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PROSPECTIVE MRMORY

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An Investigation of the Effects of Depressive-Rumination on Prospective Memory

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Depression is related to prospective memory (PM) impairment. However, the research on depression-related PM impairment remains inconclusive. No study to date has taken into account the possible effects of depressive-rumination, which is known to impair executive functions underlying PM. The current study addresses this gap in the literature. Participants: Participants were grouped according to self-reported depression severity per the Beck Depression Inventory-Second Edition (BDI-II). Fifty-five individuals with *low* (BDI-II $\leq$ 8), 17 individuals with *moderate* (BDI-II 9-18), and 16 individuals with *high* (BDI-II $\geq$ 19) symptoms of depression were included in the study. Method: Participants completed demographic and trait and state rumination questionnaires. Participants within each group were then randomly assigned to either a rumination or distraction condition. Following this manipulation, participants completed a modified version of the Memory for Intentions Test. Results: Regardless of depression severity, inducted state rumination had no effect on PM. In addition, depression severity was unrelated to both event- and time-based PM trials, and overall PM performance. Interestingly, trait rumination was negatively correlated with overall PM performance in the low group compared to the moderate group, wherein trait rumination was positively correlated with overall PM performance. Trait rumination was not correlated with overall PM performance in the high depressive symptom group. Conclusion: The current study failed to demonstrate depression-related PM impairment as a function of depressive-rumination. Furthermore, depression severity had no effect on overall PM performance. The positive correlation between trait rumination and overall PM performance in the moderate group offers some support for the positive benefits of rumination among people experiencing sub-clinical depression proposed by Albiński et al., 2012. Results from the current study should be interpreted with caution given the small sample size and low statistical power. Further research is needed to elucidate the effects of depressive-rumination on PM.

People make plans to achieve challenging goals, meet important deadlines, attend appointments, and many other significant or mundane undertakings situated in the future. Such plans and intentions illustrate a form of remembering known as *prospective memory* (PM). Prospective memory refers to the capacity to make and execute plans at a future point in time.

Event- and Time-Based Prospective Memory

Prospective memory tasks take one of two forms—event- and time-based—that can be distinguished by the type of environmental cues that indicate whether it is appropriate to complete a previously formed intention. Event-based PM cues represent situations where the intention to remember is embedded within the context of the task at hand. For example, in laboratory settings, a person may be asked to perform a particular action (e.g., press a red key) when a distinct event occurs (e.g., the presence of a specific word) while he or she rates a series of words presented on a computer screen (e.g., Kliegel, Martin, McDaniel, & Einstein, 2001). In naturalistic or everyday settings, event-based PM may be conceptualized as remembering to relay a message to a co-worker the next time this co-worker is encountered. Such PM tasks are considered less demanding of higher-level self-initiated processes (Einstein & McDaniel, 1990). Here, the prospective remembering operates more passively as the intention is generally recalled when a specific external stimulus is encountered.

In contrast, time-based PM cues are specific to either a particular point in time or after a certain amount of time has elapsed. Like event-based PM, time-based PM is a common everyday occurrence. For instance, college students constantly prepare for or procrastinate assignments that are due at a future point in time. The timeliness of when these assignments are submitted is critical, for students may be penalized for late submissions. Studies investigating time-based PM often ask people to perform a specified action at different time intervals (e.g., after two minutes) or at a specific time during the day (e.g., five o'clock). Regardless of the events and times associated with PM, this aspect of memory is distinct from, though not entirely independent of, retrospective memory—the related capacity to recall past events and experiences (Burgess & Shallice, 1997; Einstein & McDaniel, 1990; Kvavilashvili, 1987).

Prospective and Retrospective Memory

Successful PM requires both the remembrance of what actions have to be performed and when such actions are to be carried out (Einstein & McDaniel, 1996). Accessing the content of a particular memory (i.e., the *what*) represents the retrospective component of PM. Despite possessing a retrospective component, PM does not rely solely on the capacity to recall the contents of a particular memory.

What makes PM unique and distinct from retrospective memory is that the memory retrieval process is rarely prompted by external sources (Einstein & McDaniel, 1996). Retrospective remembering is elicited by an external source, which then initiates a search for some past event or experience needed for the present. For instance, a lawyer may directly question a witness about where she or he was at the time of a crime. Here, the lawyer directly prompts the witness to search for the relevant information. In contrast, prospective memory does not rely upon explicit external prompts that direct retrieval activities, such as direct questioning as in the example above. Einstein and McDaniel (1996) refer to PM as being a *spontaneous* process in the sense that it can occur without explicit guidance from external sources. This is not to say that PM is an unconscious or involuntary reaction to environmental stimuli. Rather, PM is an active self-generated process because the environmental stimuli associated with a future-orientated intention may offer relatively weak, indirect retrieval prompts. For example, event- and time-based cues, if identified as relevant to a previously formed intention, do not necessarily call the intention to mind. Instead, one often needs to search anew for a specific intention after first recalling that an intention had been made. Here, the individual may need to actively search for what is to be done in response to some meaningful cue, be it an event or a specific time. Furthermore, this active retrieval for a PM interrupts a person's stream of consciousness while he or she is engaged in some ongoing activity. This distinction has important implications for the theoretical underpinnings of PM.

In his seminal work explaining age-related deficits in memory, Craik (1986) proposed that the very nature of PM requires self-initiated mental activities given that the external cues themselves often do not lend sufficient activation of the intended action. Certain environmental cues are assumed to provide a marker of remembrance for what is to be done and when. However, such external markers are considered weak retrieval generators because they lend minimal environmental support to remember, which is why the individual must initiate the process of remembering (Craik, 1986). In addition, cues specific to time offer little, if any, memory retrieval assistance. The quality of such cues may be best conceptualized as *implicit*. In contrast, cues for retrospective memory recall are explicit and direct, increasing the efficiency of retrieval processes. Thus, according to Craik's (1986) taxonomy of memory, PM requires a greater amount of self-initiated processing of environmental cues than retrospective memory.

Prospective Memory and Executive Function

The ability to make plans intended for the future, especially those that are associated with a specific point in time, depends upon a set of mental operations known as executive functions (Gilbert & Burgess, 2008). Executive functions are higher-level cognitive processes that allow organisms to adjust behavior in light of new information and adapt to changing demands in their environments in order to optimize functioning. Examples of executive functions include behaviors ranging from overriding learned stereotyped behaviors (i.e., inhibiting learned behaviors) to developing new solutions to various problems. Whereas non-executive functions are generally thought to reflect automatic processing, executive functions are thought to reflect *controlled* mental operations. This is most apparent when a certain behavior is needed in the absence of a clear stimulus-response association and highlights the self-initiated processes of executive functioning. Given the nature of PM, specifically the absence of a memory-eliciting stimulus, PM constitutes an executive function (Gilbert & Burgess, 2008) and is in line with Craik's (1986) theory of PM, which asserts that self-initiated processing is critical for PM.

Research has consistently related executive functions to the frontal lobes of the cortex (Gilbert & Burgess, 2008). Recent research also demonstrates a relationship between frontal lobe functioning and PM performance, with low frontal lobe functioning being negatively correlated with PM performance (McFarland & Glisky, 2009; McFarland & Glisky, 2011). However, it is important to note that the term "executive function" is used liberally and is not a unitary construct (Alavares & Emory, 2006; Stuss & Alexander, 2000). In other words, evidence suggests that impairments in executive functioning depends on the nature and extent of frontal lobe damage (and other regions;

e.g., parietal lobes) as well as the executive functioning domain in question (e.g., inhibition; Alavares & Emory, 2006; Gilbert & Burgess, 2008; Stuss & Alexander, 2000). This holds true for PM research as well, which has recently localized certain aspects of PM to specific regions located in the frontal lobes (Burgess, Gonen-Yaacovi, & Volle, 2011).

Executive functioning in event- and time-based prospective memory.

