The Intention Superiority Effect and Aging:
Similar Magnitude of Effects in an Interference Paradigm

By

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B.F.A. (Hons.), York University, 1990
M.S.c., University of Victoria, 1999

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in the Department of Psychology

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Abstract

Intentions have a special status in such important cognitive operations as prospective memory, or remembering to execute actions in the future. Indeed, recent research has shown that future-oriented information (such as intentions) have a higher and more sustained level of activation in mind than do other forms of to-be-remembered information. Such enhanced activation increases the accessibility of intentions for future retrieval operations, a phenomenon known as the "intention superiority effect." Thus far, all research on the intention superiority effect has used facilitation paradigms, in which attending selectively to relevant stimuli facilitates performance on tasks that benefit from the processing of that information. The current investigation examines whether the intention superiority effect is also observed in an interference paradigm, in which sources of influence are in opposition. No previous research has demonstrated that the intention superiority effect is robust across such paradigm characteristics. Therefore, the first objective of the present study is to use a Stroop task to test the intention superiority effect within an interference paradigm.

Previous research on the intention superiority effect has been conducted largely with undergraduate university students. Little is known about whether this effect exists for cognitively vulnerable populations, such as older adults. Arguably, the absence of an intention superiority effect could account for lower performance in such related cognitive tasks as prospective memory. Therefore, the second objective of this research was to examine whether the intention superiority effect, as produced by an interference paradigm, exists also for older adults.

In a series of four experiments, participants received a brief Stroop word list including critical words from a previously encoded intention. We predicted that there would be more interference with colour naming for words that belonged to an intention that participants intended to carry out versus an intention that they did not have to carry out (i.e., intention superiority effect). Results of the four experiments for both young and older adults revealed longer latencies for words belonging to an intention that they intended to carry out. These data are the first demonstration of an intention superiority effect in an interference paradigm as well as the first demonstration of this effect in an older adult age group.

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Acknowledgments

Special thanks are extended to my supervisor Dr. Roger Dixon who persevered with me through five long years without losing his patience, generosity, or sense of humor. I wish to thank my committee, Dr. David Hultsch, Dr. Michael Masson, Dr. Geraldine Van Gyn, and Dr. Allen Dobbs for their input during both the planning stages as well as on the final product. I also want to thank Dr. D. Stephen Lindsay who provided key suggestions for the development of the research design and I wish to express gratitude for the loan of his laboratory for testing participants. Several students and colleagues within the department were also instrumental in providing feedback, support, and most importantly-- a great deal of humor, sarcasm, and wit throughout this entire process. These individuals are Bruce, Cindy B., Cindy D., Glen, John, Josh, Leora, Lisa VB, Michelle, Tanya, and Vincenza. Finally on a personal note, I would like to thank my family in Winnipeg and in Toronto for their enduring support and interest in my research pursuits.

Support for this dissertation was funded by a PGSB scholarship from the Natural Sciences and Engineering Research Council of Canada (NSERC) and a grant from the National Institute on Aging (AG08235) awarded to R. A. Dixon.

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Introduction

Prospective memory is a term that is often synonymous with the expression 'memory for intentions.' Both describe a memory phenomenon in which processing supports the realization and execution of a previously encoded intention (Ellis, 1996). This form of memory is thought to underlie everyday activities such as remembering to attend important meetings and events, make phone calls, and take medication at a prescribed time. In the current thesis, we examine a particular aspect of prospective remembering. Specifically, our motivation is to understand whether representations of intentions during the retention interval are characterized by an increased or more sustained level of activation compared to information that is not future oriented (i.e., 'intention superiority effect'). As Goschke and Kuhl (1996) write, "...very little is known about the representation of intentions in memory and the conditions that determine their activation and retrieval" (p. 53).

This dissertation focused on two primary objectives. One objective was to use an interference paradigm to demonstrate the presence of an intention superiority effect. Prior research has solely used facilitation paradigms (e.g., recognition memory, lexical decision task). In the current study, a Stroop task is used to examine the intention superiority effect because the use of an interference paradigm allows more powerful statements to be made about the activation of words due to the fact that word reading is not required for colour naming. That is, in our task participants are attempting to ignore the influence of the semantic content of words in order to attend to the colour of the words. If we can demonstrate that participants are influenced by the presence of the embedded words from the intention when they are attempting to ignore their influence and attend solely to colour naming, we have a more powerful demonstration of the intention superiority effect. This line of reasoning is supported by a long history of research (e.g., Jacoby, Lindsay, & Toth, 1992) that shows that indirect tests of a phenomenon can be more informative about the process under investigation.

Another second objective was to examine whether there are differences in the presence/absence or magnitude of the intention superiority effect for young and older adults. No other studies have examined this age-related question. This empirical question is important if we consider that a number of researchers report that prospective memory declines with age (e.g., Dobbs & Rule, 1987; Einstein, McDaniel, Smith, & Shaw, 1998; Harris & Wilkins, 1982; Mäntylä, 1993; Maylor, 1993). Through examining the absence or presence of an intention superiority effect in older adults, we may help further the understanding of prospective memory functioning. Before reviewing the extant literature on the intention superiority effect specifically, it is useful to consider an overview of research on the broader topic of prospective memory.

Prospective Memory

The first laboratory study of prospective memory was conducted by Loftus (1971) who gave participants a simple intention that they had to remember to execute at the end of the experiment. The intention consisted of telling the experimenter the U.S. state where they had been born. Her results showed that the presence of a cue and the length of the retention interval influenced performance. Loftus (1971) concluded that retention of intentions is not so different from the retention of other types of material. In the last some prospective action is to be performed when an appropriate cue is encountered -- and a *retrospective component (RM)* -- the ability to recall an intention when the prospective cue is detected. This idea has been further elaborated in the noticing+search model of prospective memory (Einstein & McDaniel, 1996; McDaniel, 1995). In this model, noticing (prospective component) is thought to reflect relatively automatic familiarity-based processing. This type of processing supports the detection of a prospective memory cue in the environment. It is the noticing of a cue that serves to elicit the search process. The search process is thought to reflect the retrospective component and reflects consciously controlled processing that serves both to establish the significance of the prospective memory cue and to retrieve the contents of the associated intention from memory. The results of a recent study indicate that the prospective and retrospective components can be dissociated at the neural and behavioral levels (West, Herndon, & Crewdson, 2001). Using event-related brain potentials (ERPs), the researchers observed unique modulations of the ERPs reflecting the prospective and retrospective components. In this study, noticing (prospective component) was associated with a negativity over the occipital-parietal region that was greatest in amplitude at roughly 320 milliseconds following stimulus onset, while search (retrospective component) was associated with a positivity over the parietal region between 400 and 1000 ms post-stimulus onset. Other researchers such as Ellis (1996) make a conceptual distinction between the prospective and retrospective components of prospective memory. She describes how these separate components correspond to her multi-phase conceptual framework of prospective memory.

In her framework, Ellis (1996) describes the general phases involved in the encoding and execution of an intention. She suggests that there are five general phases that comprise prospective remembering. *Phase A* involves the formation and encoding of intention and action. It is the planning stage that surrounds 'what you need to do' and 'when you need to do it'. Ellis claimed that this planning stage can have a large influence on the success or failure of executing an intention. *Phase B* refers to the retention interval. It is the time between encoding and the time at which the intention should be retrieved. *Phase C* is termed the performance interval and it is the point in time when an intention should rise to conscious awareness and be carried out. The subtle difference between Phase B and Phase C can be illustrated through the use of an example. If one encodes an intention to go to the grocery store tomorrow afternoon, the retention interval is from the moment of encoding till the next afternoon. The performance interval is approximately 12 noon till 5 pm (the period of time in which the intention should be carried out). *Phase D* is the actual initiation and execution of the intended action. *Phase E* is the evaluation of the outcome. This 'record' of the outcome is necessary so that output-monitoring errors can be avoided and the intention will not be mistakenly carried out again (Koriat & Ben-Zur, 1988). Ellis suggests that Phase A of this framework relates to the RM component and Phases B through to E relate to the PM component.

Depending on the extent to which an intention is simple or complex and habitual or novel, will determine the relative contributions of each of these phases (Ellis, 1996). For example, a complex and novel intention will require more extensive contributions from the planning phase (Phase A) compared to a simple and habitual intention that is supported by more routine automatized processing. That is, under some conditions an intention can be realized by automatized routine skills if all of the parameters of the intended activity are sufficiently specified. Thus, a stimulus may trigger an intention within the performance phase without any great degree of self-initiated processing. In such cases, it may be that during the planning phase, stored action schemas are set into a state of readiness and when the appropriate trigger conditions are satisfied, the intention can be executed without mediation of a conscious recollection of the intention (Goschke & Kuhl, 1996). Alternatively, if an intention needs to be postponed for a longer retention interval or if the intention cannot be realized by already known skills, then the intention cannot set action schemas in a state of readiness because further planning and controlled processing is needed (Goschke & Kuhl, 1996). Thus, one can conclude that depending on the duration between the encoding and execution of an intention and the parameters of the intended activity, prospective remembering involves automatic or more effortful processing.

At present relatively little is known about the factors that influence the efficiency of these different phases or components of prospective remembering. Furthermore, relatively little is known about the factors that influence prospective memory performance in later adulthood.

Prospective Memory and Aging

The ability to perform well in prospective memory tasks (e.g., remembering to take medication) is obviously essential for independent living. It is useful to consider why we may (or may not) expect age-related decrements in prospective memory performance. Results pertaining to age differences in prospective memory performance are mixed, with some studies reporting no deficits for older adults (e.g., Einstein &

McDaniel, 1990; Einstein, Holland, McDaniel, & Guynn, 1992) and others observing significant age-related differences (e.g., Dobbs & Rule, 1987; Einstein, McDaniel, Smith, & Shaw, 1998; West & Craik, 1999).

One account of why there might be age differences in adulthood is the following. Prospective memory may be especially vulnerable to age-related decline as opposed to retrospective memory, because this form of memory requires the participant to engage in more spontaneous and self-initiated retrieval (Craik, 1986). An important difference between prospective memory and more typical experimental memory paradigms (i.e., free recall, recognition) is that for most prospective tasks there is no explicit reminder that prompts the person to initiate a memory search (Craik, 1986; Einstein & McDaniel, 1990, Maylor, 1990). In contrast, in free recall or recognition memory tasks, a participant is informed when the test phase begins and is explicitly instructed to retrieve information (e.g., 'Recall as many words as possible from the study list') or to differentiate correct information from incorrect information (e.g., 'Respond "yes" to any previously seen words and "no" to any new words). Therefore, according to this claim, a prospective memory situation is much different because after encoding the intention, the participant is given no reminders. Therefore, the participant is required to hold the intention in mind throughout the retention interval and successfully remember to execute the intention at the appropriate time. It is these requirements that lead some researchers to conclude that prospective memory requires more self-initiated processing than some other forms of memory and there is extensive evidence that self-initiated mental activities become more difficult to execute with increasing age (d'Ydewalle, Bouckaert, & Brunfaut, 2001). For example, Maylor claimed that prospective memory is inherently effortful because an intention must be retrieved when one is in the midst of some other competing activity. That is, retrieval of the intention must interrupt the ongoing flow of thought and activity in order to be properly executed. The person must disengage from an ongoing activity to carry out some action or intention at an appropriate time (Einstein & McDaniel, 1990).

Einstein et al. (1995) proposed an explanation for age-related results based on a distinction between event-based and time-based prospective memory tasks. Event-based prospective memory is defined as a situation in which an external event or cue acts as a trigger for an intention that was encoded earlier. Thus, the event or cue helps to initiate a memory search that will eventually result in the retrieval of the intention (e.g., remembering to take a pill at dinner). Time-based prospective memory reflects a situation in which the appropriateness of an action or intention is determined by the passage of time (e.g., remembering to take a pill in two hours). Einstein et al. proposed that with time-based tasks, rather than with event-based tasks, there should be age-related differences in prospective memory because time-based tasks are especially dependent on self-initiated processing. This theoretical distinction was confirmed by results that revealed age differences on the time-based task (high in self-initiated retrieval) and no age differences on the event-based task (low in self-initiated retrieval) (Einstein et al., 1995). However, recent findings suggest that the distinction between event- and time-based prospective memory is only marginally useful and the better predictor of age-related differences is the specific requirements of the task. For example, Park, Hertzog, Kidder, and Morell (1997) found age differences on both event- and time-based tasks. Moreover, they found that deficits in time-based performance tended to be due to a fundamental deficit in time monitoring and deficits were not due to forgetting the cue or intention.

