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## Abstract

This study examined the degree to which having an established time-based intention interferes with a primary, ongoing task. Participants were assessed for reading comprehension in order to detect performance differences between 3 conditions, which included a control condition, a regular time intention condition that performed an intention every 3 minutes, and an irregular time intention condition that performed an intention at different lengths of time. Action-state orientation and working memory span were also assessed in order to examine their roles in intention interference. Results showed that the control condition had higher reading comprehension performance than the regular time intention condition. Also, working memory span was correlated with reading comprehension but overall action-state orientation did not correlate with any measures.

# Time-Based Intentions and Individual Variables: An Examination of Performance Patterns in Prospective Memory

One distinction made in memory research is that between retrospective and prospective memory. Traditionally, most psychologists have researched retrospective memory, which is memory for past experiences. Some examples of retrospective memory include recalling what one had for lunch 3 days ago or the combination to one's locker. However, within the last two decades, the amount of literature that has been published on prospective memory (PM), or remembering to perform intentions in the future, has progressively increased. This movement has been spurred by the potentially far-reaching implications of PM for everyday life. For example, people often must remember to keep appointments, or to relay a message to a friend or co-worker when encountered. PM therefore refers to the processes by which people establish intentions to perform some action at a later point in time and then remember to complete those intentions in the appropriate context. PM itself involves at least two separate components: the retrospective content of the intention (e.g., "give message to coworker") and the prospective aspect of fulfilling the intention at the appropriate time (e.g., delivering the message).

Given its everyday applicability, PM merits a thorough exploration in order to learn about how it functions in the context of naturalistic experiments with solid ecological validity (Ceci & Bronfenbrenner, 1985; Kvavilashvili, 1998; Sellen, Louie, Harris, & Wilkins, 1997; Vortac, Edwards, & Manning, 1995). Nonetheless, Ellis (1996) cautions researchers against conceptualizing and treating PM as a separate memory process, noting that PM has elements of retrospective memory as discussed earlier. In

fact, Ellis suggests the phrase "realizing delayed intentions" over PM because intentions play such a vital role in remembering future actions. Thus, it is important to explore research dealing with intentions.

*Intentions*

One important issue that affects participant performance in studies on intentions is whether or not the PM task is primary or secondary (Ceci & Bronfenbrenner, 1985; Kvavilashvili, 1998; Sellen et al., 1997; Vortac et al., 1995). Intentions are traditionally conceptualized as secondary in experimental research to simulate their typical analogues in naturalistic settings. For example, when the intention to pick up groceries on the way home is established, that intention is typically treated as secondary to the primary ongoing activities of one's workday. Clearly, some intentions are considered more important and therefore may receive relatively more attention, but delayed intentions are, on average, relegated to the background after they are established. The intention only has the potential to receive more consideration with the approach of the context in which that intention is meant to be retrieved. In addition, people of certain personality types may be more likely on average to ruminate or perseverate on uncompleted goals and intentions (Goschke & Kuhl, 1993).

In a study examining time-checking behaviors of children monitoring ovens and battery chargers, participants were focused mainly on the PM component of the experiment and played a video game as a secondary task (Ceci & Bronfenbrenner, 1985). Their performance was near ceiling on the PM task (Ceci & Bronfenbrenner, 1985). However, in another study that featured an air traffic control scenario, participants who treated the successful coordination of airplanes as the primary task and were not

continuously aware of the PM component did not perform close to ceiling (Vortac et al., 1995). In fact, in Sellen et al.'s (1997) study of PM in the workplace, participants actually performed near the floor in some situations, reinforcing the notion that adding an action to one's normal routine is harder than inhibiting a routine action (Ellis, 1996). This is supported by Kvavilashvili's (1998) findings that participants who knew the true purpose of the experiment (examining PM) and the means by which it was being studied remembered to perform their intention significantly better than those who did not know that PM was being studied. Thus, in order both to have a measure that was sensitive enough to detect the effects of intentions on an ongoing task and to mask the behaviors of interest, the PM task was secondary and the ongoing task was primary in this study.

*Event- and Time-Based Cues in Prospective Memory*

Event-based, or episodic, PM tasks are defined as those that require one to remember to execute an intention whenever one encounters a specific person or object, or gets to a certain point in a task (Ellis, 1996; Sellen et al., 1997). For example, placing a book by the door as a reminder to return it to the library is an event-based PM task because encountering the book brings the intention to mind. However, time-based, or anchor-point, tasks require an individual to remember to execute an intention at a certain point in time (Ellis, 1996; Sellen et al., 1997). Remembering to attend a 3 o'clock meeting is an example of a time-based intention because the action must be performed at a certain time. Several important findings about time-based PM tasks that are relevant to this study were reported by Ceci and Bronfenbrenner (1985). In their experiment, Ceci and Bronfenbrenner (1985) instructed children to remember either to take cupcakes out of an oven or to turn off a battery charger after thirty minutes. Time monitoring behavior

revealed that participants checked the clock regularly at the beginning of the time interval, checked the clock infrequently during the middle of the interval, and increased time-checking frequency towards the end of the interval, producing a J-shaped curve (Ceci & Bronfenbrenner, 1985). In addition, it was reported that participants who checked the clock less frequently were more likely to forget to execute the intention than individuals who checked the clock more often (Ceci & Bronfenbrenner, 1985). Lastly, Ceci & Bronfenbrenner (1985) described two different types of time monitoring: anxious and strategic. While anxious time-monitors checked the clock more frequently and continuously, strategic time-monitors checked the clock less often and at strategic points, enabling them to engage in other activities (Ceci & Bronfenbrenner, 1985). Ceci & Bronfenbrenner (1985) attributed the strategic time monitoring behavior to the individuals' abilities to "synchronize their psychological clocks," or attune their own sense of time passage to the actual passage of time. Thus, it appears that people can become routinized with respect to time-based intentions.