Considerable evidence links event- and time-based PM performance to various aspects of executive functioning. Marsh and Hicks (1998) conducted five experiments to address the underlying cognitive processes that influence event-based PM. In their study, Marsh and Hicks (1998) noted that successful PM performance was strongly related to both monitoring and planning executive processes. For instance, participants who failed to actively monitor their performance and adapt their behavior to new environmental cues exhibited poorer event-based PM. According to Marsh and Hicks (1998) event-based PM requires, to an extent, intact executive functioning. More specifically, they argue that event-based PM relies upon central executive processing—a unique executive function system dedicated to the control and appropriate allocation of attentional resources (Baddeley, 1983, 1986). In their model, central executive processing facilitates PM through active monitoring of cue-appropriate stimuli that, when recognized, activates a search for the stored intention for PM, which is then readily brought to mind.

Similarly, McDaniel, Glisky, Rubin, Guynn, and Routhieaux (1999) found that older adults characterized as possessing low frontal lobe functioning performed more poorly on an event-based PM task. Specifically, the PM impairment in that study was related to executive functioning deficits in encoding-planning processes and the ability to inhibit responses to ongoing activities in order to perform the PM task. Regarding frontal lobe involvement, Simons, Scholvinck, Gilbert, Frith, and Burgess (2006) used fMRI to determine the locality of two key components of event-based PM—cue identification and intention retrieval (McDaniel & Einstein, 1992; as cited in Simons et al., 2006)—and found that activity in the anterior prefrontal cortex (PFC) was related to both cue identification and intention retrieval. In addition, they found that the lateral PFC may be more specific to the retrieval of the PM intention whereas the medial PFC is related to PM cue identification. The involvement of the PFC and its associated executive functions, specifically planning and cognitive flexibility, appear to play an important role in event-based PM and lend support to the *multi-phasic process model* proposed by (Kliegel, Martin, McDaniel, & Einstein, 2002).

The multi-phasic process model conceptualizes PM using four distinct components: (1) intention formation, (2) maintenance of intention, (3) initiation of intended action, and (4) execution of the intention (Kliegel et al., 2002). Each component is largely dependent upon several key aspects of executive functioning. According to this model, planning is critical for the intention formation phase of PM and is a key feature of executive functioning. Retrospective memory is most strongly related to maintaining the PM intention and was unrelated to the other measures of executive functioning, lending support for the argument that PM performance cannot be explained solely by retrospective memory. Regarding the final two components of the multi-phasic model—initiation of the intended action and execution of the intention—indices of cognitive flexibility and problem solving were both crucial for successful PM performance, with cognitive flexibility being the strongest predictor of the execution component.

In a related follow-up study investigating the involvement of frontal lobe-executive involvement in PM, Martin, Kliegel, and McDaniel (2003) found additional support for the involvement of executive functioning indices (i.e., planning, monitoring, and cognitive flexibility) in successful PM performance on both event- and time-based PM tasks among young and older adults. Furthermore, performance on measures of executive functioning served as the strongest predictor of PM performance in comparison to other potentially relevant variables such as age, education, and retrospective memory. Thus, there is strong support for a link between executive functioning and successful PM performance.

Factors Influencing Prospective Memory

Prospective memory performance can be influenced by a variety of factors. Several of these factors are thought to negatively affect PM because they place additional demands upon executive functioning. These factors include cue focality and strategic monitoring as evidenced by ongoing task performance and clock monitoring.

Cue focality.

The environmental cues associated with planned future intentions can influence the execution of future intentions. Environmental cues associated with event-based PM cues are categorized as either *focal* or *non-focal* (McDaniel & Einstein, 2000). Focal cues represent stimuli that are embedded within the design of the ongoing tasks and associated with the PM task. For example, the PM task may require participants to perform a behavior whenever the letter ‘e’ is presented in an ongoing task that requires participants to determine which of two presented words contains more vowels (e.g. Altgassen, Kliegel, & Martin, 2009). Given that the PM cue (i.e., the letter ‘e’) is embedded within and processed as part of the ongoing task, it is assumed that such cue types facilitate more automatic retrieval of the PM intention.

In contrast, non-focal cues are those that are not integral to the performance of the ongoing task. For instance, sticking with the previous example in which the ongoing task requires participants to count and compare the number of ‘e’ vowels in two simultaneously presented words, a PM task that requires participants to perform a specific behavior when one of the words is a verb would represent a non-focal cue. Because successful execution of the ongoing task (i.e., counting vowels) does not require semantic processing (i.e., distinguishing verbs from nouns or adjectives), identification and classification of a word as a verb demands additional unrelated processing. For that reason, such cues are assumed to draw upon more strategic attentional resources, requiring greater self-initiated effort because the cue is not processed at the level required by the ongoing task.

Strategic monitoring.

Event-based monitoring.

The self-initiated effort to actively search for the appropriate cue is often referred to as *strategic monitoring* (McDaniel & Einstein, 2000). A major assumption in the strategic monitoring model is that portions of attentional resources are consciously employed by the individual in an effort to detect PM related cues that will facilitate remembering. Monitoring in the context of event-based PM tasks is evidenced by ongoing task performance, specifically response time (RT). For instance, Smith (2003) found that people performing a delayed intention (i.e. PM) took longer to respond to the ongoing task activities than when completing an ongoing task in isolation. The slowing of

RTs observed when participants complete both an ongoing task and a PM task is assumed to signify active monitoring because the individual is allocating attention toward other stimuli unrelated to the purpose of the ongoing task. Furthermore, Smith (2003) found that slower RTs were related to increased PM performance suggesting successful prospective remembering will come at the cost of ongoing task performance, and indicates that event-based PM requires, at the very least, some attentional resources.

More recently, Albiński, Sedek, and Kliegel (2012a) found evidence suggesting that individual differences exist in strategic monitoring when both the ongoing task and PM targets demanded more higher-order executive processing. After classifying participants based on their ongoing task performance RTs as either monitors or nonmonitors (slower RTs), Albiński, et al. (2012a) found that young and middle-aged/older adult nonmonitors performed more poorly on the event-based PM task than their monitoring counterparts. Taken together, it appears that when the current task is demanding and event-based PM cues require more self-initiated processing (i.e., non-focal), people actively monitor their environments in order to facilitate PM retrieval, which comes at the expense of ongoing task performance.

Time-based monitoring.

The frequency at which people monitor time during time-based PM tasks provides additional insight into the mechanisms underlying PM performance. Time monitoring is assumed to reflect the allocation of attentional and cognitive control resources that are necessary for time-based PM (Mioni & Stablum, 2013; Schnitzspahn et al., 2014) and research suggests that time monitoring is critical for successful time-based PM performance (Ceci & Bronfenbrenner, 1985; Einstein, McDaniel, Richardson, Guynn, &

Cunfer, 1995; Harris & Wilkins, 1982; Henry, MacLeod, Phillips, & Crawford, 2004). That is, time monitoring generally ensures more accurate responses within the prescribed time constraints for a given time-based PM task.

Moreover, studies have consistently observed a unique pattern in time monitoring behavior. This pattern becomes evident when the duration between each time-based target is divided into multiple time intervals (e.g., 10 two-minute intervals preceding a target) and typically reveals a U or J shape in time monitoring frequency during a given set of intervals leading to the target event (Einstein et al., 1995; Harris & Wilkins, 1982). In other words, people often monitor the time more frequently at the beginning of a task then gradually monitor the time less frequently until the last interval, where there is a spike in time monitoring. In addition, several studies have demonstrated that time monitoring frequency during the last interval preceding the target time is more critical to successful time-based PM performance than monitoring at other periods during the task (Ceci & Bronfenbrenner, 1985; Einstein et al., 1995; Harris & Wilkins, 1982). Thus, time monitoring serves as a behavioral index of executive processing as it demonstrates the control and allocation of attentional resources toward meaningful goals set in the future.