Rather than discovering factors that affect prospective remembering as a whole, it may be more useful to break down the act of prospective remembering into its componential processes and examine whether these components are differentially affected by age. As Dobbs and Reeves (1996) state, "treating prospective memory as a [unique] type of memory leaves the impression that it is unidimensional...it would be more fruitful to ask what aspects of prospective remembering bear a relationship to particular aspects of retrospective memory" (pp. 199 – 200). One component that Maylor (1996) claimed may be particularly vulnerable to age-related disruption is the retention interval. For example, she suggested that it may be particularly vulnerable to age-related disruption for three reasons: (1) holding an intention in mind is more likely to exceed the working memory capacity of older adults than of younger adults, (2) older adults may be more vulnerable to interfering information, and (3) the retention interval can be viewed as a type of dual task in which the intention is held in mind while other activities can be carried out.

If we think of the retention interval in terms of prospective component performance as defined by McDaniel and Einstein (1992), one would predict that prospective component performance may be more vulnerable to age-related disruption compared to retrospective component responding. Cohen, West, and Craik (2001) studied this issue. First, they examined whether adult age differences were greater for the prospective or the retrospective component of prospective memory; and second, they examined whether data-driven and conceptually driven processes differentially influence these two components. The influence of data-driven processes was varied by maintaining or changing the format of the prospective cue from study to test and the influence of conceptually driven processes was manipulated by varying the degree of semantic relatedness between the prospective cue and intention. In this study, participants were given a series of cues that were paired with intentions and the cues were either in picture or word form (data-driven manipulation) and the cues were semantically related or unrelated to the intention (conceptually driven manipulation). Results showed that there was a greater effect of age (young more accurate than older adults) for the prospective component than for the retrospective component even when the retrospective demands of the task were high. The data-driven manipulation had the greatest effect on prospective component responding and the conceptually driven manipulation had the greatest effect on the retrospective component. In a recent study, Cohen, Dixon, Lindsay, and Masson (2002) examined the effect of perceptual distinctiveness of cues on prospective memory performance for young and older adults. Once again, the prospective and retrospective components were measured separately. Results were in line with the previous study showing a greater effect of age on prospective component responding. That is, young adults successfully detected a larger proportion of cues (prospective component) than older adults; however, there were minimal effects of age on participants' ability to recall the intention once they detected a cue (retrospective component performance).

The findings of these studies are consistent with the idea that prospective memory is supported by distinct prospective and retrospective components. As described earlier, Ellis (1996) suggested that the two components outlined by McDaniel and Einstein (1992) correspond to her conceptual framework such that Phase A relates to the retrospective component and Phases B through to E relate to the prospective component. The aforementioned studies demonstrated that adult age differences were greater for performance on the prospective component than for performance on the retrospective component of prospective memory. If we map this result onto Ellis' framework, prospective component performance corresponds to Phases B through to E which represent the retention interval. Therefore, if the past studies show greater effects of age on the prospective component, this result could imply that older adults' prospective memory performance during the retention interval may be particularly vulnerable to age-related disruption. For this reason, it is important to fully examine and understand the fate of intentions during the retention interval for an older adult age group.

Research on the Intention Superiority Effect

Prospective memory is related to the concept of intentional action. Over a century ago, Baldwin (1897; as cited in Olson, Astington, & Zelazo, 1999) delivered a comprehensive account of the development of intentional action. Baldwin's theory tied intentional action to "the emergence of desire, deliberation, and effort: the conscious representation of a goal, the active consideration of alternative means and ends, and the feeling accompanying the selection and execution of a plan" (p. 2, Olson et al., 1999). As described by Baldwin, when we form an intention, it is supposed that we form a representation of that goal and the means for attaining it. If an intention has to be delayed due to situational constraints, then that intention must be postponed until it can be retrieved at a later point in time. The ability to successfully recollect and execute a postponed intention, at an appropriate moment in time, is referred to as prospective memory. As described earlier, when individuals form an intention, it is supposed that they form a representation of the goal. Therefore, the term 'goal' or 'intention' is used to refer to the idea that a mental representation has been formed to accomplish a task or achieve some desired state in the world. Throughout research on the intention superiority effect, the term "representation" is used to describe mental contents. It is important to note that the term "representation" has numerous meanings, a fact that has led to considerable confusion and doubt about the usefulness of the construct (Martinez, 1999). We do not experience the world directly; therefore, our perceptions allow us to construct a mental model of the world (Johnson-Laird, 1983). In the present context, the term "representation" is used to refer to the idea that a knowledge structure has been formed to symbolize some state of affairs (Martinez, 1999).

The intention superiority effect has been explored in a variety of paradigms. However, the notion that intention-related information may be characterized by a special tension or increased activation was preceded by a related research topic known as task interruption research conducted by Zeigarnik (1927, as cited in Goschke & Kuhl, 1996). Drawing upon Lewin's (1951) work on the theory of motivation, Zeigarnik (1927) suggested that the intention to execute a goal led to psychological tension and this tension remained active until the goal was completed (Sheikh & Koch, 1977). She demonstrated that participants had better memory for information that had been interrupted compared to information that had been completed. Zeigarnik (1927) presented participants with a number of concrete tasks (e.g., threading a needle) and participants completed one half of these tasks whereas the other half was interrupted. Then participants were given a free recall task in which they were asked to recall the names of tasks. Results showed that participants recalled reliably more of the interrupted tasks than the completed tasks. This was known as the *Zeigarnik effect*.

The effect was thought to demonstrate an unresolved task tension for uncompleted actions that was due to a persisting activation of these contents in memory. However, this research was plagued by conceptual and methodological problems such that other researchers had difficulties replicating this effect. This pattern of inconsistent findings is thought to be the reason that there was a decline in task interruption research (Goschke & Kuhl, 1996). However, Baddeley (1963) claimed that two methodological issues led to technical problems observed in the Zeigarnik paradigms: the selection of suitable materials, and the method of interrupting the task. He suggested that solving or not solving anagrams was the most efficient way to demonstrate the Zeigarnik effect. In his paradigm, participants were asked to solve a series of 12 anagram problems within a time limit. If they failed to solve an anagram, they were told the solution. When asked to recall the anagram words, participants were nearly twice as likely to recall unsolved anagram words than anagrams that they had solved (Baddeley, 1963). Regardless of the fate of the work done by Zeigarnik (1927), it has had implications for prospective memory research if we concede that memory for interrupted activities is related to memory for intentions (if those intentions have not yet been carried out).

As described above, very often a goal must be postponed or set aside temporarily. In the current thesis, the interest is in the state of that 'knowledge structure' when it must be postponed over short retention intervals. More recent research shows that in preparation for different retrieval requirements, intentions that have been postponed have a higher level of activation compared to information that is not future-oriented and this makes them more accessible for future retrieval. This phenomenon has been termed the intention superiority effect (Goschke & Kuhl, 1993). The effect has been demonstrated in a number of tasks in which participants show faster and more accurate responding to material that is intended for some future activity. This observation suggests that future-oriented information is held in mind differently compared to information that is not future-oriented (Dockree & Ellis, 2001).

There has been increasing evidence (e.g., Goschke & Kuhl, 1993, 1996; Marsh, Hicks, & Bink, 1998) that younger adults show an intention superiority effect in a number of different paradigms with a variety of task requirements. However, little research has investigated whether older adults also exhibit this effect. This empirical question is important if we consider that some prospective memory studies indicate that prospective memory declines with age (e.g., Dobbs & Rule, 1987; Einstein, McDaniel, Smith, & Shaw, 1998; Harris & Wilkins, 1982; Mäntylä, 1993; Maylor, 1993). Through examining the absence or presence of an intention superiority effect in older adults, we may help to further the understanding of prospective memory functioning. It is plausible that an absence of an intention superiority effect in older adults may help explain observed deficits in prospective memory performance. However, most research on the intention superiority effect has been conducted with younger adult age groups.

Zeigarnik's (1927) work became the impetus for research on prospective memory. For example, Goschke and Kuhl (1993) reasoned that results from Zeigarnik imply that representations of intentions or uncompleted goals may have a privileged status over more neutral information that is held in mind. In a series of four experiments, Goschke and Kuhl (1993) showed that material from scripts that were to be performed later by the participants were processed faster and more accurately, as compared to material from a neutral script. In their paradigm, younger subjects were given written descriptions of activities and they were asked to memorize such scenarios as setting the table ('Spread the table cloth. Distribute the cutlery.') or clearing a messy desk ('Open the folder. Put in the files.'). Then, in an 'execute' condition they were informed that one of these scripts would have to be executed later, whereas in the 'observe' condition they were instructed to simply observe the experimenter carrying out the task. The second script in each of these conditions was neither executed nor observed, but subjects were informed that they would receive a recognition memory test for words from both scripts. The experimenters assumed that the time it took to match a probe item with its match in long term memory would be inversely related to the level of activation of that representation (Anderson, 1983). Results showed that response latencies were reliably faster to the words from the script from the execute condition. They concluded that this information must have a heightened level of activation in memory due to its different status. They concluded that intention-related information compared to more neutral information was more accessible as reflected by shorter reaction times for intention-related words as opposed to neutral words.

In Experiment 2, Goschke and Kuhl (1993) investigated the possibility that the difference found in Experiment 1 between the intention and non-intention script was due to the ability to discriminate between them on a semantic criterion. To address this issue, all scripts in Experiment 2 belonged to a common secretarial context. Thus, all words were semantically related; any differences between words from the intention and neutral script would not be due to semantic inconsistencies. Similar to findings from Experiment

1, they found reliably shorter latencies to words from the execute condition compared to words from the neutral condition. In Experiment 3, Goschke and Kuhl addressed how long the preactivation of a representation of an intention lasts. That is, they were interested in examining the duration of this increased activation. The time between the formation of the intention and its execution was extended to 15 minutes which was six times longer than the corresponding interval in the previous two experiments. Once again, words from the to-be-executed script were recognized faster than words from the observation condition. The fourth experiment was meant to investigate whether test expectancies were determining the outcome to the previous experiments. For example, the authors surmised two potentially problematic expectancies could have arisen: (a) in the execute condition, participants may have been expecting a recall type of test, and (b) in the observe condition, they may have been expecting a type of recognition test. Therefore, in this experiment, both groups were told that they should expect a free recall test of the material from both scripts.

In addition, Goschke and Kuhl (1993) included an imagery condition as a control condition to examine whether the use of imagery was equivalent across the conditions. After the instructions were administered, participants were told to imagine both the 'execute' and neutral scripts for equal durations. If the previous intention superiority effects were due to the selective imagining of the execute script (and not the neutral script), then in the imagery condition, they should have found no differences between the two scripts. However, results from the fourth experiment were in line with the previous experiments with intention-related words being recognized reliably faster than neutral words for both the imagery and control conditions. This finding was further supported by the fact that there was no difference between strategies used in each condition. This was reflected by the results of the final recall test which showed that recall performance of the intention script did not differ from the neutral script. This last experiment provided strong evidence that the intention superiority effect was not attributable to strategy differences.

If one applies the assumption that reaction time and activation or accessibility of information is inversely related (e.g., Anderson, 1983) then results from the above experiments can be taken as evidence for an intention superiority effect. Goschke and Kuhl (1993) suggested that their results are in line with Anderson's (1983) ACT (adaptive control of thought) memory model. In this model, goal nodes possess constant amounts of activation and they do not need rehearsal to sustain their activation. This point is important because in this paradigm Goschke and Kuhl (1993) ruled out the possible explanation that rehearsal or strategy differences were responsible for the increased activation of intention-related information. The authors claimed that intentions appear to decay more slowly than other memory contents due to their representation as subthreshold nodes in long-term memory (Anderson, 1983). In Goschke and Kuhl's (1993) paradigm, encoding was equivalent for intention and neutral scripts because it was only after encoding that participants received instructions to execute the script. The time between the instructions and the recognition memory test was occupied with a task such as counting backwards by threes that eliminated the possibility that rehearsal strategies could be employed.

In an extension of Goschke and Kuhl's (1993) paradigm, Marsh et al. (1998) completed four experiments in which they investigated both the level of activation prior to script enactment as well as the fate of heightened activation after an intention has been completed. Marsh and colleagues argued that purer measures of activation could be gained by using a lexical decision task instead of a recognition memory test. Experiment 1 was undertaken to investigate whether they could replicate the findings of Goschke and Kuhl's while substituting a lexical decision task (LDT) for the speeded recognition memory task. In the second block of the test after participants either performed (execute condition) or observed (observe condition) the script, they performed a recognition memory task. Results replicated those of Goschke and Kuhl's in that a 40 ms difference between the prospective perform or execute condition and the observe only condition was detected. (See Figure 1 for results.)