*Primary Interest*

Research on PM to date has focused on factors that affect primarily the retrieval of intentions in an appropriate context (e.g., what characterizes an effective event-based cue, differences between older adults and younger adults). However, only a limited amount of research has focused on the potential cost to the establishment of intentions on other behaviors. This study was designed to test the degree to which having an established intention disrupts performance on a primary, ongoing activity. Prospective memory situations are inherently dual-task situations. That is, delayed intentions are generally secondary to the primary activity in which one is engaged (e.g., reading,

watching television, working). It could be the case that once an intention is encoded, it does not manifest itself again (i.e., occur to one) until the appropriate time, leaving ongoing activities unaffected. However, a recent hypothesis proposed by Smith (1999) is that establishing intentions will produce a cost to the performance of ongoing activities. Smith (1999) argues that people monitor their environments for the appropriate cues for the initiation of their intentions, and that this monitoring requires cognitive resources. Thus, according to Smith (1999), ongoing activities should suffer because of the resources being allocated to monitoring.

To test her hypothesis, Smith used a lexical decision task (LDT) as her primary, ongoing cognitive activity. For an LDT, people are asked to decide whether a string of letters represents a valid English word (e.g., TABLE) or a nonword (e.g., FLURBLE) as quickly and accurately as possible. The important measure during this task is how quickly the decision is made. Smith had two groups of participants complete the LDT, which included over 300 trials. The prospective, experimental group was given an intention to hit the F1 key on a computer keyboard whenever they encountered one of six target words. The control group was told that these words would be relevant in a later task in the experiment, making them irrelevant to the LDT itself. Smith (1999) found that participants in the experimental condition responded significantly slower to all non-target words and nonwords on the LDT. Furthermore, participants in the experimental condition who performed at or above the mean on the PM task had significantly slower reaction times than those who performed below the mean.

To date, only one published study has examined the effects of time-based intentions on an ongoing task, though the study was potentially flawed. Sarason,

Sarason, Keefe, Hayes, and Shearin (1986) found that participants who had to keep track of time by turning around and checking a clock directly behind them made significantly more errors on a proofreading task than those who did not monitor time. However, in the proofreading task, participants listened to a philosophy essay and made corrections if what they heard differed from what they read, allowing for the possibility that participants missed the error on the page while physically turning around to check the clock. Thus, it is not conclusive from this study whether or not merely having an intention negatively affects performance on an ongoing task. Given the suggestive nature of Smith's (1999) results in an event-based task, coupled with the methodological ambiguity of Sarason et al. (1986), this study was designed to explore the potential cognitive load produced by the establishment of a time-based intention. However, unlike Smith's (1999) and Sarason et al.'s studies, this study also measured an important personality dimension that is related to the fulfillment of goals and intentions as a potential correlate with performance.

*Action-State Orientation*

One potential predictor of performance on a time-based PM task is one's action-state orientation (Diefendorff, Hall, Lord, & Strean, 2000; Goschke & Kuhl, 1993). Action oriented individuals are more successful at focusing on an ongoing task while state oriented people tend to think more about past activities or future goals (Diefendorff et al., 2000; Goschke & Kuhl, 1993). For example, in the event that an individual gets caught in traffic and misses an appointment, an action oriented person could easily forget about the incident and move onto something else while a state oriented person would have a hard time starting a new task. Goschke and Kuhl (1993) used action-state

orientation, which is usually associated with goal theory, as a potential correlate with performance on a PM task. Interestingly, it was found that state oriented individuals recognized words related to a prospective task significantly faster than the action oriented individuals (Goschke & Kuhl, 1993). In addition, state oriented participants ruminated on the prospective task significantly more than the action oriented participants when an external cue was present (Goschke & Kuhl, 1993). One potential consequence of this rumination is that state oriented individuals have fewer available cognitive resources for goal-striving (Diefendorff et al., 2000) and successfully completing ongoing tasks. The revised Action Control Scale (Diefendorff et al., 2000), which assesses action-state orientation, was administered to participants to assess its potential moderating effects.

*Elements of the Design*

This study examined the effects of intentions on participant performance on a reading task. Only one known published study has examined whether or not time-based intentions have a detrimental effect on a primary task (Sarason et al., 1986).

Although several studies have investigated the nature of event- and time-based PM (e.g., what conditions cause the most forgetting, when and how people remember intentions), no research to date other than Smith's (1999) dissertation has tried to examine the effects of intentions on a primary task. This may be because many participants perform at ceiling on their primary tasks in PM experiments (Ceci & Bronfenbrenner, 1985; Ellis, 1996; Goschke & Kuhl, 1993; Kvavilashvili, 1998; Sellen et al., 1997; Vortac et al., 1995). Nonetheless, past research suggests that intentions might cause interference on ongoing activities because they easily or frequently come to mind (Ceci & Bronfenbrenner, 1985; Goschke & Kuhl, 1993; Sellen et al., 1997). For

example, Goschke and Kuhl (1993) demonstrated that participants recognize words from descriptions of actions that subjects had to perform later (the prospective condition) faster than they recognized words from descriptions of actions that they did not have to execute. Furthermore, the decrease in recognition time was more pronounced just before the execution of the action. Similarly, other research indicates that, in laboratory experiments, delays between the encoding of the intention and its execution do not significantly affect performance (Ellis, 1996; Goschke & Kuhl, 1993; Kvavilashvili, 1998; Vortac et al., 1995). Both of these findings suggest that intentions have a high sub threshold activation, which suggests that it will be potentially useful to investigate intention interference on an ongoing task.

In the present study, intention interference on a reading task was measured in terms of reading comprehension for text that was presented on a computer at a fixed rate. Presumably, having an intention would slow down one's reading rate and cause one to miss some of the presented material. As such, reading comprehension for the entire passage was assessed at the end of the study with multiple-choice questions. In addition, retrieval time was measured for the reading comprehension questions. Thus, the chances of detecting the potential detrimental effects of intentions on reading were increased by examining both the extent of knowledge about the text's information and the speed with which the information was recalled. This could enable the emergence of a more complete picture of intention interference.