Prospective Memory Impairment and Clinical Disorders

Prospective memory can also be affected by other factors associated with various clinical disorders. For instance, patients diagnosed with schizophrenia consistently show PM impairment on event-, time-, and activity-based PM tasks (Wang et al., 2009). Similar deficits have been observed among patients with a history of severe traumatic brain injury (Shum, Valentine, & Cutmore, 1999). Children diagnosed with attention-deficit hyperactive disorder have also demonstrated impairment on measures of PM

(Kerns & Price, 2001). Moreover, people in both the preclinical and early stages of Alzheimer's disease show PM impairment compared to healthy older adults (Duchet, Balota, & Cortese, 2006; Jones, Livner, & Bäckman, 2006).

More recently, factors related to mood disorders have generated attention in the PM literature. Research investigating the role of affective states in PM performance has yielded mixed results. Kliegel et al. (2005) found that sad mood impaired time-based PM performance momentarily among a non-clinical sample. In contrast, Rummel, Hepp, Klein, and Silberleitner (2012) found that sad mood increased PM performance whereas positive mood decreased PM performance. More recently, Schnitzspahn et al. (2014) found that both positive and negative mood states compromised young adults' PM performance on a time-based task, whereas older adults were unaffected by either mood state. Although difficult to interpret, these inconsistent findings provide insight on important clinical factors that may affect PM. These findings have also fostered meaningful dialogue on the effects of depression on PM as well as the mechanisms underlying PM and how they are compromised by depressed mood.

Depression and Prospective Memory

A large body of literature links depression with impairments in executive functioning. In a review of 113 studies investigating executive functioning among clinically depressed populations, Snyder (2013) found that major depressive disorder (MDD) is related to broad deficits in executive functioning. For instance, patients with MDD demonstrated deficits in inhibition, task shifting, and working memory—all of which have been identified to play a role in PM (Marsh & Hicks, 1998; Martin et al., 2003; Mäntylä, Carelli, & Forman, 2007). Given what is known about the consequences of depression on executive functioning, it is likely that PM impairment is associated with depressive symptoms. However, the existing literature provides somewhat inconclusive support for that notion.

Event-based prospective memory and depression.

The existing body of literature investigating the effects of depression on event-based PM has yielded mixed results. Several studies have documented depression-related event-based PM impairment among clinical and non-clinical populations. Altgassen, Kliegel, and Martin (2009) found that clinically depressed participants performed more poorly on a non-focal event-based PM task. Chen, Zhou, Cui, and Chen (2013) corroborated these findings among a sample of clinically depressed participants. However, Li et al. (2013) did not find any impairment on an event-based PM task among non-clinically depressed participants. Li, Loft, Weinborn, and Maybery (2014a) reported that depressive symptomology was not related to event-based PM performance. Similarly, Albiński, Kliegel, Sedek, and Kleszczewska-Albińska, (2012b) found that event-based PM performance was not affected by depressive symptoms. In addition, Altgassen, Henry, Bürgler, and Kliegel (2011) demonstrated that depression-related PM deficits may depend on the context of the PM, specifically the emotional valance of the PM cues. For instance, when Altgassen et al. (2011) manipulated the emotional valence of PM cues using positive, negative, and neutral words, they found that PM performance did not differ between the depressed and control group for neutral and negative PM cues. However, when positive PM cues were implemented, only the control group showed a significant increase in performance.

Time-based prospective memory and depression.

Inconsistent findings also exist for the association between depression and time-based PM. In fact, findings from the current literature indicate that depression both impairs and augments time-based PM. For example, Rude et al. (1999) observed that a non-clinical sample of depressed participants performed more poorly on a time-based PM task compared to healthy controls. Li, Weinborn Loft, and Maybery (2014b) observed similar deficits among a non-clinical sample, and Li et al. (2013) also observed that depression was related time-based PM impairments using a PM test developed specifically for clinical use. In addition to finding overall deficits on a time-based PM task, Li et al. (2013) observed that the impairments were greatest among the depressed group when the delay interval for the PM increased. Implementing a naturalistic PM task, Jeong and Cranney (2009) found that depression was negatively correlated with time-based PM performance among a non-clinical sample. However, the observed impairments were specific to the timeliness of participants prospective remembering rather than complete omission of the PM. In contrast, Albiński et al. (2012b) found that depressive symptoms improved time-based PM among a non-clinical sample of younger and older adults when compared to healthy controls.

Understanding the Varied Results

Several explanations have been given for the inconsistencies in the literature surrounding the depression-related PM impairment. Li, et al. (2014b), noted that depression severity may play an important role in depression-related deficits in PM. An important distinction was made by these authors between their reports and that of Albiński et al. (2012b), who found improved performance on a time-based PM task among depressed participants. This distinction occurs at the level of self-reported depressive symptomology. Studies reporting deficits in time-based PM among depressed participants have consistently reported mean Beck Depression Inventory (BDI) scores that approach clinical populations (see Steer, Ball, & Rnieri, 1999), with scores ranging from 24.8 (Rude et al., 1999) and 26.06 (Li et al., 2013) to 30.06 (Li et al., 2014). However, in the Albiński et al. (2012b) study the mean BDI score observed among their non-clinical sample of depressed participants was 16.3. Thus, it is possible that the inconsistencies observed in time-based PM may be attributed to differences in symptom severity, with clinical symptoms leading to poorer performance (Li et al., 2014b). However according to Li et al. (2014b), it remains unclear why participants who are mildly depressed experienced positive effects as well as improved time monitoring behaviors compared to non-depressed controls in Albiński et al. (2012b).

Dysphoric Rumination: A Plausible Explanation?

One promising avenue for research in the area of depression and PM may be the investigation of factors that potentially precipitate and exacerbate affective states. Over the past two decades, considerable progress has been made in understanding rumination and its relation to psychopathology. According to the *ruminative response style theory*, rumination is characterized by persistent negative self-reflective thoughts about the reasons for, and consequences of, a person's depressed mood (Nolen-Hoeksema, 1991). Recently, Treynor et al. (2003) identified two distinct styles of rumination—*brooding* and *reflection*—that are each associated with a unique set of symptoms and cognitive predispositions. For instance, brooding is more strongly associated with depression and with a greater tendency to engage in self-criticism as well as a lower sense of mastery over important life events. Furthermore, brooding is generally characterized by a maladaptive comparison of one's circumstances to "some unachieved standard" (Treynor et al., 2003, p. 256). In contrast, the reflection component is associated with depression to a lesser extent than brooding and is characterized by a tendency to self-reflect on one's situation and actively engages in problem solving. This process of simultaneous self-reflection in response to negative affect and/or depressed mood may provide valuable insight on the documented PM deficits among depressed people observed and clarify the inconsistencies in the literature.

Regarding Li et al.'s (2014b) unresolved question about the positive effects of depression on time-based PM documented in Albiński et al. (2012b), it is possible that mildly depressed participants, particularly those coming from a non-clinical population, engage in more ruminative reflection in response to depressed mood whereas those with moderate to severe symptoms of depression tend to brood. Evidence from several studies offer support for this speculation. For instance, the tendency to brood has consistently been associated with depressive symptoms (Lo, Ho, & Hollon, 2008; Burwell & Shirk, 2007; Moulds et al. 2007; Treynor et al., 2003) and has been found to predict increases in depressive symptoms over time (Burwell & Shirk, 2007; Treynor et al., 2003). In contrast, the relationship between reflection and depression symptoms has been generally weak and modest at best (Burwell & Shirk, 2007; Lo et al., 2008; Treynor et al., 2003).

Further support comes from Lo, Ho, and Hollon (2008) who speculated that the modest relationship between reflection and depression observed in their study may be related to the adaptive nature of this style of self-reflection. Burwell and Shirk (2007) found that reflection was associated with adaptive coping strategies such as restructuring one's attitude toward the stressors related to his or her depressed mood, which supports what Lo, et al. (2008) speculated. In addition, Lo et al. (2008) speculated that the practice of reflection may lower depressive symptoms among people who are experiencing low levels of negative affect. Therefore, it is likely that people who are exhibiting fewer symptoms of depression and ruminate in response to their depressed mood engage in more self-reflection, which would activate adaptive coping strategies such as enhanced allocation of attentional resources toward goal-directed behaviors. If true, this evidence would support Albiński et al.'s (2012b) proposition that the positive effects of depression on PM observed in their study could be driven by the *analytical rumination hypothesis* (Andrews & Thompson, 2009), which presumes that depressed people, at least those who exhibit mild symptoms of depression, engage in more self-reflective adaptive thinking when depressed.