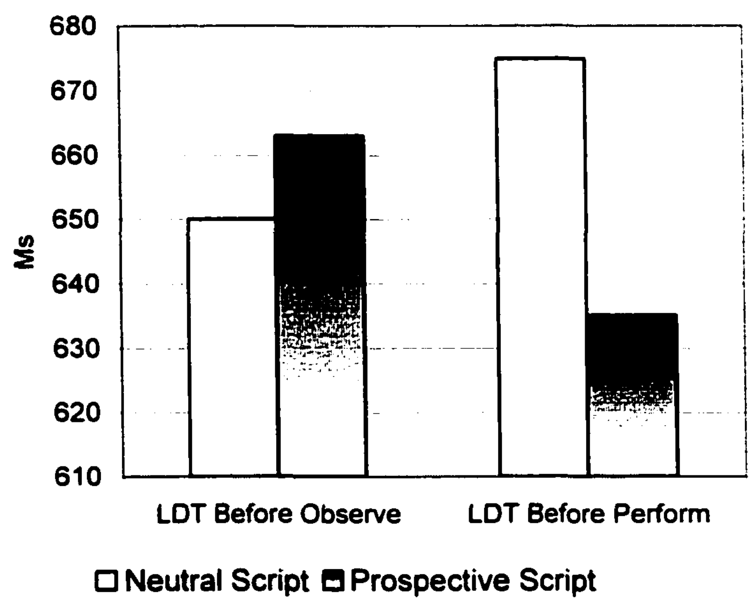

Figure 1. Latency for execute scripts and neutral scripts when LDT task occurred before observation or before performance (Marsh et al., 1998).

The possibility that completed activities undergo inhibition was explored directly in Experiment 2. In this experiment, the lexical decision task was administered after participants had already executed or observed the scripts. Results revealed a striking interaction. Before the script was carried out, latencies for the execute scripts were shorter than those for the neutral scripts. However, after the script was carried out, this effect reversed, such that the latencies for the execute script were longer than those for the neutral script. Marsh et al. (1998) explained this finding by suggesting that after an action has already been executed, the representation of the intention is inhibited because it no longer 'needs' to be in a heightened state. Thus, the representation loses its privileged status in memory. The purpose of Experiment 3 was to replicate the results from their previous two experiments by using a within-subjects manipulation. Thus, participants learned two pairs of scripts, one in which the lexical decision task preceded performance and one in which it followed performance of the script. The critical finding was a crossover interaction in response latency showing that latency was faster for the prospective script before performance and was slower after performance of the script (Marsh et al., 1998). Therefore, these results confirmed that partially completed activities were more readily available in memory (as indicated by shorter lexical decision times) and completed intentions were less available (as indicated by longer lexical decision times). Figure 2 presents these data.

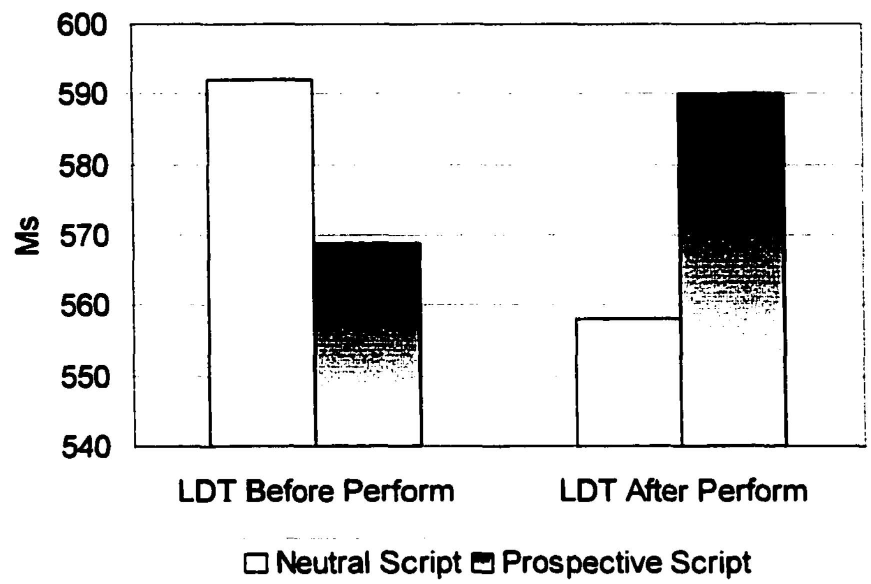

Figure 2. Latency for execute and neutral scripts when LDT task occurred *before* and *after* performance (Marsh et al., 1998).

Experiment 4 consisted of comparing a condition in which a script was interrupted with one in which the intention was completed. The results were in line with the previous experiments supporting the contention that an interrupted activity, similar to an uncompleted one, may have some privileged availability in memory whereas a completed intention is deactivated or inhibited. Marsh et al. (1998) offered a different account from that of Goschke and Kuhl's ACT explanation by suggesting that intended information is reprocessed more fluidly due to an intentional marker or internal context cue. Therefore, when this internal cue is triggered and retrieval conditions are satisfied, the intention springs forth to awareness.

Subsequently, Marsh, Hicks, and Bryan (1999) adapted their paradigm to better simulate a real world scenario. They observed that in daily life, individuals are required to form and carry out multiple intended goals. For example, the authors call attention to the idea that within a short period of time, a person may encode several unrelated intentions such as finishing a manuscript, mailing a letter, and making a phone call. Therefore, within this study, participants were asked to encode numerous unrelated activities given to them by the experimenter. Using this modified version of their task, they replicated their intention superiority effect using lexical decision latencies.

Mäntylä and Sgaramella (1997) investigated how interrupting intentions affects prospective remembering. They predicted that cue items that were associated with interruption would serve as better cues compared to cues that were associated with completion. This prediction was confirmed by two experiments that showed that anagrams that served as cues were better reminders for a group of undergraduates when they were unsolved than when they were solved. Therefore, prospective memory cues that were associated with interruption led to superior performance compared to cues that were associated with completion of a task. The authors concluded that although their findings seem to provide support for Lewin's tension system theory, they do not provide unequivocal support. For example, Mäntylä and Sgaramella (1997) asserted that it may not be that task interruption increases the activation level of the intention representation but rather that planning an intention increases the number of potential cues that can trigger that intention. Their interpretation appears to be more in line with that of Marsh et al. (1998) who suggested that the intention superiority effect is due to intended information being reprocessed more fluidly due to an intentional marker or internal context cue.

Recent research by Dockree and Ellis (2001) examined the intention superiority effect hoping to build on results found by Marsh et al. (1999). They extended upon

Marsh et al. (1999) by arguing that intentions that are formed by the individuals themselves are qualitatively different than those given to them in a laboratory situation. They cite evidence that self-referent material is encoded differently than other types of information because it evokes a "superordinate schema of the self" which creates more elaborated encoding (Dockree & Ellis, 2001; p. 1140). Thus the method involved the experimenter asking participants to encode two tasks that appeared to be unrelated to the experiment itself. They were told that the experimenter was running a concurrent study in a different room so the participant was asked to encode two short sets of instructions. One involved preparing the computer for the next participant and the other involved preparing the room for the next participant. At a later point, the experimenter explained that one of the tasks was no long necessary to carry out. Next, participants were given a lexical decision task and reaction times for intended and unintended script words were compared. Results showed the expected effect of faster responses to intention-related material than to unintended material.

In a recent paper by Altmann and Trafton (2002), they offer an alternative explanation for the general concept of goal-directed cognition. The main theoretical point from which Altmann and Trafton (2002) depart from previous research on the intention superiority effect is the idea that they do not acknowledge a structural difference between memory for goals and memory for other facts and events. They identify three constraints on goal-directed behavior.

In the *interference level*, the authors state that information decays gradually rather than instantaneously and this leads to a build up of nontarget information that makes up a type of interference or 'mental clutter'. The interference level is conceived as the expected mean activation of the most active nontarget. When the system retrieves a goal it will get the most active goal and whether this is a target or nontarget depends on their relative activation values.

The *strengthening constraint* is how the system switches to a new goal. A new goal will suffer proactive interference from old goals, so for the new goal to direct behavior it has to become more active than the interference level. Goal activation is determined by an equation adapted from Anderson and Lebiere (1998) in which the number of times a goal has been sampled over its lifetime and the length of the goal's lifetime determine its activation. Thus, the equation defines activation as a function of retrieval frequency and at the peak of a goal's activation; it rises above the interference level. But this peak level of activation is impossible to sustain and it gradually decays. Altmann and Trafton (2002) make the observation that often one has to return to an intermediate state after having already pursued other new paths. In their goal activation model, the priming constraint is necessary for the system to retrieve intermediate states from memory.

The *priming constraint* is responsible for allowing the system to resume an old goal that was suspended. The priming constraint relies on cue availability. For example, a suspended goal must be primed by a cue that was previously associated with it to overcome the interference level. Therefore, cues must be available within the environment (or long-term memory) so that the system can encode them with a goal to use at a later point to prime retrieval (Altmann & Trafton, 2002). Altmann and Trafton (2002) make the observation that, in Goschke and Kuhl's (1993) paradigm, there is enough time between encoding and the intention superiority measure for the kinds of strengthening processes to take effect as described in the goal-activation model. Even if there is only one or two seconds available for rehearsal, the cognitive system will take advantage and strengthen material that needs to be executed. The idea is that intention superiority could simply reflect a type of re-encoding or strategic memory processing which leads to the material's superiority in memory.

The research discussed previously has focused solely on the performance of young adults. There are a number of prospective memory studies that show age-related differences in prospective memory in favour of younger adults (e.g., Einstein, McDaniel, Smith, & Shaw, 1998; Maylor, 1993, West & Craik, 1999). It is important to consider how older adults perform on tasks such as those carried out by Goschke and Kuhl (1993) and Marsh et al. (1998) to better understand the nature of older adults' prospective memory performance. West and Craik (1999) have suggested that after encoding, intentions momentarily fall below consciousness and fluctuate over the course of task performance. They found that it was difficult for older adults to maintain the cue-action schema in an activated state and this led to a greater proportion of instances of forgetting. This finding raises the empirical question of whether older adults have trouble maintaining intention information in a heightened state. Perhaps older adults as opposed to younger adults lack an intention superiority effect.

The only research exploring the presence or absence of an intention superiority effect in older adults is a study that was conducted by Maylor et al. (2000). They argued that a limitation of previous work on the intention superiority effect is that it has only been examined with undergraduates. In their study, they included a group of older adults to test for the possibility that older adults may differ from young adults in their representation of to-be-performed events indicating an absence of an intention superiority effect. In using a naturalistic method, their study differed dramatically from those of the Goschke and Kuhl (1993) and Marsh et al. (1998) paradigms. In Experiment 1, the participants were divided into two age groups 'middle-aged' (M = 59.9 years) and 'older' (M = 72.9 years). Participants were told that they would be given a category and they were to write down as many instances as possible of that category. The two categories were performed tasks and to-be-performed tasks. They were given one minute to recall what they did in the last few days (performed tasks) and what they intended to do in the next few days (to-be-performed tasks). Results showed that there was no intention superiority effect for middle-aged adults however there was an intention inferiority effect for older adults (Maylor et al., 2000). In Experiment 2, groups of young (M = 19.9 years) and older (M = 69.9 years) adults, as well as Alzheimer's Disease (AD) patients (M = 78.9 years) were tested. The design of the study was identical to that of Experiment 1. Results revealed that AD patients produced fewer activities overall as expected on the basis of fluency deficits associated with AD. But although AD patients lacked an intention superiority effect compared to the young, there was no evidence that the intention inferiority effect was greater for AD patients compared to older adults. The findings of Maylor et al. (2000) are in line with suggestions made by West and Craik that older adults have difficulty maintaining the cue-action schema in an activated state (West & Craik, 1999). However, it is unclear to what extent other factors contributed to the effects observed in Maylor et al.'s (2000) study. As the authors themselves note, the observed intention inferiority effects could be due to less activities to perform in daily life or an overall age-related fluency deficit. Furthermore, the study by Maylor et al. (2000)

is not easily incorporated into the literature on the intention superiority effect because the paradigm is naturalistic.

The following conceptual figure summarizes what is known to date about the intention superiority effect and how it may relate to prospective memory in young and older adults. We depict the current findings on the intention superiority effect in young and older adults and reflect on the possible relations to prospective memory performance (see Figure 3). We refer to Maylor et al.'s (2000) study as having demonstrated a long-term naturalistic intention superiority effect and emphasize the need for a paradigm that examines young and older adult age groups that more closely mirrors those used by Goschke and Kuhl (1993) and Marsh et al. (1998).

