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Cognitive control processes underlying time-based prospective memory impairment in individuals with high depressive symptomatology

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ABSTRACT

The current study compared time-based prospective memory (PM) for individuals with high depressive symptomatology (HDS) and low depressive symptomatology (LDS). We examined PM accuracy rate, clock-checking frequency, and decrements in ongoing task performance (i.e., costs to ongoing tasks) associated with an embedded time-based PM task. HDS participants demonstrated numerically lower but statistically comparable clock-checking frequency to LDS participants. However, their PM performance was significantly poorer than that of LDS participants. The pattern of observed costs to ongoing tasks and correlational analyses between ongoing task performance and PM accuracy showed that, relative to LDS participants, HDS participants were restricted in their allocation of attentional resources to support PM. We concluded that although HDS and LDS participants externally controlled their time-based PM task performance (i.e., clock-checking) similarly, the HDS participants lacked the cognitive initiative to allocate attentional resources to internally control PM task performance. Such internal control might reflect time-estimation processes, the resources required to maintain the PM task response intention, and/or the ability to coordinate the PM task response with ongoing task demands. To our knowledge, this is the first paper to have examined time-based PM strategies used by HDS individuals beyond clock-checking. The data suggest that interventions that encourage intermittent strategic reviews of PM goals may be beneficial for individuals with high depressive symptomatology.

1. Introduction

Evidence of impaired prospective memory (PM), the ability to remember to perform an intended task at a particular moment in the future, has recently emerged in studies of depressed individuals (Altgassen, Henry, Bürgler, & Kliegel, 2011; Altgassen, Kliegel, & Martin, 2009; Li, Weinborn, Loft, & Maybery, 2013; Rude, Hertel, Jarrold, Covich, & Hedlund, 1999). Attempts at characterizing the nature of this impairment have generally revealed PM performance deficits under conditions where PM retrieval involves a greater degree of self-initiation or strategic control. Conversely, significant depression-related PM deficits under conditions where PM retrieval is strongly prompted from the environment, and therefore is less attentionally demanding, have not been found. Importantly, while the extant literature has supported this general pattern of depression-related PM impairment, identification of more specific cognitive mechanisms underlying depression-related PM deficits remains inadequately studied.

In particular, the cognitive processes underlying time-based PM (remembering to perform a task at a specific time) have received little attention. Studies to date have found time-based PM impairment amongst depressed individuals (i.e., individuals formally diagnosed with clinical depression; Rude et al., 1999) or individuals with high depressive symptomatology (i.e., HDS - elevated self-reported depressive symptoms; Li et al., 2013), and that the underlying mechanisms of the time-based PM deficit may be related to reductions in the frequency with which individuals check the external clock (Rude et al., 1999). However, the role of internal cognitive control processes has not been examined. It is crucial to do so, because research with non-depressed samples has shown that participants tasked with time-based PM requirements can be slower to perform intervening ongoing tasks than participants without PM task requirements, suggesting that the demands of a time-based intention extend beyond the immediate need to check an external clock (Hicks, Marsh, & Cook, 2005; Huang, Loft, & Humphreys, in press; Marsh, Hicks, & Cook, 2006; Waldum & Sahakyan, 2012). These 'costs' to ongoing tasks may reflect the use of internal time-estimation strategies, or the attentional resources required to maintain the intent to make PM task responses, and/or to coordinate PM responses with ongoing task demands (Huang et al., in press). If depressed individuals have particular difficulties with these internal control processes, and if this is linked to their time-based PM deficits, then this knowledge could assist in the development of appropriate interventions to improve PM functioning. The objective of the current study was to evaluate differences in external (clock-checking)

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and internal control processes used by individuals with HDS and low depressive symptomatology (LDS, that is, those individuals who report minimal depressive symptoms) to remember to perform time-based PM tasks.

1.1. Neuropsychology of prospective memory

PM is not a unitary construct but involves a complex, coordinated interaction of multiple neurocognitive processes. Specifically, PM involves (a) intention formation (during which the intention is formed and encoded), (b) intention retention when the intention is maintained in memory while performing other ongoing activities, (c) intention initiation which involves recognizing the appropriate opportunity to execute an intention (the prospective component), and finally (d) the retrieval of the content of the intention (the retrospective component) and its execution (Kliegel, Martin, McDaniel, & Einstein, 2002). Several cognitive processes come into play in each of these phases (Ellis & Freeman, 2008). For example, the ability to effectively learn and consolidate intentions, and to retrieve intention-related contents, is dependent on retrospective memory. Successful intention initiation while engaged in a demanding ongoing task requires multiple inter-related executive processes, including the ability to strategically divide attentional resources between the competing ongoing task and PM task demands. Additionally, effective self-monitoring and response co-ordination are required to ensure that the intended PM action is executed in the correct manner when the time to do so has been correctly recognized.