Rumination and Executive Functioning.

Studies investigating the consequences of rumination on neuropsychological test performance have revealed impairments on tests of executive functioning, including inhibition, perseveration, and set shifting (i.e., cognitive flexibility). Davis and Nolen-Hoeksema (2000) were the first to examine the effects of rumination on executive functioning and found that dysphoric ruminators (i.e., those ruminating while experiencing negative affect) were more likely to exhibit deficits related to cognitive flexibility. Specifically, dysphoric ruminators committed more perseverative errors and failed to adapt to changes in their environment. Watkins and Brown (2002) were the first to explore executive functioning among ruminators using the Nolen-Hoeksema & Morrow (1993) response task and found that dysphoric ruminators exhibited impairments in inhibition. These findings have been replicated and extended by Philippot and Brutoux (2008) who also found that dysphoric rumination was related to greater interference and flexibility errors when compared to dysphoric distractors. Whitmer and Banich (2007) also found that higher scores on a measure of trait rumination among depressed participants were associated with a diminished capacity to inhibit previously relevant task sets. Moreover, reported levels of depressed mood or worrying could not explain these deficits.

Recent research suggests that rumination may be more detrimental to executive functioning than general depressive symptoms. For instance, De Lissnyder, Koster, and De Raedt (2011) found that rumination is associated with cognitive control impairments when negative information was held in working memory. In contrast, depression was unrelated to cognitive control impairments, suggesting that dysphoric ruminators may be more susceptible to executive functioning impairments. In fact, Levens, Muhtadie, and Gotlib (2009) found that brooding was associated with significant reductions in controlling the allocation of cognitive resources to ongoing task demands, suggesting that brooding may impair the controlled allocation of important cognitive resources. Thus, the negative self-focus inherent to brooding may lead to executive functioning impairments among dysphoric ruminators.

Given what is known about the cognitive consequences of rumination, it is possible that the previously reported impairments in PM among depressed participants may be driven in part by ruminative thoughts. Therefore, the aim of the current study is three-fold. First, it will address the shortcomings of the Albinski et al. (2012b) study by adding a measure of trait rumination as well as the Nolen-Hoeksema and Marrow (1993) response task to induce rumination. Research has consistently demonstrated that this manipulation significantly increases dysphoria among those who are currently dysphoric compared to those who are not (Nolen-Hoeksema et al., 2008). Second, by directly testing the effects of rumination on PM, this study will provide additional insight into the nature of PM deficits among depressed populations. Lastly, studies investigating PM typically employ laboratory-based paradigms, which may limit the extent to which results can be generalized to everyday settings—an inference that is of most importance given the real-world implications of PM. Thus we will use an ecologically-valid, clinical measure of PM, the Memory for Intentions Screening Test (MIST; Raskin, 2009; Roelofs, Muris, Huibers, Peeters, & Arntz, 2006).

Given the findings from the investigations examining the relationship between rumination and executive functioning impairments and what is known about the role of executive functioning in PM performance, three hypotheses will be tested: first, it is anticipated that participants exhibiting elevated symptoms of depression (i.e., moderate and high) who undergo the rumination induction will make more time-based PM errors compared to those in the distraction condition (H1); second, it is anticipated that participants exhibiting elevated symptoms of depression who undergo the rumination induction will make more errors on 15-minute compared to 2-minute delay event-based PM trials, (H2); Lastly, it is anticipated that trait rumination will be negatively correlated with PM performance across the entire sample (H3).

Method

Participants

Participants were recruited from a pool of undergraduate students enrolled in an introductory psychology course at the University of Montana and from the greater community of Missoula Montana using print advertisements. Participants were screened using the 8-item Patient Health Questionnnaire (PHQ-8). Those in the upper and lower quartiles were invited to return to participate in the study. Participants were excluded from the study if one or more of the following conditions were met: (1) reported use of psychoactive drugs (e.g., benzodiazepines, narcotics, stimulants, or hallucinogens; cannabis use was not exclusionary) within the past 5 days; (2) reported history of or current diagnoses of any mental health disorder other than a mood disorder; (3) reported a history of attention-defecit hyperactive disorder, traumatic brain injury (with a loss of consciousness > 30 minutes), seizure(s), and/or dyslexia.

A total of 100 people participated in the study. Participants were compensated with either course credit or $15.00 for their time. All participants provided informed consent prior to completing any study-related procedures. Five participants were excluded from the study due to exclusionary mental health conditions and/or exclusionary psychoactive drug use within 5 days prior to entering the study. Three participants' data were discarded due to administration errors on the Memory for Intentions Test (MIST) and one participant's data was discarded due to a probable language barrier that precluded the individual from understanding the MIST instructions. Additionally, three participants' data were excluded from analyses due to missing data on the experimental manipulation check. Consequently, the remaining sample size for the current study is 88. Participants were grouped into one of three groups according to their scores on the Beck Depression Inventory-Second Edition (BDI-II) on the day of testing:

Low (N = 55; BDI-II $\leq$ 8), *Moderate* (N = 17; BDI-II 9-18), and *High* N = 16; BDI-II $\geq$ 19).

Materials

Demographic Questionnaire. Participants completed a demographic questionnaire using the online survey system, Qualtrics. The following demographic information was collected from participants who met initial inclusion criteria: age, biological sex at birth, and years of education. In addition, information concerning medication and substance use as well as past and current psychiatric conditions was gathered and used as exclusion criteria.

Patient Health Questionnaire (PHQ-8). The PHQ-8 is an 8-item self-report measure of depression that assesses depressive symptoms based on the DSM-IV major depressive disorder criteria. This PHQ-8 is identical to the PHQ-9 except for item 9, which is omitted because it addresses current suicide ideation. The PHQ-9 has demonstrated excellent internal (.89) and test-retest (.84) reliability (Kroenke, Spitzer, & Williams, 2001), and the PHQ-8 possesses similar psychometric characteristics (Kroenke & Spitzer, 2002).

Beck Depression Inventory-Second Edition (BDI-II). The BDI-II is a reliable and valid 21-item self-report measure of depression. The internal consistency of the BDI-II is .92 (Beck, et al., 1996), and it has been used extensively in both clinical and research settings.

Ruminative Responses Scale (RSS). The RRS is a subscale of the Response Styles Questionnaire developed by Nolen-Hoeksema and Morrow (1991). The RRS is a 22-item self-report measure of trait rumination. The internal consistency for the brooding and reflection factors is .77 and .72, respectively, and the test-retest reliability for each factor is .62 and .60, respectively over a one-year follow up period (Treynor et al., 2003).

Momentary Ruminative Self-Focus Inventory (MRSI). The momentary ruminative self-focus inventory (MRSI) is a 6-item self-report measure of state rumination (Mor, Marchetti, & Koster, 2013; as cited in Hertel, Mor, Ferrari, Hunt, & Agrawal, 2014). Example statements from the MRSI include, "right now, I am conscious of my inner feelings" and "right now, I am thinking about the possible meaning of the way I feel." Hertel et al. (2014) demonstrated good internal consistency with the MRSI (.81). The MRSI has also been shown to be sensitive to manipulations of self-focused rumination (Mor et al., 2013; as cited in Hertel et al., 2014).