Time-based intentions were chosen over event-based intentions for this study because less research has been conducted on time-based PM. Also, it is thought that time-based intentions are harder to remember than event-based intentions (Sellen et al.,

1997), meaning that potential detrimental effects on primary tasks would be more likely to surface with a time-based task.

The three conditions in this study consisted of a control group, a time-based intention group that pressed a key on a computer keyboard every 3 minutes, and a time-based intention group that pressed a key at irregular time intervals. Whereas the first two groups provided useful data about the basic nature of time-based PM, the latter condition was included in order to increase the ecological validity of the study. In everyday life, actions commonly must be performed at irregular intervals. For example, restaurant chefs must prepare several dishes at once and each dish must be checked at different times. Thus, the experiment was designed to yield both basic and more applied information about intentions.

Since reading ability could be affected by working memory span (Duff & Logie, 2001; La Pointe & Engle, 1990), a measure was used to assess for this individual difference. La Pointe and Engle's (1990) combined task, which joins an arithmetic verification task with a memory task, assesses both processing (participants must make a decision about whether or not the given equation is true or false) and recall ability (participants must remember the word presented at the end of the equation). In addition, the measure correlates highly both with reading comprehension and with another working memory span (WMS) measure that uses a sentence verification task (Duff & Logie, 2001; La Pointe & Engle, 1990). Thus, researchers agree that the task is a good measure of one's capacity to handle cognitive load (Duff & Logie, 2001; La Pointe & Engle, 1990).

In order to examine the effects of intentions on reading performance in light of personality differences, the revised ACS, or Action Control Scale (Diefendorff et al.,

2000) was administered to participants. The revised ACS features a Preoccupation dimension that measures the degree to which participants ruminate on irrelevant goals and events, a Hesitation dimension that measures the degree to which participants have difficulty initiating action, and a Volatility dimension that measures the degree to which participants can stay focused on a task (Diefendorff et al., 2000). Thus, the revised ACS is largely an overall assessment of action-state orientation, an enduring personality characteristic. For example, participants were asked to rate how often they have thought about their level of ability or personal concerns on several occasions in the past. As such, the revised ACS could possibly aid in attaining a more complete picture of intention interference.

Even though some standardized measures of individual differences were assessed and controlled for, a standardized measure of reading comprehension was not administered to participants. One reason for this is that the control group, which simply read the passage without having any intention demands, provided a solid baseline for average reading comprehension performance. Also, studies show that WMS correlates with reading comprehension (Duff & Logie, 2001; La Pointe & Engle, 1990), so a lack of significant differences between groups on this measure would suggest the absence of major significant differences between groups in overall reading comprehension abilities. Lastly, Kvavilashvili (1998) did not assess for reading comprehension in her study examining event-based intentions, relying upon random assignment to distribute individual differences evenly.

*Hypotheses*

Hypothesis 1 (Reading Comprehension): Individuals in the irregular time intention condition will perform worse in terms of reading comprehension question performance than those in the regular intention condition, who will perform worse than the control condition. It is hypothesized that the regular intention condition will perform better than the irregular intention condition both because of Ceci & Bronfenbrenner's (1985) finding that participants calibrated their personal sense of time with the actual passage of time (varying intervals of time in the irregular intention condition will inhibit such calibration) and because the routinization of time will reduce cognitive load.

Hypothesis 2 (Time checking): Ceci & Bronfenbrenner's (1985) study suggested that some participants monitored the time less frequently because they were able to calibrate their internal time clocks. Therefore, it is predicted that participants in the irregular intention condition may not be able to calibrate their internal time clocks and may subsequently display more consistent time monitoring behavior. Also, the number of times an individual checks the clock will correlate negatively with reading comprehension and reading comprehension retrieval time. Lastly, also based on Ceci & Bronfenbrenner's (1985) study, it is hypothesized that those who check the clock less often will be less likely to perform the intention on-time and more likely to perform it late.

Hypothesis 3 (Working memory span): Performance on the measures of reading comprehension and reading comprehension retrieval time will correlate positively with WMS performance. In addition, people with a higher WMS will have better on-time PM performance.

Hypothesis 4 (Action-state orientation): ACS score will correlate negatively both with reading comprehension retrieval time and with total number of time checks.

## Method

### *Participants*

Sixty undergraduates at Louisiana State University were randomly assigned to one of 3 conditions. Participants either were psychology students who participated in the study in order to receive extra credit or were recruited by the experimenter. All participants were native English speakers.

### *Materials*

The passage selected for the study was taken from a book chapter that traces the development of research in and the conceptualization of cancer. Specifically, it was chosen because of its moderate level of difficulty. That is, the text is neither as easy to read as a magazine article (e.g., *Reader's Digest*) nor as difficult to read as a scholarly journal article. Also, the text's fact-based nature serves as better material from which to formulate reading comprehension questions than a short story or other similar material. Each comprehension question was based on 2-4 sentences of text and sample questions are located in Appendix A. The comprehension questions were tested in a pilot study and only those questions to which 50-85% of participants respond correctly were included in the study itself in order to avoid both ceiling and floor performances. In addition, the control group performance was also tested to make sure that its responses to questions fell within the same range.

Both the reading passage and reading comprehension questions were presented on a personal computer. The computer presented two sentences of text per screen at a fixed

rate based upon a report by Carver (1990). According to Carver (1990), the average reading rate of an undergraduate college student is 280 words per minute, or 4.67 words per second (WPS), when reading a college reading-level passage. However, participants in a pilot experiment reported difficulty in keeping up with the 4.67 WPS rate of text presentation. Subsequently, one full second was added to each screen in order to facilitate reading. Upon completing the reading task, participants answered multiple choice reading comprehension questions that were presented on the screen. Participants pressed the letter on the keyboard corresponding to their chosen answer. Reading comprehension response times were recorded by the question program on the personal computer.

