, J. A. (Ed.), *Unintened Thought* (pp. 306-326). New York: Guilford.

Martin, L., & Tesser, A. (1996). Some ruminative thoughts. In R. S. Wyer, Jr. (Ed.), *Advances in social cognition, Vol. 9. Ruminative thoughts,* (pp. 1-47). Hillsdale, NJ, US: Lawrence Erlbaum Associates, Inc..

Martin, L. L. (1986). Set / reset: Use and disuse of concepts in impression formation. *Journal of Personality and Social Psychology, 51*, 493-504.

McAdams, D. P., & McLean, K. C. (2013). Narrative identity. *Current Directions in Psychological Science, 22*(3), 233-238.

McIntosh, W. D., & Martin, L. L. (1992). The cybernetics of happiness: The relation betewen goal attainment, rumination, and affect. In M. S. Clark (Ed.), *Review of Personality and Social Psychology* (Vol. 14, pp. 222-246). Newbury Park, CA: Sage.

McLaughlin, K. A., Borkovec, T. D., & Sibrava, N. J. (2007). The effects of worry and rumination on affect states and cognitive activity. *Behavior Therapy, 38*(1), 23-38. doi: 10.1016/j.beth.2006.03.003

McLaughlin, K. A., & Nolen-Hoeksema, S. (2011). Rumination as a transdiagnostic factor in depression and anxiety. *Behaviour Research and Therapy, 49*(3), 186-193.

McRae, K., Hughes, B., Chopra, S., Gabrieli, J. D. E., Gross, J. J., & Ochsner, K. N. (2010). The neural bases of distraction and reappraisal. *Journal of Cognitive Neuroscience, 22*(2), 248-262.

Metcalfe, J. (2017). Learning from errors. *Annual Review of Psychology, 68*, 465-489.

Mezulis, A. H., Abramson, L. Y., & Hyde, J. S. (2002). Domain specificity of gender differences in rumination. *Journal of Cognitive Psychotherapy, 16*(4), 421-434.

Miltner, W. H., Braun, C. H., & Coles, M. G. (1997). Event-related brain potentials following incorrect feedback in a time-estimation task: evidence for a "generic" neural system for error detection. *Journal of Cognitive Neuroscience, 9*(6), 788-798. doi: 10.1162/jocn.1997.9.6.788

Moberly, N. J., & Watkins, E. R. (2008). Ruminative self-focus and negative affect: an experience sampling study. *Journal of Abnormal Psychology, 117*(2), 314-323.

Moberly, N. J., & Watkins, E. R. (2010). Negative affect and ruminative self-focus during everyday goal pursuit. *Cognition & Emotion, 24*(4), 729-739.

Mogg, K., & Bradley, B. P. (2005). Attentional bias in generalized anxiety disorder versus depressive disorder. *Cognitive Therapy and Research, 29*(1), 29-45.

Moser, J. S., Hajcak, G., Bukay, E., & Simons, R. F. (2006). Intentional modulation of emotional responding to unpleasant pictures: an ERP study. *Psychophysiology, 43*(3), 292-296. doi: 10.1111/j.1469-8986.2006.00402.x

Nessler, D., Johnson, R., Jr., Bersick, M., & Friedman, D. (2006). On why the elderly have normal semantic retrieval but deficient episodic encoding: a study of left inferior frontal ERP activity. *Neuroimage, 30*(1), 299-312. doi: 10.1016/j.neuroimage.2005.09.005

Nieuwenhuis, S., Slagter, H. A., Geusau, V., Alting, N. J., Heslenfeld, D. J., & Holroyd, C. B. (2005). Knowing good from bad: differential activation of human cortical areas by positive and negative outcomes. *European Journal of Neuroscience, 21*(11), 3161-3168.

Nobre, A. C., & McCarthy, G. (1995). Language-related field potentials in the anterior-medial temporal lobe: II. Effects of word type and semantic priming. *Journal of Neuroscience, 15*(2), 1090-1098.

Nolen-Hoeksema, S. (1987). Sex differences in unipolar depression: evidence and theory. *Psychological Bulletin, 101*(2), 259-282.

Nolen-Hoeksema, S. (1990). *Sex differences in depression*: Stanford University Press.

Nolen-Hoeksema, S. (1991). Responses to depression and their effects on the duration of depressive episodes. *Journal of Abnormal Psychology, 100*(4), 569-582.

Nolen-Hoeksema, S. (1996). Chewing the cud and other ruminations. In R. S. Wyer, Jr. (Ed.), *Advances in social cognition, Vol. 9. Ruminative thoughts,* (pp. 135-144). Hillsdale, NJ, US: Lawrence Erlbaum Associates, Inc.