Response Task: Rumination Induction. The rumination induction *response task* developed by Nolen-Hoeksema and Morrow (1993) will be implemented to induce either ruminative thoughts through a self-focus manipulation or to distract participants' attention from their current emotional state. The rumination induction is designed to have participants direct their attention to their thoughts in response to a variety of statements. In each condition, participants will be asked to "think about" 45 thought-provoking statements that differ in content depending on the assigned condition. For example, participants assigned to the self-focused condition will be asked to read statements intended to induce ruminative thoughts (e.g. "think about what your feelings might mean" and "the possible consequences of the way you feel") whereas those assigned to the distraction condition will be asked to think about benign statements unrelated to the self (e.g., "think about the layout of the local shopping center" and "the size of the Golden Gate Bridge").

Memory for Intentions Screening Test (MIST). The memory for intentions screening test (MIST, Raskin, 2004; as cited in Woods, Moran, Dawson, Carey, & Grant, 2008) is a standardized measure of event- and time-based PM. For the purpose of this study, the research protocol of the MIST will be used (see Woods et al., 2008). The MIST is comprised of 8 PM cues (4 event- and 4 time-based). The duration of the test is approximately 30 minutes. For the event-based PM cues, participants are informed that they will be asked to say or do certain things (e.g. "When I hand you a red pen, sign your name on your paper", "When I show you my tape recorder, tell me to rewind the tape") while completing a word search activity. In the word search activity, participants are instructed to locate specific words presented at the bottom of the Word Search Form (analogous to a crossword puzzle). The target words may be presented horizontally, vertically, or diagonally within the Word Search form. For the time-based PM cue, participants are instructed to say or carry out certain things at specific time points that range from short to long delayed intervals (e.g. "In two minutes, please tell me two things you forgot to do this past week", and "In 15 minutes, use that paper to write the number of medications you are currently taking"). In addition, there is an optional delayed PM task that asks participants to call the researcher the following day to report how many hours they slept that night. The MIST also contains a post-test multiple-choice activity that assesses participants' retrospective memory of the PM instructions, which has been shown to discriminate PM performance from retrospective memory performance (Carey et al., 2006; Woods et al., 2008). Several studies have illustrated the convergent validity of the MIST with measures of executive functioning (Carey et al., 2006; Woods et al., 2007).

For the current study, modifications were made to the standard MIST administration to acquire information regarding time monitoring and memory for intentions. For example, monitoring activity was tracked for each participant, such that examiners noted each time a participant checked the clock throughout the duration of the test. Also, all PM test stimuli (e.g., pen, tape recorder, etc.) were removed from the table and placed out of the participant's view when either (a) they completed the PM task or (b) after 1 minute. This was done to eliminate the possibility that the presence of an item remaining on the table could serve as an additional reminder of an action to be executed or an item to be recalled (i.e., in the recall test). Finally, free- and cued-recall tests were created and administered to participants after completing the last MIST PM trial and prior to the standard recognition test. For the free recall test, participants were given the following instruction, "Please tell me each of the things that you were supposed to do during this test." If all trials were not freely recalled, they were then asked, "Is there anything else?" After completing the free recall test, participants were administered the cued-recall test and were given prompts about each trial. For both the free- and cued-recall tests, separate subscales were created and one point was given for each trial correctly recalled. Total scores for the free- and cued-recall subscales ranged from 0-8. After completing the cued-recall test, the recognition test was administered verbally to participants.

Procedure

This study was approved by the University of Montana Institutional Review Board prior to recruiting participants. After the PHQ-8 screening, eligible participants were invited to participate in the primary study. Following informed consent, participants completed all self-report measures and the rumination induction as follows: demographics questionnaire, BDI-II, RRS, MRSI (time 1; T1), rumination induction (i.e., response task), and MRSI (time 2; T2). All self-report measures, except the BDI-II, and the rumination induction were administered using the online survey platform, *Qualtrics*. Following the MRSI T1, participants were randomly assigned to either the self-focused (i.e. active rumination) or distraction condition. Following the rumination or distraction condition, participants completed the MRSI T2, after which the MIST was administered by a trained research assistant. All research assistants were blinded to the rumination induction to prevent possible experimenter effects. All study procedures took approximately sixty minutes to complete.

Results

Participant Characteristics

Participant demographic information along with depression and trait and state rumination levels are displayed by group in table 1. Independent t-tests revealed that groups did not differ significantly on age or education. Groups differed significantly from each other on depression severity, trait rumination, and brooding. Those in the low group had significantly lower scores on the MRSI T1 than those in high group, $t(47.310) = -3.882$, $p = .000$, who did not differ from the moderate group, $t(27.782) = -.902$, $p = .375$, but were not statistically different from those in the moderate group $t(70) = -1.957$, $p = .054$. In addition, those in the low group differed significantly on the RRS reflection factor than those in the moderate, $t(18.106) = -3.736$, $p = .002$, and high, $t(47.310) = -3.882$, $p = .000$, groups, whereas those in the moderate and high groups did not differ significantly from each other, $t(31) = -1.207$, p = .237.

Manipulation Check: Condition by Time

To determine if the rumination induction led to increased ruminative thinking, as measured by the MRSI, a 2 (condition: induction vs. distraction) x 2 (time: MRSI T1 vs. MRSI T2) repeated-measures mixed factorial ANOVA was performed. Rumination condition was treated as the between-subjects factor whereas time was treated as the within-subjects factor. A significant two-way interaction was found between rumination condition and time, $F(1, 89) = 12.64$, $p = .001$, $\eta^2 = .12$, indicating that participants assigned to the rumination induction reported greater state rumination at time 2 of the MRSI compared to those assigned to the distraction condition. Using the Bonferroni-adjusted alpha level for this two-way interaction, a statistically significant simple main effect of condition was found at MRSI T2, $F(1, 82) = 4.543$, $p = .000$, $\eta^2 = .052$, but not for MRSI T1, $F(1,82) = .003$, $p = .957$, $\eta^2 = .000$. Specifically, mean MRSI T2 scores were significantly higher for participants in the rumination condition compared to those assigned to the distraction condition, a mean difference (*MD*) of -3.632, 95% CI [-7.022, -.242], $p = .036$. This result indicates that participants assigned to the rumination induction reported more ruminative thoughts at MRSI T2 compared to those assigned to the distraction condition, regardless of depression severity. All other interactions were not significant ($p > .05$). Scores on the MRSI T1 and T2 were normally distributed for all conditions per the Shapiro-Wilk test ($p > .05$) except for MRSI T1 for those assigned to the rumination condition in the high group ($p = .032$).

Due to power limitations related to the small sample sizes of the moderate and high groups, we conducted a series of t-tests to determine relations between condition and time for each group. The results of a paired t-test revealed a significant difference in mean scores at T1 and T2 for the low group, $t(26) = 5.115$, $p < .000$, indicating that participants assigned to the rumination induction reported greater state rumination following the manipulation compared to those assigned to the distraction condition. Although condition by time interactions were not observed for the moderate, $F(1, 15) = 1.477$, $p = .243$, $\eta^2 = .090$, or high groups, $F(1, 14) = 2.410$, $p = .143$, $\eta^2 = .147$, additional paired t-tests were carried out for the moderate and high groups. Similar to the low group, means scores on the MRSI increased significantly from T1 to T2 in the moderate group for those in the rumination induction condition, *MD* of 3.0 (*SD* = 3.6 [95% CI, 0.036 – 5.964]), $t(7) = 2.393$, $p < .048$. No such effect was found for those who underwent the rumination induction in the high group, $t(7) = 0.887$, $p = .404$.

Finally**,** independent t-tests were used to determine whether participants assigned to the rumination induction condition in each group differed from each other at T2 of the MRSI. No significant differences emerged on the MRSI T2 for the following group comparisons: low vs. moderate, *MD* = - 2.713 (*SE* = 3.164; 95% CI [- 9.150 – 3.724]), $t(33) = -.858$, $p = .397$; moderate vs. high, *MD* = 1.250 (*SE* = 2.374; 95% CI [- 3.841 – 6.341]), $t(14) = .527$, $p = .607$; low vs. high, *MD* = - 1.463 (*SE* = 2.210; 95% CI [- 6.023 – 3.097]), $t(24.092) = -.662$, $p = .514$.