In order to record the clock checking times of individuals in the regular and irregular intention conditions, a laptop computer with a stopwatch program was used by participants. The laptop, which was angled so that participants could not see the time with their peripheral vision, was positioned to the right of the personal computer that was presenting the reading passage. Participants used the stopwatch program to monitor time and were instructed to left click on the stopwatch's "Lap" button using a computer mouse every time they checked the clock. The program recorded the times for each "Lap" button press and the experimenter closely monitored the participants to ensure that participants were performing the task correctly. After reading the passage and answering the questions, participants performed a WMS task.

The WMS task used in this study was modeled after La Pointe and Engle's (1990) computer program. Each trial consisted of a mathematical operation and a word that were seen together on the same screen. An example trial is: (7 x 1) + 6 = 13? table.

Participants read aloud the mathematical operation and immediately made an oral decision as to whether the operation was true or false. The participants then read the word presented at the end of the operation aloud and pressed the "J" key if the operation was true or the "F" key if the operation was false. The program randomly generated the operations and words without replacement (i.e., once an operation or word was used for a participant, it could not be used again) and the operation contained both a multiplication/division element and an addition/subtraction element. Integers used for the operations were between 1 and 10 and the answers to the division and multiplication elements were integers. Incorrect answers were always within two integers of the correct answer and approximately half of the operations were incorrect. The blocks of trials varied in length from 2 to 5 trials and there were four blocks of trials for each of the four lengths. Thus, each participant saw 16 blocks of trials. Half of the blocks of trials featured long words while the other half used short words, and participants had to recall the words at the end of each block of trials. Only words from the most recently seen block of trials were recalled, and participants recalled the words by typing them in when the computer program prompted them with a question mark.

After the WMS task, participants completed the revised version of the ACS (Diefendorff et al., 2000). Sample items are located in Appendix B. The revised version differs from the original version in that the Preoccupation, Hesitation, and Volatility subscale items with factor loadings below 0.48, 0.72, and 0.39, respectively, are omitted. The revised ACS (Diefendorff et al., 2000) is a forced-choice measure that assesses individuals' action-state orientations by presenting them with a statement or situation (e.g., when something really gets me down) and gives them two options to complete the

situation (e.g., they decide between responding: A. I have trouble doing anything at all, and B. I find it easy to distract myself by doing other things).

*Procedure*

All participants began the experiment by completing a consent form upon entering the lab. Individuals wearing watches were told to remove them. They were instructed that they would read a lengthy passage about the early history of cancer research on the computer screen, that the computer would present 2 sentences per screen, and that the computer would automatically advance to the next screen without the option of returning to a previous screen. At this point, participants in the intention conditions were shown the computer clock and how to check it; they were also told that they would need to use the clock later during the reading portion of the experiment. Participants were told that they would answer questions about the passages at the end of the study. In addition, participants in the intention conditions were told that, after the first few screens, a sentence would appear instructing them to press the "Enter" key in a certain amount of time.

Participants read through 6 screens of text. In the control condition (Group 1), participants simply continued to read the passage for the remaining 10 minutes. However, in the two intention conditions, the instruction sentences began appearing. In Group 2, or the regular intention condition, the instruction sentences indicated to participants each time that they should press the "Enter" key in three minutes. In the irregular intention condition, or Group 3, the instruction sentences told participants to press "Enter" after two, four, and three minutes, respectively. Thus, there were an equal number of intentions in both conditions (three intentions) and the total intention interval

time was also equal (9 minutes). After the target time had passed, participants were given about 20 s to remember to press "Enter" before the new instruction sentence appeared. For example, in the irregular intention group, the first instruction sentence appeared at one minute and informed the participant that the intention interval was two minutes. The participant had until 3 minutes and 20 s of elapsed time to respond before the next instruction sentence would appear. Participants used the laptop computer clock program to monitor the passage of time throughout the intention intervals. The times for all of the "Enter" presses were recorded by the experimenter.

At the end of the allotted eleven minutes, individuals took a reading comprehension test in order to assess their knowledge of the passage. The questions covered material throughout the passage. Also, the computer measured the reading comprehension question response times of the participants. Immediately following the reading comprehension questions, participants performed the WMS task (La Pointe & Engle, 1990) and completed the revised ACS (Diefendorff et al., 2000). At the end of the study, all participants were debriefed.

## Results

Although a pilot study was conducted to prevent floor and ceiling performances on any one reading comprehension question, the control group answered 3 of the 16 questions correctly at least 90% of the time. In order to assess for any potential statistical discrepancies, analyses were run using both the entire set of 16 questions and the smaller set of 13 questions. The inclusion of the 3 questions did not change any of the results and therefore all reported reading comprehension statistics use all 16 questions.

In their study, La Pointe and Engle (1990) scored their WMS task in 4 different ways and found no major inconsistencies in the results. For this study, overall WMS was calculated by simply adding the total number of words recalled correctly. In addition, WMS for both long words and short words were also calculated by adding the respective number of words recalled correctly in each subgroup.

For the PM task, participants had to press the "Enter" key in the amount of time dictated by the intention sentence. On-time PM performance was defined as intention execution 10 seconds before and after the halfway point of the 5 seconds long intention screen. For example, if the intention sentence is on the screen from 2:00 to 2:05, then the halfway point of the screen is 2:02.5. Therefore, in this example, the on-time range would be from 1:52.5 to 2:12.5. Although the 20 seconds range of time is liberal, a more conservative time range of 10 seconds (defined as intention execution 5 seconds before and after the halfway point of the 5 seconds long intention screen) was also used and showed the same PM performance trends as the liberal range. Therefore, the more liberal range was used. Late PM performance was defined as intention execution after the upper limit of the 20 seconds on-time range but before the presentation of the next intention sentence. Continuing with the above example, the late PM range would be after 2:12.5 but before the presentation of the next intention sentence.

In order to check for random assignment, a one-way analysis of variance (ANOVA) was performed on total ACS score, total WMS, and reading comprehension scores on the 3 questions about material that was presented before the intention groups saw their first intention sentence. The three conditions did not significantly differ from each other on total ACS score, $F(2, 58) = .79, p > .10$, total WMS, $F(2, 58) = .65, p > .10$,

or reading comprehension for the first 3 questions, $F(2, 58) = 1.57, p > .10$. All statistical analyses reported in the results and discussion sections maintain a .05 probability of Type I error.