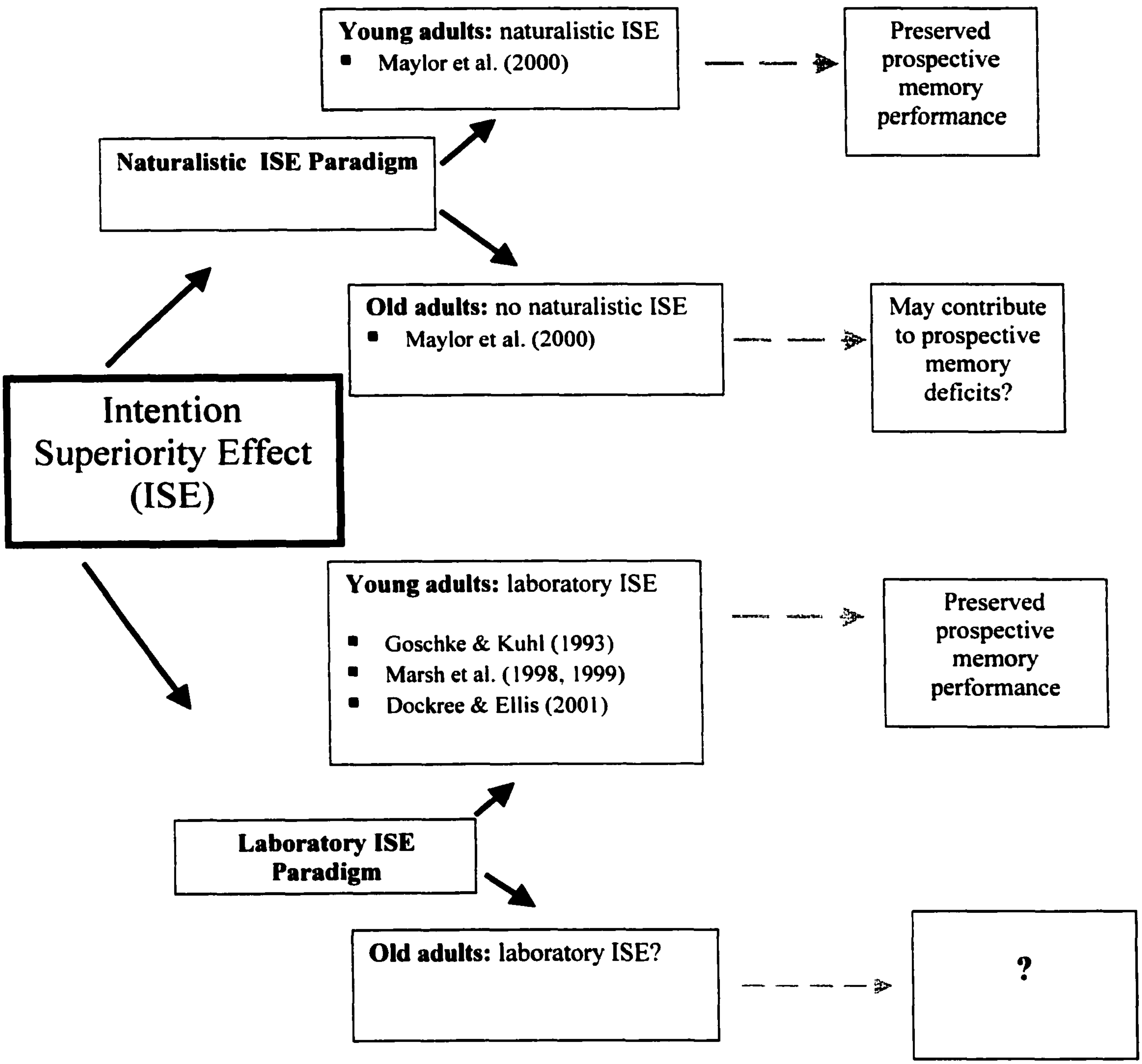

Figure 3. Schematic of the current literature and the possible relation between the intention superiority effect and prospective memory performance for young and older adults.

Inspection of the Figure above shows the gap in the current literature on the intention superiority effect because no research to date has investigated whether older adults exhibit an intention superiority effect. It is necessary to examine this phenomenon in a paradigm that more closely resembles that of Goschke & Kuhl (1993) and Marsh et al. (1998) comparing a group of young adults to a group of older adults.

Rationale for Current Study

There were several motivations for the experiments reported here. First, a primary motivation was to create a new paradigm to examine the intention superiority effect observed by Goschke and Kuhl (1993), Marsh et al. (1998, 1999), and Dockree and Ellis (2001). In Experiments 1 and 2, we examine the intention superiority effect within the context of an interference paradigm. Until now, paradigms used to test the intention superiority effect have been facilitation paradigms. In previous studies of the intention superiority effect, facilitation paradigms were used to show that attending selectively to relevant stimuli facilitates performance on certain tasks that benefit from the processing of that information. Another method of demonstrating attentional bias is to show that performance can suffer as a result of attending selectively to relevant stimuli where the processing of that information leads to disruption of performance (Williams, Mathews, & MacLeod, 1996). If we demonstrate that participants are influenced by the presence of the embedded words from the intention while they are attempting to ignore their influence, we have a powerful demonstration of the intention superiority effect. This line of reasoning is supported by a long history of research (Jacoby et al., 1992) that shows that indirect tests of a phenomenon can be more informative about the process under investigation. This paradigm is informative because it allows one to examine a phenomenon (influence of semantic content of words) that is counter to what individuals are trying to do (ignore semantic content of words).

Second, another primary objective of these experiments was to compare performance of young and older adults because no paradigm to date has investigated whether older adults demonstrate an intention superiority effect. Experiments 3 and 4 examine and compare the performance of a young and older adult age group on the intention superiority effect. As Ellis (1996) points out, there is evidence that failures to carry out a previously encoded intention are associated with a low frequency of recollections of that intention during retention intervals. Therefore, failures in prospective memory are thought to occur due to an inability to maintain an intention throughout the retention interval of the task. For example in a study by Maylor (1998), young, middle-aged, and older adults completed an event-based task in which they were instructed to identify the names of famous faces. The prospective memory task required them to mark the trial number for any of the faces wearing glasses. Results showed that mean accuracy declined across age groups (*M*'s = .77, .62, .26) with the older adults correctly identifying only 26% of the prospective memory cues. Based on self-reports from participants, the author concluded that older adults appeared to think less of the prospective memory instructions during the retention interval relative to other age groups. This observation might imply that age-related failures in prospective memory were due to an inability to maintain the intention throughout the retention interval. Craik and Kerr (1996) discuss this same phenomenon in terms of momentary lapses of intentions (MLI's). They define MLI's as lapses that occur when intentions in short-term retention intervals drop from awareness. They suggest that it is during the retention interval that older adults may become more absorbed in an ongoing task disrupting performance on the prospective memory task. These lapses are suggested to occur because intentions are difficult to maintain in mind in the midst of other attention demanding ongoing activities.

In the current set of experiments, an interference paradigm has been selected to examine the intention superiority effect. This method of demonstrating attentional bias allows us to show that performance can suffer as a result of attending selectively to relevant stimuli where the processing of that information leads to disruption of performance (Williams et al., 1996). Specifically, the interference task we chose to use is the Stroop task. In the original version of the Stroop (1935) task, participants were asked to name as quickly and accurately as possible the ink in which an item was presented while attempting to ignore the item itself. These items could be rows of X's or names of colours. A name of a colour could appear in ink that was congruent (*blue* in blue ink) to its name or incongruent (*blue* in red ink). Much research has shown that participants are slower to name the colours when the base items are incongruent colour names than when they are rows of meaningless stimuli (see MacLeod 1991).

Subsequent research has shown that any common word shows some interference, especially if that word has some special meaning to the individual (Williams et al., 1996). Research conducted by Warren (1972) showed that priming of to-be-ignored items could enhance their capability to interfere. Warren (1972) investigated whether priming ordinary non-colour words by prior exposure could enhance the interference they caused when they had to be ignored in a Stroop-like colour-naming task. Therefore, he investigated whether incongruent colour words would interfere with colour naming not solely because of their incongruence but also because of their activation within the task.

Warren (1972) observed that primes caused substantially increased interference in colour naming relative to unprimed words. In another study, Warren (1974) used a very similar procedure but examined associative connections. He showed that priming a to-be-ignored target word (e.g., BOY in green) by an associatively related word (GIRL) versus by an unrelated word (CASE) resulted in enhanced interference. Furthermore, that interference was even graded by degree of association, with interference increasing from 20 ms to 95 ms as associative strength moved from low to high (Warren, 1974). These patterns make sense if it is assumed that words interfere with colour naming to the extent that these words are activated in memory, and that activation can be accomplished either semantically or episodically (Williams et al., 1996).

An emotional analog of the Stroop task was developed that showed colour naming of emotional words (compared to emotionally neutral words) was slowed in emotionally disturbed individuals compared to control groups. For example, a study by Richards, French, Johnson, Naparstek, and Williams (1992) showed that individuals high on trait anxiety responded slower to anxiety-related words compared to matched neutral words. An earlier study by Geller and Shaver (1976) revealed that more interference was observed with a nonclinical population using a manipulation of self-awareness. Specifically, participants performed a Stroop task in which they named colours of self-referent words. Results showed greater interference if a participant had to perform the task in front of a camera and mirror. This finding was interpreted as showing that the mirror and camera enhanced self-awareness and that under those circumstances made it more likely that a self-referent word's semantic meaning would be activated creating interference for colour naming (Geller & Shaver, 1976).

An enduring debate within the prospective memory literature is whether prospective memory is a type of memory distinct from retrospective memory. There are some who have argued that the construct of prospective memory is not distinctive from retrospective memory because manipulated variables tend to have parallel effects on both prospective and retrospective tests (Roediger, 1996). Research on the intention superiority effect provides counter evidence to this contention, as it demonstrates that intention-related material is held in mind differently compared to information that is not intention-related. Some argue that it is the self-referential quality of executing intentions that leads to its superiority in memory. If self-awareness in Geller and Shaver's (1976) study made it more likely that a self-referent word's semantic meaning would be activated creating interference for colour naming, then the Stroop task may provide a valuable opportunity to examine the intention superiority effect. For example, in the typical intention superiority effect paradigm, participants encode intentions that are high in a degree of self-reference because they themselves will have to carry them out. That is, by their very nature, encoding and executing the intentions involves a degree of self-referent processing. It may be that the self-referent quality of intentional action leads to related material being more accessible in memory leading to increased interference for that material in the Stroop task. This hypothesis was tested in the following experiment.

Experiment 1

In this study, we tested whether intention-related material will show more interference compared to material that was not intention-related. The logic was that intention-related material might have an increased accessibility in mind which will lead to the activation of its semantic meaning leading to greater interference with colour naming. The method involved asking a group of undergraduate participants to read a series of brief descriptions of activities (e.g., Put the marble in the plastic bag) then after each description they were given instructions to either 'Do the Task' or 'Forget the Task'. Following this instruction (and before they actually carried out any tasks), participants received a brief Stroop word list. Participants were instructed to state the colour of each word as quickly as possible. Each Stroop word list was made up of three critical words from the intention (marble, plastic, bag), 13 neutral words (table, sing, lake) and 8 congruent colour words (blue, red, green) for a total of 24 words.

At the conclusion of each Stroop list, participants were asked, "Is there anything you are supposed to do?" If the participant had just completed a 'do the task' trial, they were required to remember to carry out the task using materials that were located on an adjacent table. If the participant had just completed a 'forget the task' trial, they were supposed to respond, "no there is nothing I am supposed to do." It is important to note that the participant was probed to some degree by the experimenter to recall the intention therefore we cannot claim that this task is prospective in this respect. However, it was a necessary limitation to the paradigm and did not detract from our main objective which was to observe the effect that holding an intention in mind has on behaviour. The prediction was that participants would exhibit significantly longer latencies for colour naming of critical words belonging to 'Do the Task' trials versus critical words belonging to 'Forget the Task' trials reflecting an intention superiority effect.

Method

Participants

Twenty-eight undergraduate students participated in the experiment. Undergraduate students participated in exchange for optional extra credit in a first-year introductory psychology course. One participant failed to follow instructions properly and another participant experienced excessive microphone failures. As a result, both participants' data were excluded from analyses.

Design and Materials

The design was a 2 (Instructions: do the task, forget the task) × 3 (Word Type: critical, neutral, colour) repeated measures design. The dependent variable was reaction time on correct responses. Each participant received a series of 24 intentions (e.g., Put the marble in the plastic bag) and each intention contained three critical words that later appeared embedded in 24 yoked corresponding Stroop lists. However, before actually completing each Stroop list, participants received instructions to either 'do the task' (12 trials) or 'forget the task' (12 trials). Across the 24 trials, order of the 'Do/forget' instructions was in 12 random fixed orders counterbalanced across participants. Each of the 24 Stroop lists had 24 words in total consisting of the 3 critical words from the preceding intention, 13 novel neutral words (chosen from the MRC Psycholinguistic Database), and 8 congruent colour words. Seven colours were used (i.e., *red, blue, green, yellow, pink, white,* and *black*). No incongruent colour words were used in this experiment.