Prospective Memory

Due to power limitations in the moderate and high depression groups, we briefly present the results of analyses involving those groups, but also present analyses of the low depression group by itself, for which we had a much larger sample.

Hypothesis 1

To examine whether state rumination had a greater effect on time-based compared to event-based PM in those exhibiting elevated symptoms of depression (H1), a 3 (group: low vs. moderate vs. high) x 2 (condition: induction vs. distraction) x 2 (cue type: event-based cue vs. time-based cue) repeated-measures mixed factorial ANOVA was performed. Depression group and rumination condition were treated as between-subjects factors and PM cue-type as a within-subjects factor. The three-way interaction between depression group, rumination condition, and PM cue type was not significant $F(2, 82) = 1.006$, $p = .370$. A significant two-way interaction between condition and cue type was found $F(1,82) = 4.607$, $p = .035$, suggesting that those in the distraction condition performed better on time-based PM trials compared to those in the rumination condition but not on event-based cues. Lastly, a significant main effect of cue type was found $F(1,85) = 36.675$, $p = .000$, $\eta^2 = .308$. Post hoc tests using Bonferroni adjustment showed that mean scores were higher on event-based compared to time-based PM trials, *MD* of .937 (*SE* = .155, 95% CI [.629 – 1.246], $p = .000$) for all participants, regardless of depression group and rumination condition.

<u>Low Depression Group Only</u>

The results of a 2 (condition: rumination vs. distraction) x 2 (cue type: event-based cue vs. time-based cue) repeated-measures mixed factorial ANOVA revealed no significant interaction between condition and cue type, $F(1, 53) = .155$, $p = .695$, $\eta^2 = .003$. Consistent with analyses involving all participants, a significant main effect of cue type was found, $F(1, 53) = 34.209$, $p = < .001$, $\eta^2 = .392$. Post hoc tests using Bonferroni adjustment showed that performance was significantly higher on event-based trials compared to time-based trials, *MD* of 1.110 (*SE* = .190, 95% CI [.730 – 1.491], p = < .001) regardless of rumination condition.

Hypothesis 2

To assess whether depression and state rumination interacted with PM cue type and delay interval (H2), a 3 (group: low vs. moderate vs. high depressive symptoms) x 2 (condition: rumination vs. distraction) x 2 (cue type: event vs. time) x 2 (delay interval: 2-minute vs. 15-minunte) repeated-measures mixed factorial ANOVA was conducted. Depression group and rumination condition were treated as between-subjects factors while PM cue type and delay interval were treated as within-subjects factors. There was no significant 4-way interaction between depression group, rumination condition, cue type, and delay interval $F(2, 82) = 1.807$, $p = .171$, $\eta^2 = .042$.

A significant two-way interaction was revealed between cue type and delay interval $F(1, 82) = 33.320$, $p = .000$, $\eta^2 = .289$. Specifically, participants' PM performance on event- and time-based 2-minute delay trials was almost identical, whereas participants' PM performance was worse on time-based 15-minute delay trials compared to event-based 15-mintue delay trials. Moreover, a statistically significant simple main effect of delay interval was found for time-based PM trials $F(1, 82) = 61.022$, $p = .000$, $\eta^2 = .427$, but not for event-based trials, $F(1, 82) = .430$, $p = 514$, $\eta^2 = .005$. Specifically, mean time-based PM performance was higher for 2-minute delay trials than for 15-minute delay trials, *MD* of .950, 95% CI [.708 – 1.192], $p = 000$. In addition, a statistically significant main effect of cue type was found $F(82, 1) = 36.547$, $p = .000$, $\eta^2 = .308$, indicating that participants' PM performance was better for event-based trails compared to time-based trials. A statistically significant main effect of delay interval was also found $F(82, 1) = 55.358$, $p = .000$, $\eta^2 = .403$, indicating that participants' PM performance was better for 2-minute delay interval trials compared to 15-minute delay interval trials.

Low Depression Group Only

We ran similar analyses for the low group only. The results of a 2 (condition: rumination vs. distraction) x 2 (cue type: event vs. time) x 2 (delay interval: 2-minute vs. 15-minunte) repeated-measures mixed factorial ANOVA did not reveal a significant interaction between condition, cue type, and delay interval, $F(1, 53) = .048$, $p = .828$, $\eta^2 = .001$. A significant interaction was found between cue type and delay interval, $F(1, 53) = 22.904$, $p = < .001$, $\eta^2 = .302$, indicating that performance on 2-minute delay time-based trials was significantly higher than 15-minute delay time-based trials, *MD* of .962 ($SE = .136$, 95% CI [.690 – 1.234], $p = < .001$). No other significant interactions were observed. Additionally, a significant main effect of delay interval, $F(1, 53) = 62.956$, $p = < .001$, $\eta^2 = .543$, revealed that PM performance was better for 2-minute than 15-minute delay trials, *MD* of .535 ($SE = .067$, 95% CI [.400 – .671], $p < .001$).

We ran additional independent t-tests for event- and time-based as well as 2-minute and 15-minute-delay interval PM trials. The assumption of equal variance was met for all comparisons except for the 2-minute delay PM trials. A marginal difference between the distraction and induction conditions approached significance on 2-minute delay PM trials, *MD* of .262 ($SE = .129$, 95% CI [- .001 – .524]), $t(34.746) = 2.027$, $p = .050$. Specifically, participants in the induction condition performed worse on 2-minute delay PM trials than those in the distraction condition. No other significant differences were found between conditions on event-, $t(53) = .504$, $p = .617$, time-, $t(53) = .671$, $p = .505$, and 15-minute delay, $t(53) = .155$, $p = .877$, PM trials.

Hypothesis 3

Hypothesis 3, that trait rumination would be negatively correlated with PM performance, was not supported. Results revealed that trait rumination (i.e., RRS) was not correlated with overall PM performance, $r = .029$, $p = .787$. Nor was the RRS and overall PM performance significantly correlated in the high group, $r =. 325$, $p = .219$. However, several significant correlations were found among the moderate and low groups. For instance, the RRS was positively correlated with overall PM performance in the moderate group ($r = .508$, $p = .037$). Similarly, the brooding factor of the RRS was positively correlated ($r = .591$, $p = .013$) with overall PM performance in the moderate group. In contrast, the RRS was negatively correlated with overall PM performance ($r = -.314$, $p = .020$) in the low group. Specifically, the reflection factor of the RRS was negatively correlated with both overall PM performance ($r = - .329$, $p = .014$) and event-based trials ($r = - .278$, $p = .040$) in the low group. Additionally, both the MRSI T1 ($r = -.292$, $p = .031$) and MRSI T2 ($r = - .272$, $p = .044$) were negatively correlated with time-based PM trials in the low group (see table 3).

Additional Analyses

Monitoring and Ongoing Task Performance. To determine whether depression severity and state rumination affected time monitoring and ongoing task performance, a 3 (group: low vs. moderate vs. high) x 2 (condition: rumination induction vs. distraction) ANOVA was carried out for each dependent variable, respectively. No significant interaction between group and condition was found for monitoring performance $F(2, 82)$

$= .807$, $p = .450$, $\eta^2 = .019$, or ongoing task performance, $F(2, 82) = 1.091$, $p = .341$, $\eta^2 = .026$. No other significant interactions or main effects were found for monitoring or ongoing task performance.

We also sought to determine whether condition had any effect on monitoring and ongoing task performance in the low group only. Results of a one-way ANOVA revealed no significant differences in monitoring performance between conditions, $F(1, 53) = .069$, $p = .793$, or ongoing task performance, $F(1, 53) = .738$, $p = .394$, indicating that state rumination had no effect on either dependent variable.

Retrospective Memory of PM Tasks. To determine whether depression severity and state rumination affected retrospective memory of MIST PM tasks, a 3 (group: low vs. moderate vs. high) x 2 (condition: rumination induction vs. distraction) ANOVA was carried out for the free-, cued-, and recognition recall variables. No significant interactions were found between group and condition for free-, $f(2, 82) = .036$, $p = .964$, $\eta^2 = .055$, cued-, $f(2, 82) = .151$, $p = .860$, $\eta^2 = .073$, and recognition recall, $f(2, 82) = .026$, $p = .974$, $\eta^2 = .054$. Lastly, no significant main effects were found for group or condition on any of the retrospective memory variables.