The data for one participant in Condition 2, the regular intention group, was not included in statistical analyses due to abnormally low reading comprehension performance. The participant's score was 7.00, or more than two standard deviations below the mean, and was therefore removed from all analyses.

*Primary Analyses*

*Reading comprehension.* Reading comprehension performance between the three conditions was analyzed using a one-way ANOVA, and the results were significant, $F(2, 58) = 3.94, p < .05$. A Tukey HSD comparison showed that the mean percentage of the control condition (72.50) was significantly different from the mean percentage of the regular intention condition (58.22). The irregular intention condition ($M = 60.63$) did not differ significantly from either of the other conditions.

Because participants in the regular and irregular intention conditions had to check the clock while reading the passage, some of them missed screens that contained the answers to the reading comprehension questions. In order to assure that performance differences were not caused by missed information, reading comprehension performance was also assessed for only the questions that corresponded to non-missed screens. The screens of missed information pertaining to reading comprehensions were determined by examining the clock checking times recorded by the stopwatch program on the laptop computer. This valid reading comprehension (VRC) performance was also analyzed using a one-way ANOVA and the results were still significant, $F(2, 58) = 3.69, p < .05$.

A Tukey HSD comparison again showed that the control condition ($M = 72.50$) was significantly different from the regular intention condition ($M = 58.33$) and that the irregular intention condition ($M = 60.52$) did not significantly differ from either of the other conditions. Descriptive statistics for VRC percentage are located in Table 1. All other statistical analyses performed on reading comprehension use VRC instead of reading comprehension scores that include questions about missed information. The average number of missed question information screens for the regular intention condition was 1.95 and the irregular intention condition averaged 2.20 missed screens. An independent samples t test showed that this difference was not significant, $t(37) = -.55$, $p > .10$, indicating that, on average, the same number of reading comprehension questions were taken out of analyses for both intention conditions.

*Time checking.* Total number of time checks between the regular ($M = 8.11$) and irregular ($M = 10.05$) intention conditions were analyzed using an independent samples t test and results were not significant, $t(37) = -1.54$, $p > .10$. In addition, time checking rates were calculated for each of the three time intervals by dividing total number of checks in an interval by the number of minutes in that interval. Thus, the rates reflect number of checks per minute. While the regular and irregular conditions did not differ significantly on time checking rates for the second and third time intervals, the results of an independent samples t test showed that the checking rate for the first time interval in the regular interval condition ($M = 1.11$) differed significantly from the irregular interval condition ($M = 1.58$), $t(37) = -2.04$, $p < .05$. Descriptive statistics for the time checking rates for each time interval are located in Table 2. Although total number of time checks did not correlate significantly with either VRC percentages or on-time PM performance,

a Pearson product-moment analysis shows that the correlation between total number of time checks and VRC retrieval time (or the average response time for the questions that correspond to the non-missed screens) was significant, $r(39) = .45, p < .05$. Total number of time checks did not significantly correlate with late PM performance.

*Working memory span.* A Pearson product-moment analysis showed that total WMS and VRC percentages were significantly correlated, $r(59) = .31, p < .05$. In an examination of the working memory subsets, a Pearson product-moment analysis indicated that the correlation between WMS for long words (WMS-L) and VRC percentages was also significant, $r(59) = .35, p < .05$. However, a similar correlation between WMS for short words (WMS-S) and VRC percentages was only marginally significant, $r(59) = .23, p < .10$. Table 3 lists the correlations between VRC percentage and each of the WMS scores. Neither on-time PM performance nor VRC retrieval time significantly correlated with total WMS, WMS-L, or WMS-S.

*Action-state orientation.* The ACS was scored by assigning a value of 1 to answers that were action oriented and a value of 0 to answers that were state oriented. Therefore, a high score on total ACS or 1 of the 3 subscales indicates an action orientation. For example, individuals with high scores on the Hesitation subscale do not have trouble initiating action, whereas those with low scores do have trouble initiating action. Total ACS score, and the Volatility and Preoccupation subscales, did not significantly correlate with total WMS, WMS-L, WMS-S, VRC percentage, VRC retrieval time, on-time PM performance, or total number of time checks. The Hesitation subscale did not correlate significantly with any of the above measures except for WMS-L words and total number of time checks. A Pearson product-moment analysis showed a

significant correlation with both WMS-L, $r(59) = -.28, p < .05$, and total number of time checks, $r(39) = .33, p < .05$.

*Secondary Analyses*

The mean number of on-time PM performance was only 1.58 (or 53%) for the regular intention condition and 2.30 (or 77%) for the irregular intention condition. An independent samples t test was run on total on-time PM performance between the regular and irregular intention conditions was significant, $t(37) = -2.26, p < .05$. Only participants in the regular intention condition executed intentions late. Subsequently, late PM performance between the regular ($M = .26$) and irregular ($M = 0$) intention conditions was analyzed using an independent samples t test. A Levene's test for equality of variances was violated, $F(37) = 65.59, p < .05$, and the corrected statistic for equal variances not assumed was used. The corrected t test showed that the difference was significant $t(18) = 2.54, p < .05$. A one-way ANOVA was also run on VRC retrieval time between the control ($M = 19451.91$ ms), regular intention ($M = 20381.66$ ms), and irregular intention ($M = 22485.10$ ms) conditions and was only marginally significant, $F(2, 58) = 2.60, p < .10$. Descriptive statistics for VRC retrieval times are located in Table 4.