Presentation of the 24 words in each Stroop list were in a random fixed order with the constraint that critical words always appeared between the 6th and 19th words with at least one neutral or colour word between each of the critical words. Across the 24 lists, the first critical item appeared on average in the 11^{th} position, the second critical item appeared on average in the 14^{th} position, and the third critical item appeared on average in the 17^{th} position. Order of intentions and their corresponding Stroop lists were counterbalanced across participants. The Stroop portion of the task was administered on a computer. The character size of the stimuli were no smaller than approximately 10 × 14 mm. Words were presented in lower case in the centre of the screen (see Appendix for an example of Stroop list).

Procedure

Participants were tested individually with each testing session lasting approximately 45 minutes. They were tested on an IBM-compatible personal computer using Schneider's Micro-Experimental Laboratory Professional software package (Schneider, 1988). Upon arrival to the laboratory, the experimenter obtained informed consent from participants. Participants were seated in front of the computer monitor with the experimenter sitting off to one side. The study was described to participants by the experimenter and participants also read instructions on the computer screen outlining the requirements of the study. Participants were given a short training phase to ensure that the instructions for the primary task were clearly understood. The instructions were as follows:

> Sometimes in life we have to remember to do things and at other times there is no need to remember to do things. People have a limited capacity of attention therefore it can be useful to be able to forget certain things. If people remembered and retained every aspect of their environment, there

may be few resources left for remembering the things that we really need to remember. Therefore, in a sense forgetting can be useful if it 'makes room' for the things we need to remember.

In this study, you will receive a series of short instructions to perform certain activities ("Peel the orange and place in trash") and after this you will receive further instructions to either "DO THE TASK" or "FORGET THE TASK". In the trials where you are asked to DO THE TASK, you will actually carry it out and in the trials where you are told to FORGET THE TASK, you will not have to carry it out. In between these instruction trials, you will receive word lists in which your task is simply to read out as quickly as possible the colour of the font in which a word is presented. (This serves as an interlude between the instruction trials.) Please try to repeat back to me the instructions in your own words to show that you understand them.

The experimenter calibrated the microphone for each individual before the experiment began so that it was sensitive to each person's vocal responses. Participants were then given a short training phase to ensure that they had understood the instructions.

Training Phase. The experimenter showed the participant a white 12.5 cm x 20 cm cue card that had a sentence (e.g., Draw a large circle on the notepad) printed in the center of the card in black size 24-font. Participants were asked to read the sentence out loud. Then the card was turned over immediately to reveal a new card that had either of two instructions printed on it: 'do the task' or 'forget the task.' The experimenter explained to the participants that if the instructions printed on the card said 'do the task', then they would actually be asked to execute the task and if the instructions printed on the card said 'forget the task', then they would not have to execute the task. (For the purpose of the practice trial, participants were instructed to 'do the task'). Therefore, in the practice trial participants were told that they would have to actually carry out the task of 'drawing a large circle on the notepad' but only after they performed a short colour-naming task (i.e., the Stroop task). Thus, immediately after receiving instructions to 'do the task', and before they carried it out, participants performed a brief Stroop task consisting of 10 words. For the Stroop task, participants were instructed to read out loud into the microphone as quickly as possible the colour of the font in which a word was presented while ignoring the semantic meaning of the words.

Following the last word in the Stroop list of the training phase, the participant was asked, "is there anything you are supposed to do?" At this point, the individual was required to respond with "I am supposed to draw a large circle on the notepad" and then they would proceed to actually carry out the task using the relevant materials. Each intention had accompanying objects that were placed on a table to the right of the participant. Therefore, the task materials were within easy reach but not within direct view of the participant. The experimenter asked the participant if they had any questions before the actual experimental phase commenced.

Experimental Phase. In the experiment, there were 24 trials in total with 12 being 'do the task' trials and the remaining 12 being 'forget the task' trials. The ordering of 'do the task' and 'forget the task' trials was in 12 random fixed orders that were counterbalanced across participants. Because participants received the instructions to do/ forget a task after they had already encoded the intention, they could not anticipate during the encoding stage whether they would have to do/forget the intention. Immediately after the presentation of the do/forget instruction, participants engaged in the Stroop task. On completion of the Stroop task, participants were asked, "Is there anything you are supposed to do?" If they had been given a 'do the task' instruction, participants were required to carry out the task and if they had been given a 'forget the task' instruction, they were required to respond, "No, there is nothing I am supposed to do." We anticipated that participants may notice that selected words from the intention were contained within the Stroop list. If participants asked questions about the presence of the intention words in the Stroop list, they were told that this was not the focus of the study and that they should continue focusing on the primary goal of naming the colours of words as quickly as possible. They were also reminded that their colour-naming performance would be enhanced by ignoring the semantic meaning of the words to the best of their ability (see Figure 4).

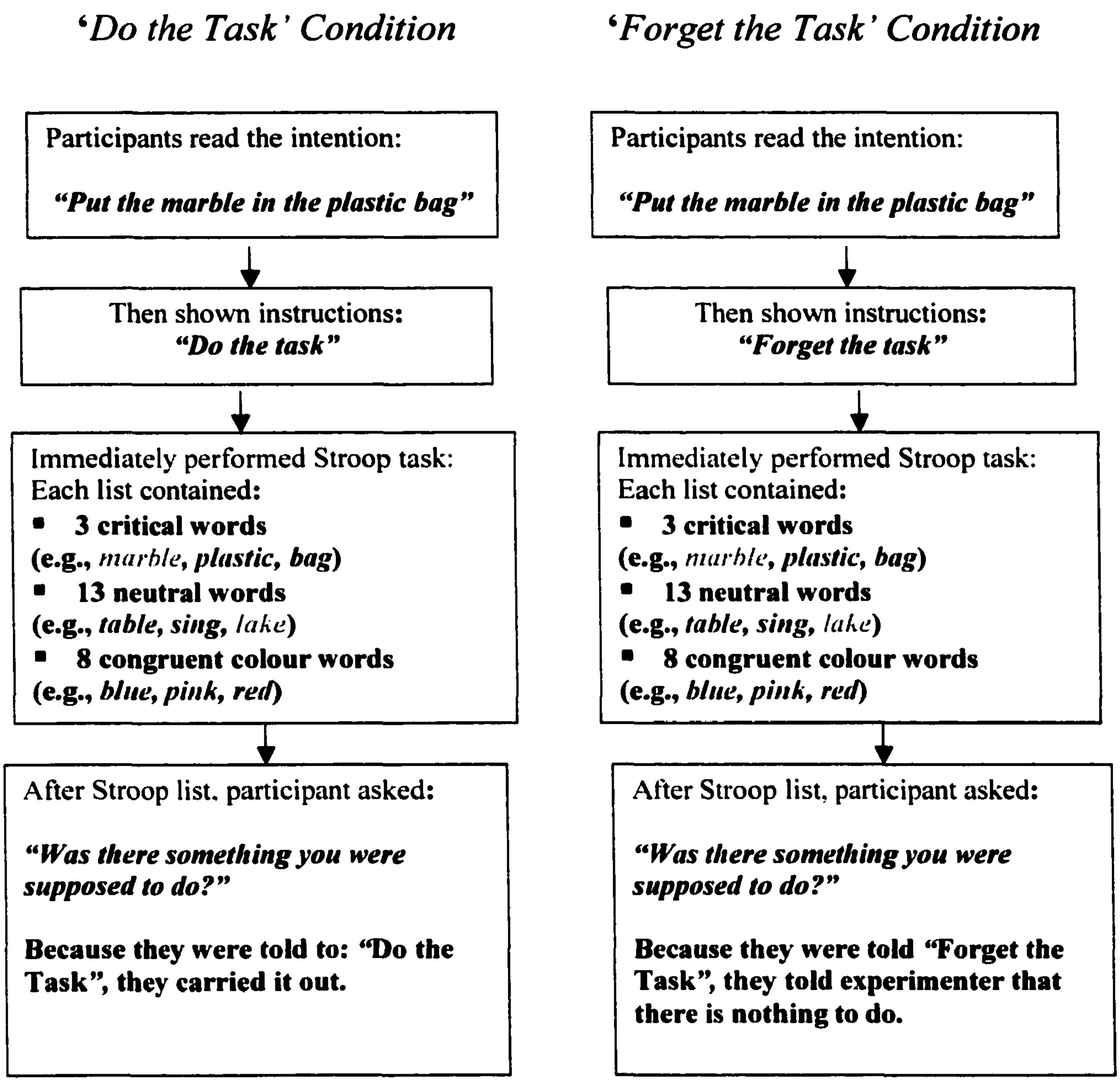

Figure 4. Schematic for 'Do the task and 'Forget the task' conditions.

Results

Following Marsh, Hicks, and Bink (1998), all incorrect responses were removed from analyses of the Stroop data and latencies beyond 3 standard deviations of each participant's mean response or less than 300 ms were also deleted. Because Stroop lists were short in length (24 words) and there were no incongruent colour words, accuracy was very high resulting in little data being removed. The result was the removal of .55% of all responses as errors and .69% as outliers. This result translates on average as each participant having committed approximately 4 errors and having 5 scores deleted as outliers. The alpha level for all reported tests was .05 unless otherwise noted.

Response latencies were examined using a 2 (Instructions: Do the Task, Forget the Task) × 3 (Word Type: critical, neutral, colour) repeated measures analysis of variance (ANOVA). A main effect of Instructions was observed, $F(1, 27) = 10.62, p < .01, \eta^2 = .28$, showing that colour naming was slower in 'Do the Task' ($M = 637.30$ ms, $SD = 95.03$) compared to 'Forget the Task' ($M = 618.70$ ms, $SD = 73.26$) trials. Analyses revealed a main effect of Word Type, $F(2, 54) = 74.49, p < .001, \eta^2 = .73$. Pair-wise comparisons revealed that colour naming was slowest for critical words ($M = 682.18$ ms, $SD = 114.89$), which were slower than neutral words ($M = 648.73$ ms, $SD = 79.94$), which were slower than colour words ($M = 553.08$ ms, $SD = 57.61$). Most importantly, the interaction between Instructions and Word Type was significant, $F(2, 54) = 6.77, p < .002, \eta^2 = .20$ showing that there was a greater difference between latencies for critical items in the 'Do the Task' and 'Forget the Task' conditions than for neutral or colour items reflecting an intention superiority effect (see Figure 5).

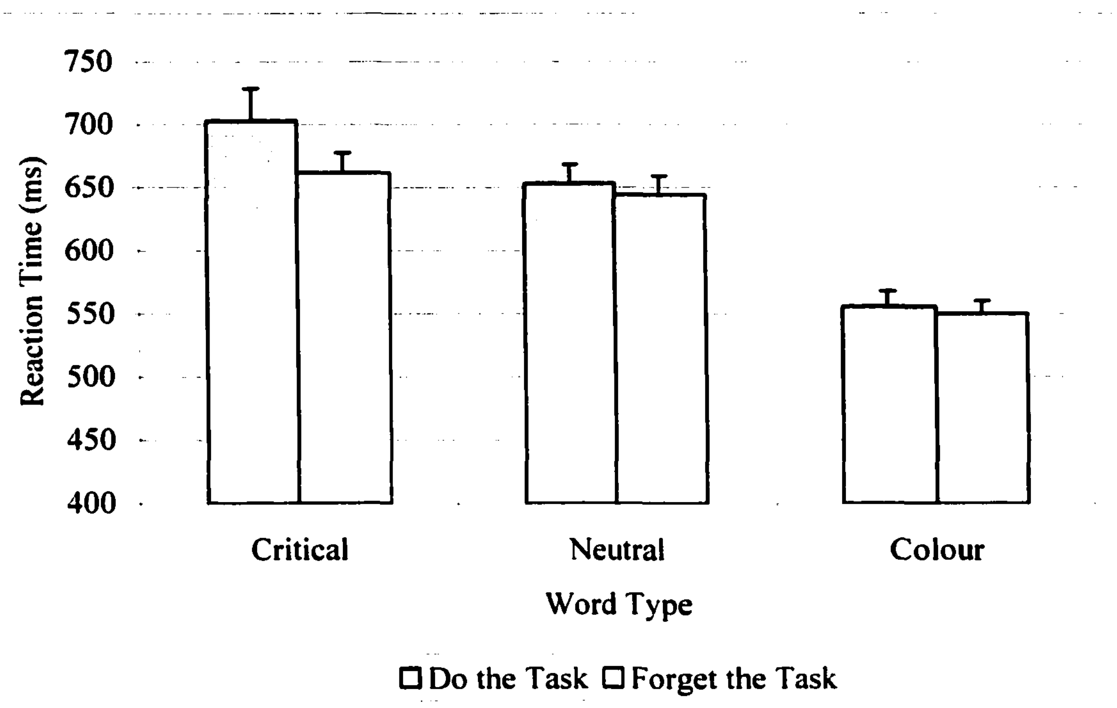

Figure 5. Reaction time performance on the Stroop task in Experiment 1 as a function of Word Type and Instructions. Bars represent standard error.