Discussion

Accumulating evidence suggests that depression is associated with PM impairment (Zhou et al., 2016). In addition, research shows that rumination can thwart executive functions crucial for PM. However, it remains unknown whether depressive-rumination contributes to documented depression-related PM impairment. Given the negative effects of depressive-rumination on executive functions crucial for PM, we manipulated state rumination in a non-clinical sample exhibiting low, moderate, and high symptoms of depression. We hypothesized that participants in the moderate and high groups who were induced to ruminate would perform more poorly on time-based (H1) and 15-minute delay event-based PM trials (H2). Lastly, we expected that trait rumination would be negatively correlated with overall PM performance (H3).

Regarding H1, induced state rumination had no effect on time-based PM compared to those in the distraction condition across all three depression groups (H1). This finding remained even when the moderate and severe groups were excluded from analyses. Moreover, induced state rumination had no effect on overall PM performance regardless of depression severity.

Although Li et al. (2013) found that depressed participants performed more poorly on time-based and 15-minute delay trials compared to event-based and 2-minute delay trials, respectively, no such interactions were found in the current study (H2). These findings also conflict with Rude et al. (1999), who reported depression-related PM impairment on time-based PM tasks. However, the aforementioned null findings are not entirely inconsistent with previous research.

The finding that no relation was observed between depressive symptoms and event-based PM is consistent with prior research. For instance, previous work has not revealed depression related event-based PM deficits (Albiński et al., 2012b; Li et al., 2013, 2014). One possible explanation for this effect relates to the nature of the MIST event-based trials. Specifically, cues may be more focal, requiring fewer executive resources to carry out. Although Li et al. (2013) argue that the MIST event-based trials are non-focal due to a delay-interval effect on event-based trials, no such effect was found in our study. It is likely that the qualities of MIST event-based stimuli are, instead, highly salient. For instance, asking participants sign their name on their paper when they are handed a red pen is less likely to require effortful retrieval of the intention (i.e., signing name) when the cue is encountered (i.e., seeing the red pen). Thus, the finding that depressive symptoms were not related to event-based PM is consistent with existing research and PM theory.

Our third hypothesis, that trait rumination would be negatively correlated with overall PM, was not supported when looking at the entire sample. However, several significant and notable correlations were found when depression severity (e.g., low, moderate, and high) was analyzed separately. For instance, in the low group, both trait and state rumination were negatively correlated with PM performance. Specifically, higher trait rumination, especially reflection, was negatively correlated with overall PM performance. In addition, elevated state rumination as evidenced by the MRSI T2, was negatively correlated with time-based PM trials. In contrast, trait rumination was positively correlated with PM for those in the moderate group. For example, trait rumination, especially brooding, was related to better overall PM performance.

Although the current findings related to rumination, depression, and memory are at odds with much of the published literature, in which negative relations between rumination and memory are more commonly observed only in the context of depression, we offer two explanations for our results. First, rumination is a broad construct with several varieties, and its negative consequences are not necessarily limited to depressed mood. For instance, Whitmer and Banich (2007) found that angry rumination and intellectual ruminations were related to problems with cognitive flexibility, whereas depressive-rumination, specifically brooding and reflection, was related to impaired inhibition. In addition, Whitmer and Banich (2010) found that ruminations unrelated to depressed mood were related to decreased inhibition of irrelevant material from long term memory (LTM). The latter findings are particularly relevant given that an inability to inhibit irrelevant information from LTM may potentiate the retrieval of similar, but task-irrelevant information (Whitmer & Banich, 2010). If true, ruminations in general may (a) lead to the retrieval of task-irrelevant information and/or (b) interfere with the retrieval of task-relevant information needed to execute the correct future intention. The latter may explain why trait and state rumination was negatively correlated with PM performance for participants in the low group. Further support for this notion comes from a marginal and near significant finding that those who underwent the rumination induction in the low group exhibited worse performance on 2-minute delay PM trials. However, this induction effect was not found for any other MIST PM variables (e.g., event- and time-based PM) in the low group, which remains curious. Alternatively, it is possible that the negative correlations found between PM performance and both trait and state rumination in the low depression group may have been the result of other more general ruminations thwarting the retrieval of relevant PM instructions. Although plausible, this is assertion is speculative because we did not include any additional measures of rumination.

Second, amounting evidence indicates that rumination may confer positive benefits to cognition. For instance, Smallwood et al. (2003) found that when high trait ruminators are experiencing elevated symptoms of depression they are more likely to direct their attention to monitoring ongoing task performance. Moreover, this increased focus on task performance is thought to be adaptive such that ruminating about ongoing task performance will minimize future failure and subsequent distress. Similarly, Altamirano et al. (2010) found that higher trait rumination was related to better goal-maintenance in a sample of people exhibiting elevated symptoms of depression (mean BDI-II of 19.8). Therefore, it is possible that a proclivity to ruminate as measured by the RRS in conjunction with sub-clinical symptoms of depression may be contextually adaptive and confer functional benefits, especially when the task at hand does not require a great deal of mental flexibility and objectives are consistent across time. Taken together, such an explanation is consistent with Albiński et al. (2012b), who found that sub-clinical depression was found to enhance PM and speculated that depressive-rumination may have increased depressed participants' focus on task performance to minimize task errors and rectify their depressed mood.

The lack of evidence supporting our hypotheses and the significant correlations found among the low and moderate groups need to be interpreted cautiously given the low statistical power of the current study due to small sample sizes for the moderate and high depressive groups. This issue of power is especially pertinent to the effects of the experimental manipulation of state rumination. For instance, our analyses revealed no group by condition interactions between the pre- and post-manipulation measures. However, when pre- and post-manipulation measures were analyzed separately for each group, we found significant increases in state rumination effects for those in the low and moderate groups, but not the high group. As noted above, this outcome is inconsistent with previous research (Nolen-Hoeksema, Blair, & Lyubomirsky 2008). To our knowledge, this is the first study to observe such an effect using this rumination induction. Although the number of participants in the moderate and high groups were low, mean scores on the manipulation check (i.e., MRSI T2) trended in the expected direction with those assigned to the induction condition scoring higher on the MRSI T2 in both groups. Thus, the finding that depression severity (i.e., low, moderate, and high) was unrelated to significant changes in ruminative thoughts in those assigned to the induction condition may be a consequence of low statistical power because previous research has shown that the MRSI is sensitive to changes in state rumination using the same induction procedure employed in this study (Mor et al., 2013; as cited in Hertel et al., 2014).

Additionally, it is possible that those in the moderate and high groups were already in a heightened state of rumination at the time they entered the study. Specifically, participants in the low group scored substantially lower on the MRSI T1 than those in the moderate and high groups. However, participants assigned to the rumination induction reported almost the same level of state rumination per their scores on the MRSI T2 across all three groups. In fact, there was no significant group differences on the MRSI T2. Thus, those with elevated symptoms of depression may have already been actively ruminating when they entered the study, especially those in the high depressive symptom group. If this was indeed the case, the experimental rumination induction used in this study may only be effective at increasing ruminative thoughts to a degree, which could explain why MRSI T2 scores were equivalent across all three rumination induction groups.

The fact that participants assigned to the rumination induction in the low group reported a similar state of rumination comparable to those assigned to the same condition in the moderate and high groups remains curious. It is possible that the ruminative thoughts among those in the low group may have been directed toward benign content that was less distressing and more reflective in nature. Related to this point, we found a significant, though marginal, positive correlation between scores on the MRSI T2 and the reflection items on the RRS. This relationship may be suggestive of increased reflective rumination among participants who underwent the rumination induction in the low group. Moreover, the MRSI appears to contain only one item that taps 'brooding' content. It is possible that the rumination induction increased brooding that was not captured by the MRSI. Given the relationship between the MRSI T2 and the reflection factor of the RRS, the MRSI may not be a robust measure of state rumination, which would limit its ability to detect state changes in brooding.