Nolen-Hoeksema, S., & Jackson, B. (2001). Mediators of the gender difference in rumination. *Psychology of Women Quarterly, 25*(1), 37-47.

Nolen-Hoeksema, S., Larson, J., & Grayson, C. (1999). Explaining the gender difference in depressive symptoms. *Journal of Personality and Social Psychology, 77*(5), 1061-1072.

Nolen-Hoeksema, S., & Morrow, J. (1991). A prospective study of depression and posttraumatic stress symptoms after a natural disaster: the 1989 Loma Prieta Earthquake. *Journal of Personality and Social Psychology, 61*(1), 115-121.

Nolen-Hoeksema, S., & Morrow, J. (1993). Effects of rumination and distraction on naturally occurring depressed mood. *Cognition & Emotion, 7*(6), 561-570.

Nolen-Hoeksema, S., Morrow, J., & Fredrickson, B. L. (1993). Response styles and the duration of episodes of depressed mood. *Journal of Abnormal Psychology, 102*(1), 20-28.

Nolen-Hoeksema, S., Parker, L. E., & Larson, J. (1994). Ruminative coping with depressed mood following loss. *Journal of Personality and Social Psychology, 67*(1), 92-104.

Nolen-Hoeksema, S., & Watkins, E. R. (2011). A heuristic for developing transdiagnostic models of psychopathology: Explaining multifinality and divergent trajectories. *Perspectives on Psychological Science, 6*(6), 589-609.

Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking Rumination. *Perspectives on Psychological Science, 3*(5), 400-424. doi: 10.1111/j.1745-6924.2008.00088.x

Olvet, D. M., & Hajcak, G. (2009). The stability of error-related brain activity with increasing trials. *Psychophysiology, 46*(5), 957-961. doi: PSYP848 [pii]

10.1111/j.1469-8986.2009.00848.x

Owens, M., & Gibb, B. E. (2017). Brooding rumination and attentional biases in currently non-depressed individuals: an eye-tracking study. *Cognition and Emotion, 31*(5), 1062-1069.

Paller, K. A., & Wagner, A. D. (2002). Observing the transformation of experience into memory. *Trends in Cognitive Sciences, 6*(2), 93-102.

Pazzaglia, A. M., Staub, A., & Rotello, C. M. (2014). Encoding time and the mirror effect in recognition memory: Evidence from eyetracking. *Journal of Memory and Language, 75*, 77-92.

Pennebaker, J. W. (1997). Writing about emotional experiences as a therapeutic process. *Psychological Science, 8*(3), 162-166.

Pessoa, L. (2010). Emergent processes in cognitive-emotional interactions. *Dialogues in Clinical Neuroscience, 12*(4), 433-448.

Pyszczynski, T., & Greenberg, J. (1987). Self-regulatory perseveration and the depressive self-focusing style: a self-awareness theory of reactive depression. *Psychological Bulletin, 102*(1), 122-138.

Raes, F., Watkins, E. R., Williams, J. M. G., & Hermans, D. (2008). Non-ruminative processing reduces overgeneral autobiographical memory retrieval in students. *Behaviour Research and Therapy, 46*(6), 748-756.

Ramirez, G., & Beilock, S. L. (2011). Writing about testing worries boosts exam performance in the classroom. *Science, 331*(6014), 211-213.

Ray, R. D., Ochsner, K. N., Cooper, J. C., Robertson, E. R., Gabrieli, J. D., & Gross, J. J. (2005). Individual differences in trait rumination and the neural systems supporting cognitive reappraisal. *Cognitive, Affective, & Behavioral Neuroscience, 5*(2), 156-168.

Rayner, K. (1979). Eye guidance in reading: Fixation locations within words. *Perception, 8*(1), 21-30.

Rayner, K. (1984). Visual selection in reading, picture perception, and visual-search: a tutorial review. *Attention and Performance, 10*, 67-96.

Rayner, K., & Duffy, S. A. (1986). Lexical complexity and fixation times in reading: Effects of word frequency, verb complexity, and lexical ambiguity. *Memory & Cognition, 14*(3), 191-201.

Reichle, E. D., Rayner, K., & Pollatsek, A. (2003). The EZ Reader model of eye-movement control in reading: Comparisons to other models. *Behavioral and Brain Sciences, 26*(4), 445-476.

Reichle, E. D., Reineberg, A. E., & Schooler, J. W. (2010). Eye movements during mindless reading. *Psychological Science, 21*(9), 1300-1310.

Roberts, H., Watkins, E. R., & Wills, A. J. (2013). Cueing an unresolved personal goal causes persistent ruminative self-focus: An experimental evaluation of control theories of rumination. *Journal of Behavior Therapy and Experimental Psychiatry, 44*(4), 449-455.