In order to assess whether or not WMS differentially affected individuals' reading comprehension scores in the intention conditions, a two way between subjects ANOVA was run. In order to run the analysis, individuals were placed into one of two groups based upon total WMS. Participants with total WMS scores above the mean ($M = 40.66$) were in the high span group and those with scores below the mean were in the low span group. VRC percentages were analyzed with a 2 x 2 (WMS Group x Intention

Condition) ANOVA. The results showed that there were no significant main effects of both WMS group, $F(1,38) = .93, p > .10$, and intention condition, $F(1,38) = .12, p > .10$. In addition, the WMS Group x Intention Condition interaction was not significant, $F(1, 38) = .11, p > .10$.

A two way between subjects ANOVA was run in order to assess whether or not there was a tradeoff between reading comprehension and on-time PM performance as a function of WMS. Individuals were placed into one of two groups based upon total WMS for long words. Participants with WMS for long words (WMS-L) scores above the mean ($M = 19.00$) were in the high span group and those with scores below the mean were in the low span group. Similarly, participants in the intention conditions were divided into two groups based upon on-time PM performance. Participants who performed the intention on-time for all three intervals were in the high PM group, whereas those who performed the intention on-time for two or fewer intervals were in the low PM group. VRC percentages were analyzed with a 2 x 2 (WMS-L Group x PM Group) ANOVA. The results showed that there was not a significant main effect of PM group, $F(1,38) < .01, p > .10$. However, there was a significant main effect of WMS-L group: individuals in the high WMS-L group ($M = 66.20$) had significantly higher VRC percentages than those in the low WMS-L group ($M = 53.40$), $F(1,38) = 6.06, p < .05$. In addition, the WMS-L Group x PM Group interaction was significant, $F(1, 38) = 5.57, p < .05$. Descriptive statistics for the subgroups within the interaction are located in Table 5 and Figure 1 illustrates the two-way interaction. Similar analyses run on VRC percentage between PM group and either overall WMS group or WMS-S groups instead of WMS-L group did not produce any statistically significant findings.

## Discussion

### *Reading Comprehension*

As hypothesized, the VRC percentages seem to indicate that having an intention interferes with cognitive processing on the ongoing reading task. Even though the VRC percentages of participants in the irregular intention condition ($M = 60.52$) did not statistically differ from those in the control condition ($M = 72.50$), the difference between the two means suggests that adding more participants to each condition would render the difference statistically significant. The significant difference found between the VRC percentages of the control and regular intention conditions corroborates with Smith's (1999) findings that the slower LDT decisions made by individuals in an event-based intention condition demonstrated that the intention exacted a cognitive load. However, the significant difference in percentages between the control and regular intention conditions could be caused by the fact that individuals in the two intention conditions missed screens of text when checking the clock. Though questions pertaining to screens of missed information were removed from analyses, it may be the case that missing any information could negatively affect VRC percentages because the narration of the passage would be disrupted, rendering other information harder to comprehend. It could also be the case that missing some screens has a more negative impact on reading comprehension than missing other screens. Therefore, a smaller control study was run to explore these possibilities.

*Post hoc control experiment.* Thirty-two individuals from the same population as the main experiment were randomly assigned to one of two conditions. Both conditions only saw half of the passage's screens. Control group 1 saw the odd numbered screens

and control group 2 saw the even numbered screens. An independent samples t test was run on reading comprehension (all 16 questions) between control group 1 ($M = 48.83$) and control group 2 ($M = 53.13$) and showed that the difference was not significant, $t(30) = -.74$, $p > .10$. This suggests that the screens that an individual missed, regardless of whether or not they answered a reading comprehension question about it, did not differentially affect overall reading comprehension. However, 8 of the 16 questions covered material that was seen on two consecutive screens. As such, both conditions missed half of the information for half of the questions. Subsequently, mean reading comprehension percentages were calculated for the questions both that corresponded to only one screen and that the respective conditions did not miss. An independent samples t test was run on this more valid reading comprehension score between control group 1 ($M = 60.42$) and control group 2 ($M = 75.00$). A Levene's test of equality of variances was violated, $F(30) = 8.59$, $p < .05$, and the corrected analysis showed that the difference between the control groups was not significant, $t(22) = -1.27$, $p > .10$. This seems to indicate that, because the mean percentages of the two conditions were not significantly different, reading comprehension for non-missed screens was not differentially affected by which screens were missed.

Even though the valid reading comprehension percentages were not significantly different between the two control groups, the two valid reading comprehension percentages appear very different. Also, control group 1's mean reading comprehension percentage is well below the mean VRC percentage of the control condition in the main experiment ($M = 72.50$). These odd findings may be explained by both the large number of screens missed and the small number of valid reading comprehension questions in the

control experiment. Both of the groups in the post hoc control experiment missed half of the 70 screens of text. However, the two intention conditions in the main experiment missed an average of about 9 screens. Subsequently, the participants in the post hoc control experiment were at a severe disadvantage and still managed to perform above chance on reading comprehension for all 16 questions. In addition, there were only 6 valid reading comprehension questions for control group 1 and a paltry 2 valid reading comprehension questions for control group 2. In the two intention conditions in the main experiment, by contrast, there were an average of about 14 valid reading comprehension questions. Therefore, even though the two control experiment groups performed well in spite of missing half of the screens, no definitive conclusions can be drawn from the data because of the low number of valid reading comprehension questions.

*Time Checking*

The difference in total number of time checks between the regular and irregular intention conditions was not significant. Nonetheless, the trend was in the hypothesized direction and a larger number of participants could have caused the difference to become significant. In addition, consistent with the hypotheses was the finding that the time checking rate for the first time interval was significantly higher in the irregular intention condition, which had a 2-minute first interval, than in the regular intention condition, which had a 3-minute first interval. This is congruent with Ceci and Bronfenbrenner's (1985) contention that individuals can calibrate internal time clocks with the actual passage of time. According to this explanation, individuals in the irregular intention condition monitored the clock at a high rate both because they did not yet have their internal time clocks calibrated and because they had to execute their intention a full

minute before the regular intention condition, which gave them less time to calibrate their clocks. As a result, they were unsure of the time and checked the clock more often. This explanation also helps to clarify why time checking rate did not differ between the intention conditions for the second and third time intervals. Seemingly, both conditions had already calibrated their internal time clocks.