Given the multiple processes involved in the successful completion of a PM task, it is unsurprising that neuroimaging studies have implicated a distributed network involving multiple neural regions. This includes the rostral prefrontal cortex (Brodmann area 10), thought to be involved in executive processes (e.g., planning, monitoring, strategic attention allocation) and the prospective component (Burgess et al., 2008), and the hippocampal complex which appear to be involved in the retrospective component of PM tasks (Burgess et al., 2008; Okuda et al., 1998; West, 2008).

1.2. Neurocognitive and prospective memory deficits in depression

Depression is associated with neurostructural abnormalities such as reduced gray matter volume in the hippocampus, prefrontal cortex, cingulate cortex, and striatum; and neurochemical dysregulation in the dopaminergic, serotonergic and cholinergic systems (Drevets, Price, & Furey, 2008). Further, while some individual variability exists, group-level neurocognitive deficits in depression such as disturbances in executive function, attention, memory, and speed of processing have been documented (Clark, Chamberlain, & Sahakian, 2009). As can be seen, some of the neuroanatomical and neurocognitive processes affected by depression are also implicated in normal PM functioning, suggesting that PM impairments are more likely in depressed individuals or those with HDS. To better predict the nature of PM impairment in depression, a particular theoretical framework, the cognitive initiative hypothesis (Hertel, 2000) has been drawn upon (e.g., Altgassen et al., 2009; Li et al., 2013). Specifically, the cognitive initiative hypothesis proposes that depression is associated with a reduced initiative to direct attentional resources to relevant tasks. Subsequently, researchers investigating PM function in depression or HDS have predicted deficits to emerge primarily under conditions that depend on strategic resource allocation.

For example, in the event-based PM literature, it has been reported that depressed participants performed more poorly than matched control participants when PM targets were non-focal to the processing required for the ongoing task (Altgassen et al., 2009; Chen, Zhou, Cui, & Chen, 2013), but not when they were focal to ongoing tasks (Altgassen et al., 2009) or salient (i.e., presented in red bold font, Albiński, Kliegel, Sędek, & Kleszczewska-Albińska, 2012). For time-based PM, early work by Rude et al. (1999) found that when depressed participants were required to perform a habitual time-based PM task (i.e., press a key every 5 min), they checked the clock less often and had poorer time-based PM performance than non-depressed participants. Li et al. (2013), using a clinical semi-naturalistic measure of PM (the Memory for Intentions Screening Test), found poorer PM performance for HDS participants compared to LDS participants on time-based PM tasks and PM tasks with longer delay intervals (15 min), but not on event-based PM tasks, or PM tasks with shorter delay intervals (2 min). Note however that Li et al. did not measure clock-checking behavior in the time-based PM tasks. In contrast, Albiński et al. (2012) reported better time-based PM performance (i.e., the PM task was to stop a story-reading task after 4 min) and significantly more clock-checking in the final minute preceding the target time, for HDS participants compared to non-depressed participants. Albiński et al. speculated that perhaps the mild rumination in their HDS sample might have functionally kept their time-based intention heightened compared to the non-depressed participants, and that this facilitated PM performance. We return to this rather surprising finding of the Albiński et al. (2012) study in the Discussion section.

1.3. Current study

The current study was concerned with the relationship between depressive symptomatology and time-based PM. Notably, none of the three aforementioned studies that investigated this relationship (Albiński et al., 2012; Li et al., 2013; Rude et al., 1999) incorporated a baseline condition in which participants performed the ongoing task without PM demands. That is, PM task demands were always embedded in the ongoing task. Rude found significantly poorer ongoing task performance (general knowledge test) in the depressed participants compared to the non-depressed participants, whereas Li et al. and Albiński et al. found no difference between HDS and LDS groups on an ongoing word-search puzzle task and story-reading task, respectively. However without a non-PM baseline condition in these studies, it is not possible to compare the extent to which depressed or HDS participants and matched control participants allocated attentional resources to internally control their time-based PM task demands. Therefore, we incorporated a non-PM baseline to compare changes in ongoing task performance (i.e., costs) for HDS and LDS participants that resulted from time-based PM demands.

The current study presented participants with an ongoing lexical decision task that required them to remember to press a specific key after 4, 8 and 12 min had elapsed. We chose a lexical decision task because this task has been proven to be a sensitive measure of costs in PM paradigms (Hicks et al., 2005; Huang et al., in press; Loft & Yeo, 2007; Waldum & Sahakyan, 2012). Based on our preceding analysis of neurocognitive deficits in depression (e.g., Clark et al., 2009; Hertel, 2000) and past empirical research, our predictions were as follows. Firstly, given that two out of the three time-based PM studies conducted to date have found PM deficits with depression or HDS (Li et al., 2013; Rude et al., 1999), we expected HDS participants to have poorer time-based PM performance than LDS participants. We also expected that HDS participants would check the clock (external control; Huang et al., in press) less often than LDS participants (Rude et al., 1999). In addition, we expected greater costs to ongoing tasks for LDS participants compared to HDS participants, reflecting the fact that LDS participant would be more likely to use internal control strategies. To the extent that internal control strategies adopted by participants increase the likelihood of successfully making time-based PM responses, response times to the lexical decision task and PM accuracy should be positively correlated.