Rosenbaum, D., Haipt, A., Fuhr, K., Haeussinger, F. B., Metzger, F. G., Nuerk, H.-C., . . . Ehlis, A.-C. (2017). Aberrant functional connectivity in depression as an index of state and trait rumination. *Scientific Reports, 7*(1), 2174.

Sabatinelli, D., Lang, P. J., Keil, A., & Bradley, M. M. (2007). Emotional perception: correlation of functional MRI and event-related potentials. *Cerebral Cortex, 17*(5), 1085-1091.

Sakamoto, S., Kambara, M., Tanno, Y. (2001). Response styles and cognitive and affective symptoms of depression. *Personality and Individual Differences, 31*(7), 1053-1065. doi: 10.1016/S0191-8869(00)00203-8

San Martín, R. (2012). Event-related potential studies of outcome processing and feedback-guided learning. *Frontiers in Human Neuroscience, 7*(6), 304.

Santesso, D. L., Steele, K. T., Bogdan, R., Holmes, A. J., Deveney, C. M., Meites, T. M., & Pizzagalli, D. A. (2008). Enhanced negative feedback responses in remitted depression. *Neuroreport, 19*(10), 1045-1048.

Sarin, S., Abela, J. R., & Auerbach, R. P. (2005). The response styles theory of depression: a test of specificity and causal mediation. *Cognition & Emotion, 19*(5), 751-761.

Schmader, T., Johns, M., & Forbes, C. (2008). An integrated process model of stereotype threat effects on performance. *Psychological Review, 115*(2), 336-356. doi: 10.1037/0033-295X.115.2.336

Schupp, H., Cuthbert, B., Bradley, M., Hillman, C., Hamm, A., & Lang, P. (2004). Brain processes in emotional perception: Motivated attention. *Cognition & Emotion, 18*(5), 593-611. doi: 10.1080/02699930341000239

Schupp, H. T., Junghofer, M., Weike, A. I., & Hamm, A. O. (2004). The selective processing of briefly presented affective pictures: an ERP analysis. *Psychophysiology, 41*(3), 441-449. doi: 10.1111/j.1469-8986.2004.00174.x

Seeley, S. H., Yanez, B., Stanton, A. L., & Hoyt, M. A. (2017). An emotional processing writing intervention and heart rate variability: the role of emotional approach. *Cognition & Emotion, 31*(5), 988-994.

Sharot, T., Riccardi, A. M., Raio, C. M., & Phelps, E. A. (2007). Neural mechanisms mediating optimism bias. *Nature, 450*(7166), 102-105.

Shatzman, K. B., & McQueen, J. M. (2006). Segment duration as a cue to word boundaries in spoken-word recognition. *Perception & Psychophysics, 68*(1), 1-16.

Siegle, G. J., Steinhauer, S. R., Thase, M. E., Stenger, V. A., & Carter, C. S. (2002). Can't shake that feeling: event-related fMRI assessment of sustained amygdala activity in response to emotional information in depressed individuals. *Biological Psychiatry, 51*(9), 693-707.

Simons, R. F. (2010). The way of our errors: theme and variations. *Psychophysiology, 47*(1), 1-14. doi: 10.1111/j.1469-8986.2009.00929.x

Sloan, D. M., Marx, B. P., Epstein, E. M., & Dobbs, J. L. (2008). Expressive writing buffers against maladaptive rumination. *Emotion, 8*(2), 302-306.

Smallwood, J., & Schooler, J. W. (2006). The restless mind. *Psychological Bulletin, 132*(6), 946-958.

Southworth, F., Grafton, B., MacLeod, C., & Watkins, E. (2017). Heightened ruminative disposition is associated with impaired attentional disengagement from negative relative to positive information: support for the "impaired disengagement" hypothesis. *Cognition & Emotion, 31*(3), 422-434.

Staub, A., White, S. J., Drieghe, D., Hollway, E. C., & Rayner, K. (2010). Distributional effects of word frequency on eye fixation durations. *Journal of Experimental Psychology: Human Perception and Performance, 36*(5), 1280-1293.

Stern, E. R., & Mangels, J. A. (2006). An electrophysiological investigation of preparatory attentional control in a spatial Stroop task. *Journal of Cognitive Neuroscience, 18*(6), 1004-1017. doi: 10.1162/jocn.2006.18.6.1004

Teasdale, J. D., Segal, Z. V., Williams, J. M. G., Ridgeway, V. A., Soulsby, J. M., & Lau, M. A. (2000). Prevention of relapse/recurrence in major depression by mindfulness-based cognitive therapy. *Journal of Consulting and Clinical Psychology, 68*(4), 615-623.