Another important limitation of the current study pertains to the reliance of self-reported depressive symptoms, especially in a non-clinical depression. It is crucial to distinguish between clinical (i.e., those meeting criteria for a formal psychiatric diagnosis) and non-clinical depressed populations (i.e., individuals who endorse elevated depressive symptoms per self-report measures such as the BDI-II without a formal diagnosis; Gotlib & Joorman, 2010). For instance, clinically depressed individuals consistently show executive control deficits for negative compared to positive-valanced material (Whitmer & Gotlib, 2013), whereas this finding is less robust among non-clinical samples. Furthermore, results from the current study highlight this discrepancy given that depression-related PM impairment has been evidenced in a clinical sample (e.g., Rude et al., 1999). To further complicate matters, Galatzer-Levy and Bryant (2013) showed that there are approximately 227 possible combinations of MDD per DSM-5 criteria. Thus, there is room for considerable heterogeneity even within clinical samples. Going forward, future research would benefit from relying less on dichotomizing continuous variables when non-clinical samples are used because such practices weakens statistical power and can contribute to erroneous results (Cohen, 1983).

Notwithstanding these limitations, the current study contributes to our knowledge of depression and PM. First, this is the first study to include measures of both trait and state rumination. The only other study to date (i.e., Albiński et al., 2012b) that considered the effects of depressive-rumination on PM did not include any measures of trait or state rumination. Second, to our knowledge this is the first study to include a measure of monitoring behavior and tests of free- and cued-recall for MIST PM trials in addition to the standard recognition memory trial. The inclusion of these measures provide a more complete picture of the executive functions involved in PM as well as the contributions made by retrospective memory. Measures of free recall, especially following a delay, represent a more strategic and effortful cognitive activity because unlike cued recall and recognition, there are no external stimuli to guide the retrieval of previously encoded experiences. In the present study, we did not find any significant differences between depression severity and monitoring behavior or performance on free-, cued-, or recognition memory. Moreover, no significant relations emerged between the rumination induction and any of these measures, regardless of depression severity. These findings are consistent with some literature investigating the relations between depression and episodic memory performance (Beblo et al., 2017; O'Jile et al., 2005), but not with others (Hermens et al., 2010; Lyche et al., 2010).

Future Directions

The current study is the first to address the effects of depressive-rumination on PM in a non-clinical sample composed primarily of undergraduate students. Although addressing an important gap in the literature, additional research is required to: (a) replicate our findings, (b) address the shortcomings of our study, and explore other important factors that may affect PM in people exhibiting depressive symptoms.

Future research will need to further explore the effects of depressive-rumination on PM among clinically depressed populations. To date, most studies investigating the effects of depression on PM have relied on non-clinical populations. It is well known that clinical and non-clinical populations may differ in performance of tests of cognitive function (e.g., executive function). Thus, more research is needed to determine whether PM and related cognitive functions are indeed impaired in individuals who meet criteria for MDD. It will also be critical to consider how depression status (i.e., current major depressive episode or in remission) affects PM. In addition, it remains unknown whether depressive ruminations will confer positive effects on PM performance in clinically depressed patients.

Another crucial area to explore pertains to the type of ruminations people engage in when experiencing negative or positive mood states, and how each contributes to PM performance. As noted in the previous section, there are several distinct varieties of rumination (e.g., brooding, reflection, anger, and intellectual) with each affecting cognition in different ways. Therefore, future research in this area will need to account for these different ruminative styles and determine whether any dissociable effects exist regarding PM.

Clinical Application

Although the relationship between rumination and PM remains ambiguous, research to date indicates that depression is associated with impaired PM (McFarland &

Vasterling, in press; Zhou et al., 2016). In addition, research consistently demonstrates that rumination, especially among individuals with depression, is related to executive function impairment (Whitmer & Gotlib, 2013). Clinical interventions, such as mindfulness-based cognitive interventions, targeting ruminative tendencies among patients with depression have shown considerable promise in minimizing depressive-rumination and depressive symptoms (Ramel, Carmona, & McQuaid, 2004; Deyo, Wilson, Ong, & Koopman, 2009). Moreover, mindfulness-based interventions have been found to improve executive functions related to response inhibition, cognitive flexibility, and working memory (Gallant, 2016). Based on this literature, if depressive-rumination does indeed thwart executive functions that are crucial for PM and mindfulness-based therapies are effective at restoring executive functions, then such interventions may also confer positive benefits for PM. This would be a fruitful area for future research given the documented PM impairment in individuals experiencing depression.

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Appendix A

Table 1
Participant Characteristics

	Low	Moderate	High
Female n (%)	40 (72.7)	12 (70.6)	15 (93.8)
Age	21.3 7.5)	19.0 (1.1)	25.6 (14.8)
Education	13.1 (1.7)	13.4 (0.9)	13.3 (1.7)
Race[a] n (%)	49 (89.1)	17 (100.0)	15 (93.8)
Language[b] n (%)	53 (96.4)	17 (100.0)	16 (100.0)
Anxiety n (%)	1 (1.8)	2 (11.8)	2 (12.5)
Antidepressant n (%)	5 (9.1)	1 (5.9)	5 (31.3)
Cannabis n (%)	1 (1.8)	2 (11.8)	2 (12.5)

Note: Means and (standard deviations) are reported unless indicated otherwise.
[a] = White
[b] = English

Appendix B

Table 2
Participant Characteristics

	Low	Moderate	High
BDI-II	3.8 (2.6)	13.8 (3.4)	30.4 (8.5)
RRS	30.0 (5.5)	45.4 (10.6)	56.9 (7.8)
Brooding	7.0 (1.6)	9.9 (2.4)	12.7 (2.4)
Reflection	6.8 (1.6)	10.1 (3.6)	11.4 (2.6)
MRSI T1	25.2 (7.2)	29.0 (5.9)	30.6 (3.9)

Note: Means and (standard deviations) are reported.
BDI-II = Beck Depression Inventory-Second Edition; RRS = Ruminative Response Scale; MRSI T1 = Momentary Rumination Self-Focused Inventory Time 1.

Appendix C

Table 3

Bivariate Pearson Correlation Coefficients for the Low Group

		RRS	Brooding	Reflection	MRSI T1	MRSI T2	TB-PM	PM Total
RRS	r	1	.723**	.681**	.244	.351**	-.305*	-.314*
	Sig.		.000	.000	.072	.009	.024	.020
	N	55	55	55	55	55	55	55
Brooding	r	.723**	1	.427**	.255	.238	-.256	-.255
	Sig.	.000		.001	.060	.080	.059	.061
	N	55	55	55	55	55	55	55
Reflection	r	.681**	.427**	1	.263	.260	-.230	-.329*
	Sig.	.000	.001		.052	.055	.091	.014
	N	55	55	55	55	55	55	55
MRSI T1	r	.244	.255	.263	1	.791**	-.292*	-.301*
	Sig.	.072	.060	.052		.000	.031	.026
	N	55	55	55	55	55	55	55
MRSI T2	r	.351**	.238	.260	.791**	1	-.272*	-.243
	Sig.	.009	.080	.055	.000		.044	.074
	N	55	55	55	55	55	55	55
TB-PM	r	-.305*	-.256	-.230	-.292*	-.272*	1	.906**
	Sig.	.024	.059	.091	.031	.044		.000
	N	55	55	55	55	55	55	55
PM Total	r	-.314*	-.255	-.329*	-.301*	-.243	.906**	1
	Sig.	.020	.061	.014	.026	.074	.000	
	N	55	55	55	55	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

RRS = Ruminative Response Scale; MRSI T1 & T2 = Momentary Rumination Self-Focused Inventory time 1 and time 2; PM Total = overall prospective memory performance; TB-PM = time-based prospective memory trials.