The next analysis was conducted to examine whether there was an effect of order of critical items. There were three critical items belonging to an intention that always appeared in the Stroop list. We were interested in whether response latencies for the three critical items varied as a function of their order in the Stroop or as a function of Instructions. Response latencies were evaluated using a 2 (Instructions: Do the Task, Forget the Task) × 3 (Critical Item Order: first, second, third) repeated measures ANOVA. There was a main effect of Instructions, $F(1, 27) = 9.46, p < .05, \eta^2 = .26$ showing that colour naming was slower in 'Do the Task' ($M = 702.51$ ms, $SD = 148.69$) compared to 'Forget the Task' ($M = 661.85$ ms, $SD = 105.71$) trials. There was a marginal effect of Critical Item Order, $F(2, 26) = 2.89$, $p = .06$, $\eta^2 = .10$. Pair-wise comparisons showed that there was a significant difference between response latencies for critical items in the first (M = 668.70 ms, SD = 112.63) and second (M = 690.08 ms, SD = 122.50) positions. No other pairwise comparisons were significant. The interaction between Instructions and Critical Item Order was not statistically significant ($F = 2.23$). However, pairwise comparisons showed a significant difference ($p = .004$) between critical items in the first (M = 676.94 ms, SD = 127.62) and second (M = 719.63 ms, SD = 158.14) position but only for the 'do the task' condition (see Figure 6).

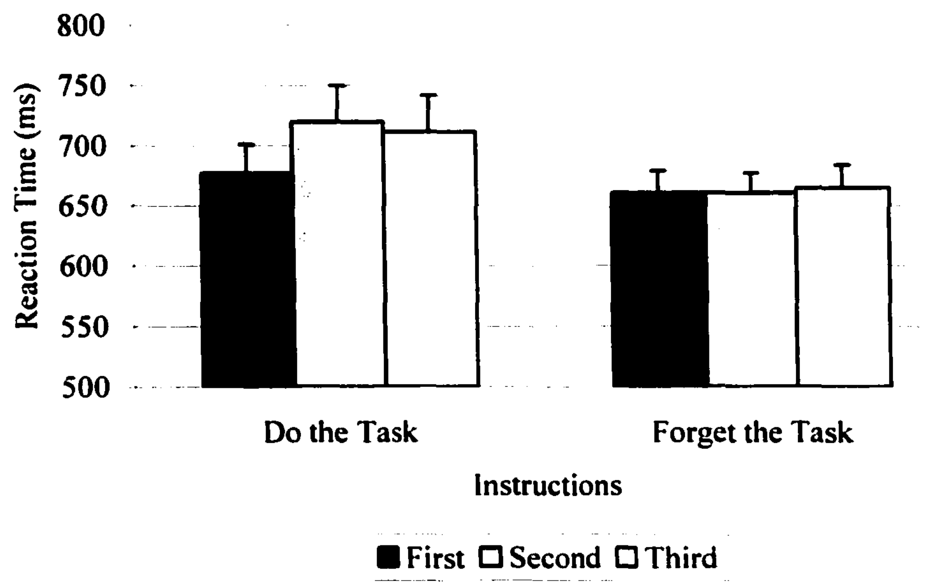

Figure 6. Reaction time performance on the Stroop task in Experiment 1 as a function of Critical Item Order and Instructions. Bars represent standard error.

Discussion

This experiment showed that enhancing critical words through linking them to an intention appears to increase their power to interfere with colour naming. The magnitude of this effect (approximately 41 ms) was very similar to the magnitude of the effect found by Goschke and Kuhl (1993) and Marsh et al. (1998). If we assume that response latencies reflect the availability of concepts in memory, these results indicate that material related to the intended action was more available and interfered with Stroop performance compared to information that was not to be executed. When participants form an intention, it may involve more detailed processing and this detailed processing offers more opportunities for future processing to overlap. Therefore, this effect can be explained in terms of the reinstatement of prior processing. Because this result was found in the context of an interference paradigm, it provides an even stronger demonstration of the intention superiority effect. The reason it is a stronger demonstration is because word reading is not required for colour naming, therefore, effects on colour-naming latencies are not as likely to be contaminated by strategies directed toward identification of the word itself (Burt, 1999).

Although the interaction between instructions and critical item order was not statistically significant, inspection of the means shows that interference increased from the first critical item to the third critical item more for 'do the task' trials and this pattern was not evident for 'forget the task' trials. When participants believe that they will have to carry out the task, it may be that the notion that there is 'something to do' is brought to mind after the first critical word acts as a cue or intentional marker. In line with this idea, Marsh et al. (1998) argued that intended information might be reprocessed more efficiently as a consequence of an internal marker. Instead of understanding the intention superiority effect in terms of activation level, Marsh et al. suggested that this effect may be explained as a phenomenon in which intended information is reprocessed more quickly because an internal marker has been associated with that intention as (Marsh et al., 1998). So, it is not the activation level of the intention but rather the strength of association between the encoded intention and the retrieval context.

It is interesting to note that critical (M = 661.63 ms) and neutral (M = 644.19 ms) items in 'forget the task' trials showed a significant difference of 17 ms ($p < .05$). The question that stems from this finding is whether this represents some form of repetition priming. The only difference between critical and neutral words in the 'forget the task' condition was that the critical words were read in a sentence prior to exposure to the Stroop list whereas the neutral words were encountered only once in the Stroop list. Therefore, it may be that simply reading the critical words in an intention and then later encountering them in the Stroop task, leads to a form of repetition priming. We felt that this unanswered question should be addressed more closely. Therefore, in the following experiment, the procedure was almost identical except that participants did not encode any intentions nor were they instructed to do/forget any material. Instead, participants simply read sentences and then performed the Stroop task with critical items from the sentences embedded within the Stroop lists.

Experiment 2

In this experiment, we examined more closely the impact that the intentional manipulation to perform or not perform the task had on performance. We were interested in posing the question: What would be the fate of the critical items, if we took away the directive and instructional aspect of the design? By addressing this issue, we will have a better understanding of the intention superiority effect. For example, it is possible that in Experiment 1, the intention superiority effect was partly influenced by the fact that the critical words appeared twice (once in the intention and then a second time in the Stroop list). In Experiment 2, we eliminate the instructions to do anything with the material so that we can examine the effect that simply reading a sentence and having words from the sentence appear in the Stroop list has on performance. By conducting this experiment, we have a better idea of how the do/forget manipulation influences performance. Therefore, the method was identical to that of Experiment 1 except that participants did not receive any instructions to 'do the task' or 'forget the task'. In this experiment, the experimenter asked participants to read sentences that were almost identical to those in Experiment 1 except that any directive was taken out of the sentence. In the instruction phase of this experiment, a false reason was created to establish a reason for why participants had to read the sentences before they performed each Stroop task. Therefore, this experiment allowed us to examine the effect that reading words in a sentence (containing no future oriented activity) had on Stroop performance. Based on results from Experiment 1, we predicted that merely reading the critical words in a sentence prior to the Stroop task would lead to interference due to repetition priming. The prediction was that having read the critical words in sentences would activate the semantic meaning of the words when they were later encountered in the Stroop list leading to interference in colour naming compared to neutral words that were encountered for the first time within the Stroop list.

Method

Participants and Materials

Twenty-eight undergraduates participated in exchange for optional extra credit in an introductory psychology course. None had participated in Experiment 1. Materials were identical to those of the previous experiments with one exception. The experimenter showed the participant the 12.5 cm x 20 cm cue card with sentences that had the directive taken out. Therefore, in the previous experiment the intention was worded as: 'Put the marble in the plastic bag.' In the current experiment, the future-oriented aspect of the sentences was eliminated such that participants received a sentence worded as: 'The marble is in the plastic bag'. Immediately following the reading of the sentence, participants performed the Stroop task that contained the same materials as those used in the previous experiment.

Procedure

Once again participants were tested individually with the testing session lasting approximately 35 minutes. The experimenter described the study to participants and they also read instructions on the computer screen outlining the requirements of the study. Participants were given a brief training phase to familiarize them with the task. The procedure was almost identical to the previous experiment except that all directives were taken out of the study. Therefore, we constructed a false reason to explain the reason that we wanted participants to read the sentences aloud. Participants were told that the Stroop task was an interlude between the other task of reading the sentences aloud. Thus, instead of receiving an intention such as 'Put the marble in the plastic bag' participants received a sentence such as 'The marble is in the plastic bag.' Following presentation of each sentence, participants did not receive any instructions to 'do/forget' the materials. Instead, they began immediately performing the Stroop task. By including this change to the task design, we eliminated the need for participants to interact with the materials (e.g., putting the marble in the plastic bag); therefore this aspect of Experiment 1 was also eliminated from this experiment. All objects that had been used as experimental materials in the previous experiment (e.g., marble, plastic bag) were physically removed from the laboratory room. Therefore, we tried to keep the procedure consistent with the previous experiment while excluding the need to execute an intention. Below is an example of the instructions that were administered to participants. We constructed a set of instructions that contained a false reason for why participants were asked to read the sentences out loud.

> This experiment investigates the hypothesis that words in a sentence that are read aloud with a recurrent stress/intonation pattern can facilitate processing on later cognitive performance. However, other research has shown that recurrent stress/intonation patterns can interfere with later cognitive performance.
>
> In this study, you will be asked to read a series of sentences aloud into a microphone. It is important that you read the sentences as clearly as possible in what you would consider to be your normal level tone. In between these sentence-reading trials, you will receive word lists in which your task is simply to read out as quickly as possible the colour of the font in which the word is presented. (This serves as an interlude between the sentence trials.)

Results

All incorrect responses were removed from analyses and latencies beyond 3 standard deviations or below 300 ms were also excluded. This resulted in the removal of .32% as errors and .43% as outliers.

The design was a one-way ANOVA with Word Type (critical, neutral, colour) as a within-subjects variable. The dependent variable was response latencies on the Stroop task. Analysis revealed a main effect of Word Type, $F(2, 54) = 133.67$, $p < .001$, $\eta^2 = .83$. Pair-wise comparisons showed that colour naming was slowest for critical words ($M = 700.86$ ms, $SD = 82.69$) which were slower than neutral words ($M = 677.56$ ms, $SD = 80.92$) which were slower ($M = 561.41$ ms, $SD = 50.81$) than colour words (see Figure 7).

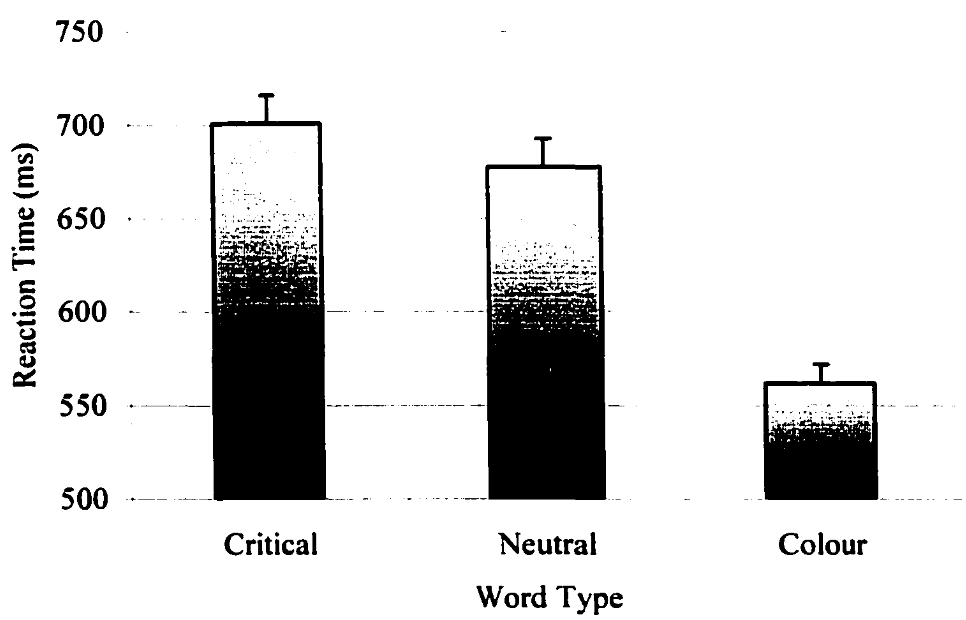

Figure 7. Reaction time performance on the Stroop task in Experiment 2 as a function of Word Type. Bars represent standard error.

An analysis of critical item order was conducted. Results revealed a marginal main effect of Critical Item Order, $F(2, 26) = 3.23$, $p = .06$, $\eta^2 = .20$. Inspection of the pairwise comparisons showed that this effect was due to a significant difference (p = .003) between critical items in the first position (M = 689.10 ms, SD = 79.08) and critical items in the second position (M = 712.51 ms, SD = 89.09). There were no other significant differences between pairs of means (see Figure 8).