As hypothesized, there was a significant correlation between total number of time checks and VRC retrieval time. If total number of time checks is viewed as an indication of the level of salience an intention has for an individual, then this correlation is consistent with Smith's (1999) assertion that having both an ongoing task and an intention cause divided attention. The cognitive load caused by the intention would presumably interfere with the storing of information from the reading passage and, therefore, would slow retrieval rates on the reading comprehension questions. In other words, it would take longer to retrieve information that was not encoded very well due to intrusion from the intention. However, because the results of the post hoc control experiment were inconclusive, other explanations for the correlation cannot be ruled out. One alternate explanation is that, because increased time checking also means that more screens of information were missed, it takes individuals longer to remember and recognize the correct answers from a disrupted narrative.

The correlation between total number of time checks and on-time PM performance was not significant. This contradicts both the hypotheses and Ceci and Bronfenbrenner's (1985) finding that individuals who checked the clock infrequently performed poorly on the PM task. However, the lack of correlation is similar to Sellen et al.'s (1997) finding that even though participants frequently thought about the time-based

intention, they were more likely to forget to perform the time-based intention than the event-based intention. This suggests that, even though a time-based intention remains highly salient in an individual's mind, high intention salience does not necessarily translate into on-time PM performance. Also contrary to the hypotheses, the correlation between total number of time checks and VRC percentage was not significant. It is not exactly clear why VRC percentage does not correlate significantly with total number of time checks if the latter is an indication of an intention's salience. One possible explanation for this phenomenon is that even though the intention had a negative effect on reading comprehension, it is not necessarily the case that higher levels of intention salience correspond to progressively worse reading comprehension.

*Working Memory Span*

As hypothesized, both total WMS and WMS-L significantly correlated with VRC percentage. However, the correlation between VRC percentage and WMS-S was only marginally significant. With a larger number of participants, the correlation might have been significant. Nonetheless, these findings are congruent with La Pointe and Engle (1990), who found that all three WMS scores significantly correlated with the Verbal subscale of the Scholastic Aptitude Test (VSAT). Contrary to the hypotheses, the three WMS scores correlated with neither on-time PM performance nor VRC retrieval time. A possible explanation for these phenomena is range restriction. Participants in the intention conditions who failed to perform the PM task at least twice were dismissed from study. Therefore, participants who performed at floor levels on the PM task were not included in the analyses and, as a result, even individuals with low WMS still performed the intention at a high rate.

*Action-State Orientation*

Though it was hypothesized that ACS scores would correlate positively with VRC retrieval time and negatively with total number of time checks, only the Hesitation scale significantly correlated with total number of time checks. The Hesitation scale also significantly correlated with WMS-L, though the other ACS scales did not correlate significantly with measures such as the WMS scores or on-time PM performance. The lack of correlations, however, is consistent with Goschke and Kuhl's (1993) findings on event- and time-based intentions. In conditions where the intention was externally initiated (event-based), state oriented individuals both had significantly faster reaction times to intention-related words and thought about the prospective task significantly more often than action oriented individuals. However, both action and state oriented participants reacted quickly to intention-related words in self-initiated (time-based) intention conditions. Therefore, these findings suggest that, in time-based prospective memory situations, one's action-state orientation becomes a non-significant correlate with rumination because the intention maintains a high level of activation.

Individuals who score high on the Hesitation subscale of the ACS do not have trouble initiating action. One possible explanation for the positive correlation between the Hesitation scale and total number of time checks is that individuals with high Hesitation scores are anxious to perform the intention. As a result, these individuals check the clock frequently so that they can perform the intention as quickly as possible. Similarly, the negative correlation between scores on the Hesitation scale and WMS for long words can be interpreted as unfamiliarity with delaying action. That is, since individuals with high scores on the Hesitation scale are accustomed to performing actions

immediately, they are not used to withholding action-related information and will become impatient.

*Other Analyses*

On-time PM performance for both intention conditions was relatively low (53% in the regular intention condition and 77% in the irregular intention condition). This phenomenon corroborates both with the lack of correlation between total number of clock checks and on-time PM performance and with Sellen et al.'s (1997) finding that participants thought about the time-based task more often than the event-based task but forgot to perform the time-based intention more often. In fact, Sellen et al. (1997) report that individuals who did well on the time-based tasks were able to link the tasks with contextual cues. Therefore, the low on-time PM performance reinforces the notion that even though time-based intentions occur to individuals frequently, they are harder to remember to execute than event-based intentions. Analyses also showed that individuals in the irregular intention interval had a higher on-time PM performance than those in the regular intention interval. One interpretation for this result is that, even though the total number of time checks did not significantly differ between the two conditions, the regular intention condition's poor on-time PM performance and infrequent clock checking mirrors the findings of Ceci and Bronfenbrenner (1985). In their study, Ceci and Bronfenbrenner (1985) found that individuals who checked the clock infrequently were more likely to perform the PM task late. This is supported by the fact that individuals in the regular intention condition had significantly more late PM executions than individuals in the irregular intention condition, who did not have any late PM executions.

VRC retrieval time was marginally different between the three conditions. Once again, adding participants to each condition could potentially boost the statistic to a significant level. The trend indicates that VRC retrieval rate of the irregular intention condition is slower than the VRC retrieval time of the other two conditions. An examining of this trend fits with the results of other analyses because of the higher on-time PM performance and lack of late PM execution in the irregular intention condition. This suggests that there is a tradeoff between on-time PM performance and VRC retrieval time, which could reflect an intention interference with passage encoding as discussed earlier.