Thayer, J., & Johnsen, B. H. (2000). Sex differences in judgement of facial affect: A multivariate analysis of recognition errors. *Scandinavian Journal of Psychology, 41*(3), 243-246.

Thayer, J. F., Rossy, L. A., Ruiz-Padial, E., & Johnsen, B. H. (2003). Gender differences in the relationship between emotional regulation and depressive symptoms. *Cognitive Therapy and Research, 27*(3), 349-364.

Treynor, W., Gonzalez, R., & Nolen-Hoeksema, S. (2003). Rumination reconsidered: A psychometric analysis. *Cognitive Therapy Ressearch, 27*, 247-259. doi: 10.1023/A:1023910315561

Tucker, D. M., Luu, P., Frishkoff, G., Quiring, J., & Poulsen, C. (2003). Frontolimbic response to negative feedback in clinical depression. *Journal of Abnormal Psychology, 112*(4), 667-678. doi: 10.1037/0021-843X.112.4.667

Vanderhasselt, M. A., Kuhn, S., & De Raedt, R. (2011). Healthy brooders employ more attentional resources when disengaging from the negative: an event-related fMRI study. *Cognitive, Affective, & Behavioral Neuroscience, 11*(2), 207-216. doi: 10.3758/s13415-011-0022-5

Watkins, E., & Baracaia, S. (2001). Why do people ruminate in dysphoric moods? *Personality and Individual Differences, 30*(5), 723-734.

Watkins, E., & Brown, R. G. (2002). Rumination and executive function in depression: An experimental study. *Journal of Neurology, Neurosurgery & Psychiatry, 72*(3), 400-402.

Watkins, E., Grafton, B., Weinstein, S. M., & MacLeod, C. (2015). For ruminators, the emotional future is bound to the emotional past: heightened ruminative disposition is characterized by increased emotional extrapolation. *Clinical Psychological Science, 3*(4), 648-658.

Watkins, E. D., & Moulds, M. (2005). Distinct modes of ruminative self-focus: impact of abstract versus concrete rumination on problem solving in depression. *Emotion, 5*(3), 319-328.

Watkins, E. D., & Teasdale, J. D. (2001). Rumination and overgeneral memory in depression: effects of self-focus and analytic thinking. *Journal of Abnormal Psychology, 110*(2), 353-357.

Watkins, E. D., Teasdale, J. D., & Williams, R. M. (2000). Decentring and distraction reduce overgeneral autobiographical memory in depression. *Psychological Medicine, 30*(4), 911-920.

Watkins, E. R. (2008). Constructive and unconstructive repetitive thought. *Psychological Bulletin, 134*(2), 163-206. doi: 10.1037/0033-2909.134.2.163

Watkins, E. R. (2011). Dysregulation in level of goal and action identification across psychological disorders. *Clinical Psychology Review, 31*(2), 260-278. doi: 10.1016/j.cpr.2010.05.004

Watkins, E. R., & Nolen-Hoeksema, S. (2014). A habit-goal framework of depressive rumination. *Journal of Abnormal Psychology, 123*(1), 24-34.

Weinberg, A., & Hajcak, G. (2011). The late positive potential predicts subsequent interference with target processing. *Journal of Cognitive Neuroscience, 23*(10), 2994-3007.

Weinberg, A., Hilgard, J., Bartholow, B. D., & Hajcak, G. (2012). Emotional targets: evaluative categorization as a function of context and content. *International Journal of Psychophysiology, 84*(2), 149-154.

Whiteman, R. C., & Mangels, J. A. (2016). Rumination and Rebound from Failure as a Function of Gender and Time on Task. *Brain Sciences, 6*(1), 7; https://doi.org/10.3390/brainsci6010007

Whitmer, A. J., & Banich, M. T. (2007). Inhibition versus switching deficits in different forms of rumination. *Psychological Sciences, 18*(6), 546-553. doi: 10.1111/j.1467-9280.2007.01936.x

Whitmer, A. J., & Banich, M. T. (2010). Trait rumination and inhibitory deficits in long-term memory. *Cognition & Emotion, 24*(1), 168-179.

Whitmer, A. J., & Gotlib, I. H. (2013). An attentional scope model of rumination. *Psychological Bulletin, 139*(5), 1036-1061. doi: 10.1037/a0030923

Yang, Q., Gu, R., Tang, P., & Luo, Y. J. (2013). How does cognitive reappraisal affect the response to gains and losses? *Psychophysiology, 50*(11), 1094-1103. doi: 10.1111/psyp.12091

Zetsche, U., & Joormann, J. (2011). Components of interference control predict depressive symptoms and rumination cross-sectionally and at six months follow-up. *Journal of Behavior Therapy and Experimenal Psychiatry, 42*(1), 65-73. doi: 10.1016/j.jbtep.2010.06.001