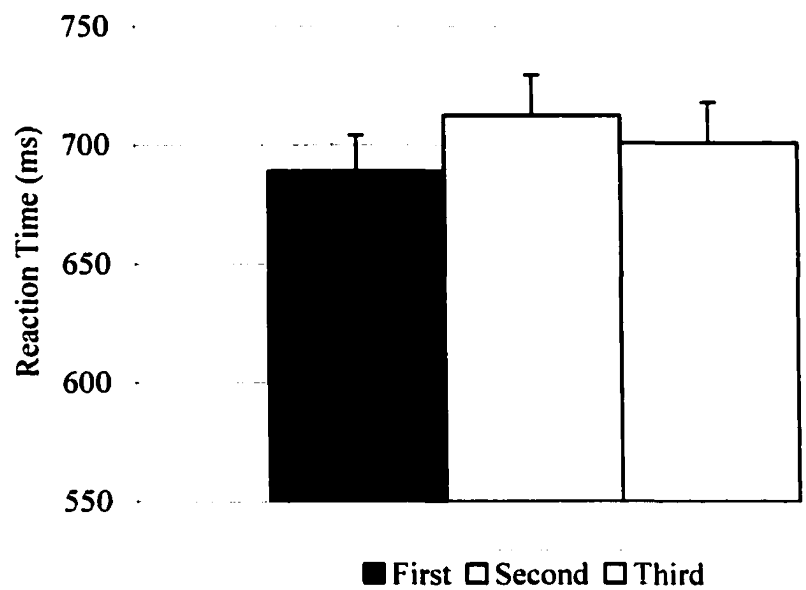

Figure 8. Reaction time performance on the Stroop task in Experiment 2 as a function of Critical Item Order. Bars represent standard error.

Discussion

The results of Experiment 2 showed that there was a significant difference between response latencies for critical and neutral words (M = 23 ms) implying that reading critical words in a sentence prior to the Stroop task resulted in increased interference in colour naming compared to neutral items. Results of this study showed that interference is increased even in the absence of instructions to 'do anything' with the material. That is, in this experiment participants were simply told to read the sentences but they were not instructed to remember the sentence or process them in any specific way. Even in the absence of instructions to process the sentences in any detailed way, participants displayed significantly more interference for colour naming critical items compared to neutral items. This effect could be explained in terms of the association between critical items. It is likely that reading the words in a sentence allowed participants the opportunity to make an association among the critical items enhancing their semantic meaning and leading to increased interference when they were later encountered in a Stroop task. If the critical words had been read in a list rather than in the context of a sentence, we may not have observed this effect. This idea was addressed in research that was conducted on item priming in colour naming for Stroop tasks. For example, Burt (1999) showed in line with a proposal made by Warren (1972, 1974) that the articulatory program for word reading competes with the articulatory program for colour naming. That is, she demonstrated that any experimental manipulation that enhances the activation of a word can lead to colour-naming interference. Therefore, manipulations that activate the semantic association between a word and its later presentation can lead to interference and manipulations that facilitate word recognition without recruiting additional semantic processing can actually lead to facilitation of colour naming. In the current experiment, results indicate that instructing participants to read a sentence out loud appeared to enhance the semantic processing of the words leading to interference when the words had to be ignored in a colour-naming task. The effect in this experiment can be compared to the priming effect that was found for performance in the 'forget the task' condition in Experiment 1. That is, the magnitude of the two results is quite similar because if we compare the difference in latencies between critical and neutral items in the 'forget the task' condition in Experiment 1 ($M = 17$ ms) it is fairly similar to the difference observed in Experiment 2 ($M = 23$ ms).

There was a marginal effect of Critical Item Order similar to the pattern of effects in Experiment 1. Although the difference between critical items in the first and second position was smaller (23 ms) than the effect found in Experiment 1 (43 ms), results from both experiments exhibit a similar pattern such that the first critical item appears to act as a form of cue or external marker for the rest of the critical items. It may be that this first critical word that is encountered in the Stroop list acts as a trigger for the associated items leading to the step-wise interference effects that were observed. For example, the first critical word may cause the remaining second and third items to be retrieved from long-term memory back into working memory where they lead to increased interference for colour naming.

Experiment 3

The previous two experiments focused solely on the performance of young adults. It is important to consider how older adults perform on tasks that examine the intention superiority effect because it may allow us to better understand the nature of older adults' performance on prospective memory tasks. As mentioned previously, there are a number of prospective memory studies that show age-related differences in prospective memory in favour of younger adults (e.g., Einstein, McDaniel, Smith, & Shaw, 1998; Maylor, 1993, West & Craik, 1999). Researchers such as West and Craik (1999) suggest that after encoding, intentions momentarily fall below consciousness and fluctuate over the course of task performance. Craik and Kerr (1996) referred to this phenomenon as momentary lapses in intentions. They found that it was difficult for older adults to maintain the cue-action schema in an activated state and this led to a greater proportion of instances of forgetting. This finding raises the empirical question of whether older adults may have trouble maintaining intention information in a heightened state. Perhaps older adults as opposed to younger adults lack an intention superiority effect.

No paradigm to date has investigated whether an intention superiority effect exists in older adults. Maylor et al. (2000) employed a naturalistic paradigm in which a written fluency task was used to investigate whether older adults exhibited an intention superiority effect. Results showed an intention superiority effect for young adults but not for older adults. Maylor et al. suggested that the absence of an intention superiority effect might help explain the decline in prospective memory observed in aging and dementia. However, their paradigm was very different from those of Goschke and Kuhl (1993) and Marsh et al. (1998, 1999). Although older adults may not exhibit an intention superiority effect in the speeded fluency task used in the Maylor et al. (2000) paradigm, the question still remains whether they will exhibit an intention superiority effect in a paradigm that more closely resembles that of Goschke and Kuhl (1993). This question is important to address because the paradigm used in the Maylor et al. (2000) study was naturalistic and examined a qualitatively different research question. In the Maylor et al. paradigm, they asked participants to retrieve as many future events as possible within a set period of time. By using an experimental method in the current experiment, we control for the various factors that could have influenced performance in the Maylor et al. (2000) study such as retrieval deficits or the possibility that older adults simply had less future activities to do. Experiment 3 was carried out in an attempt to address this gap in the literature. The method of this experiment was identical to that of Experiment 1 except that an older adult age group was included.

Method

Participants

Twenty-eight young adults (range = 17 to 30 years; M = 19.29 years, SD = 2.79) and 24 older adults (range = 56 to 77 years; M = 69.71 years, SD = 5.83) participated in the experiment. None of the young adults participated in the previous two experiments. Although the sample was well-educated, a one-way analysis of variance (ANOVA) revealed that older adults had significantly more years of education (range = 11 to 19 years; M = 14.17, SD = 2.41) compared to young adults (range = 12 to 16 years; M = 12.68 years, SD = 1.16), $F(50) = 8.45$, $p < .05$. Self-reported health was measured using a 5-point Likert style scale. Participants were asked to reflect on their health in the last month and then rate themselves on a five-point scale (1=very good, 2=good, 3=fair, 4=poor, 5=very poor). Results showed that young adults (M = 1.54, SD = .58) did not differ from older adults (M = 1.54, SD = .66) in their levels of self-reported health (F < 1).

Undergraduate students participated in exchange for optional extra credit in an introductory psychology course. The older participants were recruited from a volunteer pool maintained by the laboratory of Roger Dixon at the University of Victoria. These community-dwelling participants were reimbursed for their travel expenses (e.g., bus fare, parking). One younger adult failed to follow instructions properly and was excluded from analyses.

Materials and Design

The character size of the stimuli were no smaller than approximately 10 × 14 mm and this size was considered to be suitable for all age levels of visual acuity. The design was a 2 (Age: young, old) × 3 (Word Type: critical, neutral, colour) × 2 (Instructions: do the task, forget the task) mixed factorial design with age as the between-subject variable and Word Type and Instructions as the within-subject variables. The dependent variable was reaction time on correct responses.

Procedure

The procedure was identical to that of Experiment 1. There were 24 trials in total with 12 being 'do the task' trials and the remaining 12 being 'forget the task' trials. The ordering of 'do the task' and 'forget the task' trials was in 12 random fixed orders that were counterbalanced across participants. Because participants received the instructions to do/ forget a task after they had already encoded the intention, they could not anticipate during the encoding stage whether they would have to do/forget the intention. Immediately after the presentation of the do/forget instruction, participants engaged in the Stroop task.

Results

All incorrect responses were removed from analyses of the Stroop data and latencies beyond 3 standard deviations of each participant's mean response or less than 300 ms were also deleted. The result was the overall removal of on average .43% of all responses as errors and .86% as outliers. By age group, this resulted in young adults having .30% as errors removed and .52% as outliers and older adults having .56% as errors and 1.2% as outliers removed.

Reaction time performance was evaluated using a 2 (Age Group: young, old) × 2 (Instructions: do the task, forget the task) × 3 (Word Type: critical, neutral, colour) mixed factorial analysis of variance (ANOVA) with repeated measures on the second and third factors. There was a main effect of age group, $F(1, 50) = 29.01, p < .001, \eta^2 = .37$, revealing that reaction time was significantly faster for younger adults ($M = 651.79$ ms, $SD = 93.50$) than for older adults ($M = 771.06$ ms, $SD = 81.54$). However, Age group did not interact with any other factors. The cell means are displayed in Table 1.

Table 1

Mean Response Latencies and Standard Deviations for Performance on the Stroop task as a function of Instructions and Word Type

	Do the Task		Forget the Task	
	M	*SD*	*M*	*SD*
YOUNG				
Critical	747.05	(141.20)	702.40	(118.04)
Neutral	683.29	(95.89)	671.44	(94.78)
Colour	555.24	(61.65)	551.31	(65.55)
OLD				
Critical	875.10	(104.09)	836.15	(78.20)
Neutral	797.41	(70.28)	792.61	(71.16)
Colour	673.14	(88.29)	651.96	(77.24)

Analyses revealed a main effect of Instructions, $F(1, 50) = 22.52, p < .001, \eta^2 = .31$ showing that performance was slower in 'Do the Task' ($M = 721.87$ ms, $SD = 109.57$) compared to 'Forget the Task' ($M = 700.98$ ms, $SD = 103.87$) trials. There was a main effect of Word Type, $F(2, 49) = 144.09, p < .001, \eta^2 = .86$. Pairwise comparisons revealed that responses were fastest to colour words ($M = 607.92$ ms, $SD = 90.96$), which were faster than neutral words ($M = 736.19$ ms, $SD = 102.84$), which were faster than critical words ($M = 790.17$ ms, $SD = 126.36$).

As observed in Experiment 1, there was a reliable interaction between Word Type and Instructions, $F(2, 49) = 6.85, p < .01, \eta^2 = .22$, revealing that there was a larger difference between "Do the Task" and "Forget the Task' trials for critical words than for colour and neutral words (see Figure 9).

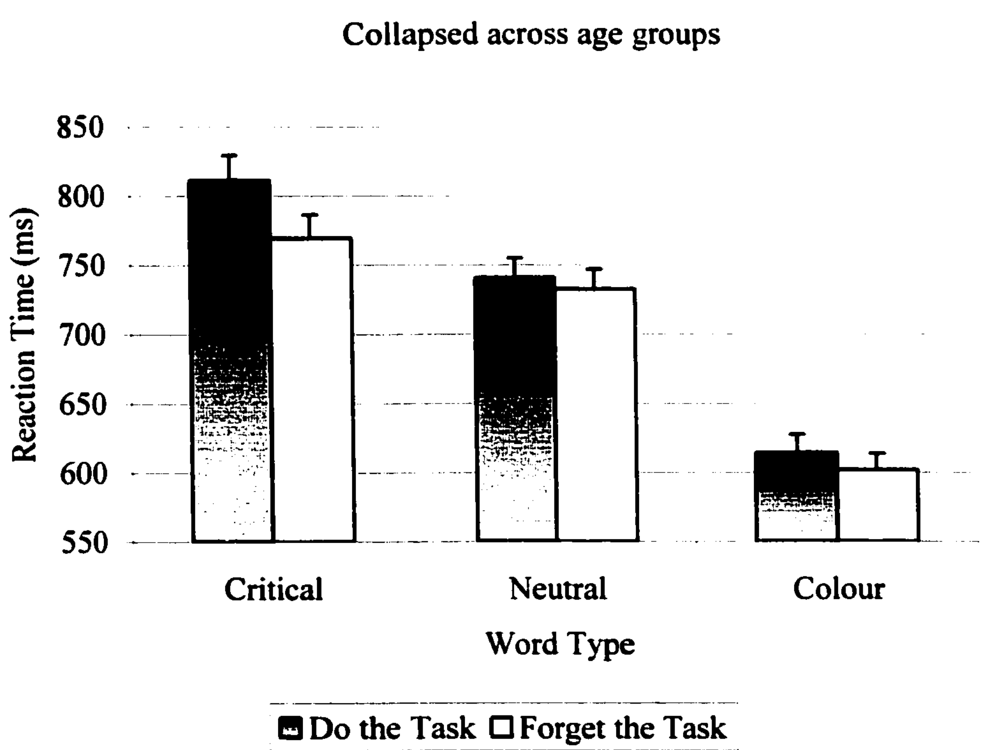

Figure 9. Reaction time performance on the Stroop task in Experiment 3 as a function of Word Type and Instructions. Bars represent standard error.