There were neither main effects nor an interaction for the two way ANOVA run on high/ low WMS groups and intention condition on the variable of VRC percentage. This indicates that high and low WMS performance did not differentially affected VRC percentage in either of the intention conditions. Nonetheless, the two way ANOVA run on VRC percentage between high/ low WMS-L groups and high/ low on-time PM performance groups showed both a significant main effect of WMS-L group and a significant interaction between WMS-L group and on-time PM performance group. The main effect of WMS-L, which showed that individuals in the high WMS-L group had significantly higher VRC percentages than the low WMS-L group, is not surprising since the correlation between WMS-L and VRC percentage was high. The means indicate that individuals with low on-time PM have almost identical VRC percentages across high ($M$ = 60.00) and low ($M$ = 59.40) WMS-L groups. However, individuals in the low WMS-L group have low VRC percentages ($M$ = 47.40) when they are in the high on-time PM group, whereas individuals in the high WMS-L group have high VRC percentages ($M$ =

72.50) when they are in the high on-time PM group. These findings suggest that, for individuals with low WMS, there is a tradeoff between on-time PM performance and reading comprehension. The findings also indicate that, for some individuals with high WMS, there may not be a tradeoff between on-time PM performance and reading comprehension. If there is a tradeoff for these individuals, their control-condition level of reading comprehension indicates that their performance would normally be near the ceiling on reading comprehension. Though there is a lack of statistically significant findings for two way ANOVAs run on VRC percentage between on-time PM performance groups and either overall WMS groups or WMS-S groups instead of WMS-L groups, this study was not originally designed to detect interactions. As a result, a larger number of participants in the conditions might have yielded significant results.

*Limitations and Recommendations*

One possible criticism of this study is the lack of different time interval orders in the irregular intention condition. Because each participant in the irregular intention condition had to perform their intention after 2 minutes, then 4 minutes, and then 3 minutes, the results could be a function of order effects instead of the irregularity of the intention interval.

Another possible criticism of the study is the fact that the control condition did not have to use the laptop and the mouse. While individuals in the intention conditions had to check the time by using the computer mouse of a laptop, individuals in the control condition read the passage without having to perform tasks that interrupted the narrative. A more internally valid approach would be to have the control condition use the mouse and laptop.

The limited design of the study coupled with the large number of variables is also a possible criticism. The study was originally designed to identify the basic patterns associated with time-based intentions. As such, interactions were neither hypothesized about nor easy to detect in this study. The moderate number of participants also did not aid in the discovery of complex relationships between variables. However, based on the results of this study, future studies with large sample sizes can be designed to test hypotheses about and to detect very specific, complicated interactions and associations.

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# Appendix A

## Cancer Passage Reading Comprehension Questions—Sample Items

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1. What do cancer epidemiologists study in human populations?

    a. The genetic inheritability of cancer.

    b. The incidences of cancer cases.

    c. The incidences of cancer relapse.

    d. The average age of cancer onset.

    e. The average lifespan of cancer patients.

2. What was the expected life span of Europeans in the 19$^{th}$ Century?

    a. 35

    b. 40

    c. 45

    d. 50

    e. None of the above.

Appendix B

Action Control Scale—Sample Items

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*Preoccupation subscale* (8 Items)

4. If I've worked for weeks on one project and then everything else goes completely wrong with the project:

   A. It takes me a long time to adjust myself to it

   B. It bothers me for a while, but then I don't think about it anymore

---

*Hesitation subscale* (8 Items)

2. When I know I must finish something soon:

   A. I have to push myself to get started

   B. I find it easy to get it done and over with

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*Volatility subscale* (6 Items)

3. When I have learned a new and interesting game:

   A. I quickly get tired of it and do something else

   B. I can really get into it for a long time

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*Note.* The items are from the revised version of the ACS found in "Action-state orientation: Construct validity of a revised measure and its relationship to work-related variables" in *Journal of Applied Psychology, 85,* (pp. 250-263), by J. Diefendorff, R.

Hall, R. Lord, and M. Strean (2000). The complete scale and item scoring can be found in Kuhl (1994).

Table 1

*Descriptive Statistics: Valid Reading Comprehension Percentages*

| Condition | *N* | *M* | *SD* | Min. | Max |
|---|---|---|---|---|---|
| Control | 20 | 72.50 | 18.41 | 31.00 | 100.00 |
| Regular Intention | 19 | 58.33 | 19.86 | 15.00 | 87.00 |
| Irregular Intention | 20 | 60.52 | 14.31 | 38.00 | 92.00 |

Table 2

*Descriptive Statistics: Time Checking Rate by Condition for Time Intervals*

| | Regular Intention[a] | | Irregular Intention[b] | |
|---|---|---|---|---|
| Interval | *M* | *SD* | *M* | *SD* |
| First | 1.11 | .56 | 1.58 | .85 |
| Second | .75 | .40 | .99 | .51 |
| Third | .84 | .34 | .98 | .48 |

*Note.* [a]$n = 19$. [b]$n = 20$.

Table 3

*Correlations Between WMS Scores and Valid Reading Comprehension Percentages*

| Measure | Total WMS | WMS-L | WMS-S |
|---|---|---|---|
| Valid Reading Comprehension | .31* | .35* | .23 |

*Note.* $n = 59$. WMS = Working Memory Span. WMS-L = Working Memory Span for Long Words. WMS-S = Working Memory Span for Short Words.

*$p < .02$.

Table 4

*Descriptive Statistics: Valid Reading Comprehension Retrieval Times*

| Condition | *N* | *M* | *SD* | Min. | Max |
|---|---|---|---|---|---|
| Control | 20 | 19451.91 | 4134.12 | 11608.31 | 31126.94 |
| Regular Intention | 19 | 20381.66 | 3664.81 | 14526.46 | 29820.60 |
| Irregular Intention | 20 | 22485.10 | 4976.67 | 13553.00 | 35155.58 |

Table 5

*Descriptive Statistics: Valid Reading Comprehension Percentages as a Function of PM Group and WMS-L Group*

| | High PM Group | | Low PM Group | |
|---|---|---|---|---|
| WMS-L Group | *M* | *SE* | *M* | *SE* |
| High | 72.50 | .06 | 60.00 | .05 |
| Low | 47.40 | .06 | 59.40 | .04 |

*Note.* $n = 39$. WMS-L = Working Memory Span for Long Words. PM = Prospective Memory.