The next analysis was conducted to examine whether there was an effect of order of critical items. Once again we investigated whether a similar pattern of results to those of Experiment 1 would be found with critical item order. Reaction time performance was evaluated using a 2 (Age Group: young, old) × 2 (Instructions: do the task, forget the task) × 3 (Critical Item Order: first, second, third) mixed factorial analysis of variance (ANOVA) with repeated measures on the second and third factor. There was the expected main effect of Age Group, $F(1, 50) = 20.34, p < .001, \eta^2 = .29$, revealing that reaction time was significantly faster for younger adults (M = 724.78 ms, SD = 131.39) than for older adults (M = 855.34 ms, SD = 111.48). There was a main effect of Instructions, $F(1, 50) = 21.13, p < .001, \eta^2 = .30$ showing that performance was slower in 'Do the Task' (M = 810.90 ms, SD = 143.51) compared to Forget the Task' (M = 769.22 ms, SD = 133.56) trials.

A significant interaction was found between Instructions and Critical Item Order, $F(1, 100) = 3.64, p < .05, \eta^2 = .07$, revealing that there was a greater difference between order of words for the 'do the task' instructions than for the 'forget the task' instructions. Pairwise comparisons showed that for 'do the task' trials there was a reliable difference between latencies for critical words that appeared in the first position (M = 782.72 ms, SD = 127.34) in the Stroop list compared to critical words that appeared in the second position (M = 831.14 ms, SD = 157.34). There was also a significant difference between critical words appearing in the first position compared to those appearing in the third position (*M* = 818.84 ms, *SD* = 145.85) (see Figure 10). There were no significant interactions with age.

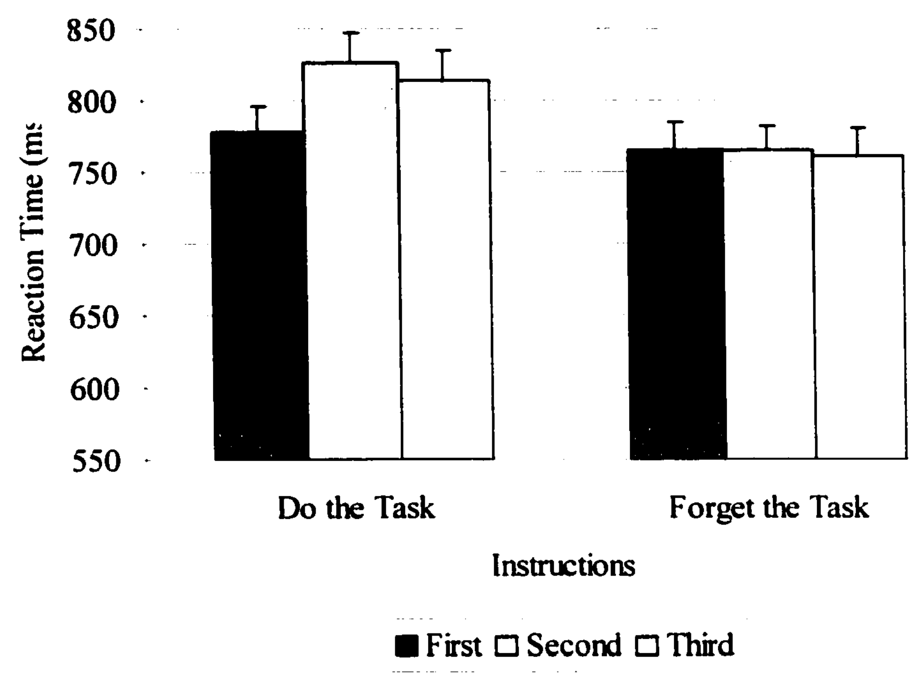

Figure 10. Reaction time performance on the Stroop task in Experiment 3 as a function of Critical Item Order and Instructions. Bars represent standard error.

Discussion

Experiment 3 revealed an intention superiority effect (ISE = 42 ms) that replicated the effect found in Experiment 1 (ISE = 41 ms). The results reveal that enhancing critical words through linking them to an intention appeared to increase their power to interfere with colour naming. Even more interestingly, there were no interactions with age group--older adults exhibited the same pattern of performance (albeit slower overall) to that of the young adults. That is, older adults displayed an intention superiority effect similar in magnitude to younger adults. This result is the first demonstration of a laboratory intention superiority effect in an older adult age group and its presence has several implications for theory building in prospective memory and aging. Our results extend the investigation of the intention superiority effect conducted by Maylor et al. (2000). In their naturalistic paradigm, a long-term intention superiority effect was found for younger adults but not for an older adult age group. The method of their study differed quite significantly from the current study and that of Goschke and Kuhl (1993) and Marsh et al. (1998). In their study, participants were told that they would be given a category and they were to write down as many instances as possible of that category. The two categories were performed tasks and to-be-performed tasks. Results showed that there was no intention superiority effect for middle-aged adults however there was an intention *inferiority* effect for older adults (Maylor et al., 2000). The current paradigm is much closer to that of Goschke and Kuhl (1993), as well as the paradigm used in Marsh et al. (1998). Therefore, our results contribute to the current literature by extending upon prior studies through demonstrating a comparable sized magnitude of an effect for an intention superiority effect in an interference paradigm for an older adult age group. In our paradigm, the retention interval was relatively short and closer to that of Goschke and Kuhl (1993) and the Marsh et al. (1998) paradigms. Thus, it may be the case that the processes necessary to support maintaining intentions in mind across shorter delays, such as in our paradigm, are less vulnerable to age-related disruptions. This result has implications for prospective memory functioning. For example, it implies that observed deficits in prospective memory performance may not be due to older adults' inability to maintain intentions in mind across short delays because our results demonstrate a comparable intention superiority effect for older adults to that of younger adults. It would be prudent to note, however, that the mechanism driving the ISE effect may not be necessarily the same for both young and older adult groups. That is, although the magnitude of the observed ISE was similar for both young and older adults, we cannot assume that the same mechanism is driving performance for both age groups. It would be useful to conduct a future study that would adjust empirically for differences between young and old through making the task more difficult for younger adults. Then reaction times would be equivalent across age groups and comparisons could be made more easily.

Once again, an analysis of critical item order was conducted and a similar result was exhibited to that of Experiment 1. That is, a significant interaction was found between Instructions and Critical Item Order showing that there was a greater difference between order of critical words for 'do the task' than for 'forget the task' trials. Specifically, for performance in 'do the task' trials, there was a reliable difference between latencies for critical words that appeared in the first position compared to critical words in the second position (e.g., difference of 43 ms) in the Stroop list and there was a significant difference between the first and third critical items (e.g., difference of 34 ms). There were no interactions with Age group in this analysis which shows that older adults are exhibiting the same pattern of performance as young adults. Older adults' performance was also characterized by the same gradient in the pattern of interference with latencies increasing from the first critical word to the second and third critical words. It may be that this pattern of interference reveals a case in which the first critical item acts as a retrieval cue for the remaining second and third critical items. Therefore, this pattern of response times reflects the first critical item cuing information that was held in long-term memory and is suddenly brought back into working memory. It may be that the second and third items show higher levels of interference because they have been brought back into working memory where they interfere with colour naming performance.

In the next experiment, we were interested in examining the effect that completing an intention had on young and older adults' Stroop performance. If participants completed the intention, it may be that the critical items would cause less interference when later encountered in the Stroop task. This hypothesis was tested in the following experiment.

Experiment 4

In the fourth experiment, we tested the effect that completing an intention has on the representation of intentions. We test the idea that a completed task no longer 'needs' to be in a heightened state because the action has already been executed. A major theoretical viewpoint of normal aging posits that older adults are deficient with respect to the ability to inhibit or ignore irrelevant information (Hasher & Zacks, 1988). The main idea behind this theory is that older adults have difficulty discarding no-longer-relevant information from working memory. If this were the case, one would expect that when older adults completed an intention and therefore no longer needed to keep it in mind—they would still show an intention superiority effect because they were unable to 'delete' this information from working memory. Therefore, in this experiment, a group of young and older adults were compared because we were interested in examining the hypothesis that older adults would not show this decrease in activation level for critical items belonging to already completed intentions because of an inhibition deficit theory of aging (e.g., Hasher, Zacks, & Rahal, 1999).

In this experiment, similar to the procedure for Experiment 3, participants were asked to read the description of the intention (e.g., place the marble in the plastic bag) and then they were instructed to either perform the task "NOW" or "LATER." In 12 of the "NOW" trials, participants completed the intention *before* the Stroop list. And in the 12 LATER trials, participants completed the intention *after* the Stroop task. The prediction was that when participants have to complete the intention after the Stroop task, they are required to hold the information in mind, therefore it is more difficult to ignore the semantic content of critical words which leads to increased interference for colour naming. In contrast, in the NOW trials, participants complete the intention before the Stroop task; therefore they will experience less interference because there is no need to hold the intention in mind. Thus, the prediction was that there would be longer latencies for colour naming of critical items in LATER trials compared to NOW trials in which they have already executed the intention.

Method

Participants

Twenty-four young adults (range = 18 to 34 years; M = 19.67 years, SD = 3.37) and 24 older adults (range = 62 to 78 years; M = 69.54 years, SD = 4.96) participated in the experiment. None had participated in the three previous experiments. Years of education was analyzed with a one-way (ANOVA) to reveal that older adults had significantly more years of education (range = 10 to 20 years; M = 14.83, SD = 2.73) compared to young adults (range = 12 to 16 years; M = 12.96 years, SD = 1.27), $F(46)$ =

9.32, $p < .05$. Self-reported health was once again measured using a 5-point Likert style scale. Participants were asked to reflect on their health in the last month and then rate themselves on a five-point scale (1=very good, 2=good, 3=fair, 4=poor, 5=very poor). Analyses revealed that young adults (M = 1.88, SD = .54) did not differ from older adults (M = 1.67, SD = .76) in their levels of self-reported health ($F < 1$).

Participants were tested individually with each testing session lasting approximately 45 minutes. Undergraduate students participated in exchange for optional extra credit in an introductory psychology course. Older adults were recruited from a volunteer pool maintained by the laboratory of Roger Dixon at the University of Victoria. These healthy community-dwelling participants were reimbursed for any travel expenses (e.g., bus fare, parking). One older adult failed to follow instructions and was excluded from analyses.

Design

The design was similar to Experiment 3. It was a 2 (Age group: young, old) × 3 (Word Type: critical, neutral, colour) × 2 (Instructions: now, later) mixed factorial design with age as the between-subject variable and Word Type and Instructions as the within-subject variables. The dependent variable was reaction time on correct responses.

Materials

The materials for Experiment 4 were exactly the same as those used in Experiment 3 except for the Instruction phase. After reading the intention, participants received instructions to either complete the task 'NOW' (12 trials) or 'LATER' (12 trials). Across the 24 trials, order of the 'Now/Later' instructions was in 12 random fixed orders that were counterbalanced across participants.

Procedure

The procedure in Experiment 4 was identical to that of Experiment 3 except for the following change. As in Experiments 1 and 3, participants were asked to read the description of the intention (e.g., Place the marble in the plastic bag) but then they were given instructions to either complete the intention "NOW" or "LATER." In 12 of the "NOW" trials, they completed the intention *before* the Stroop list. And in 12 LATER trials, they completed the intention *after* the Stroop task. The instructions were as follows:

> Sometimes in life, we have to remember to carry out a task immediately and at other times we have to remember to carry out a task later. In this study, you will receive a series of short instructions to perform certain activities (e.g., Draw a large circle on the notepad). After this, you will receive further instructions to either do the task NOW or do the task LATER.
>
> In the trials where you are asked to do the task NOW, you will actually carry it out immediately. In trials where you are asked to do the task LATER, you will actually carry out the task later after you have performed a computer task.
>
> In the computer task, you will receive word lists in which your task is simply to read out as quickly as possible the colour of the font in which a word is presented. (This serves as an interlude between the instruction trials.) Please try to repeat back to me the instructions in your own words to show that you understand them.

See Figure 11 for a schematic of the procedure for Experiment 4.

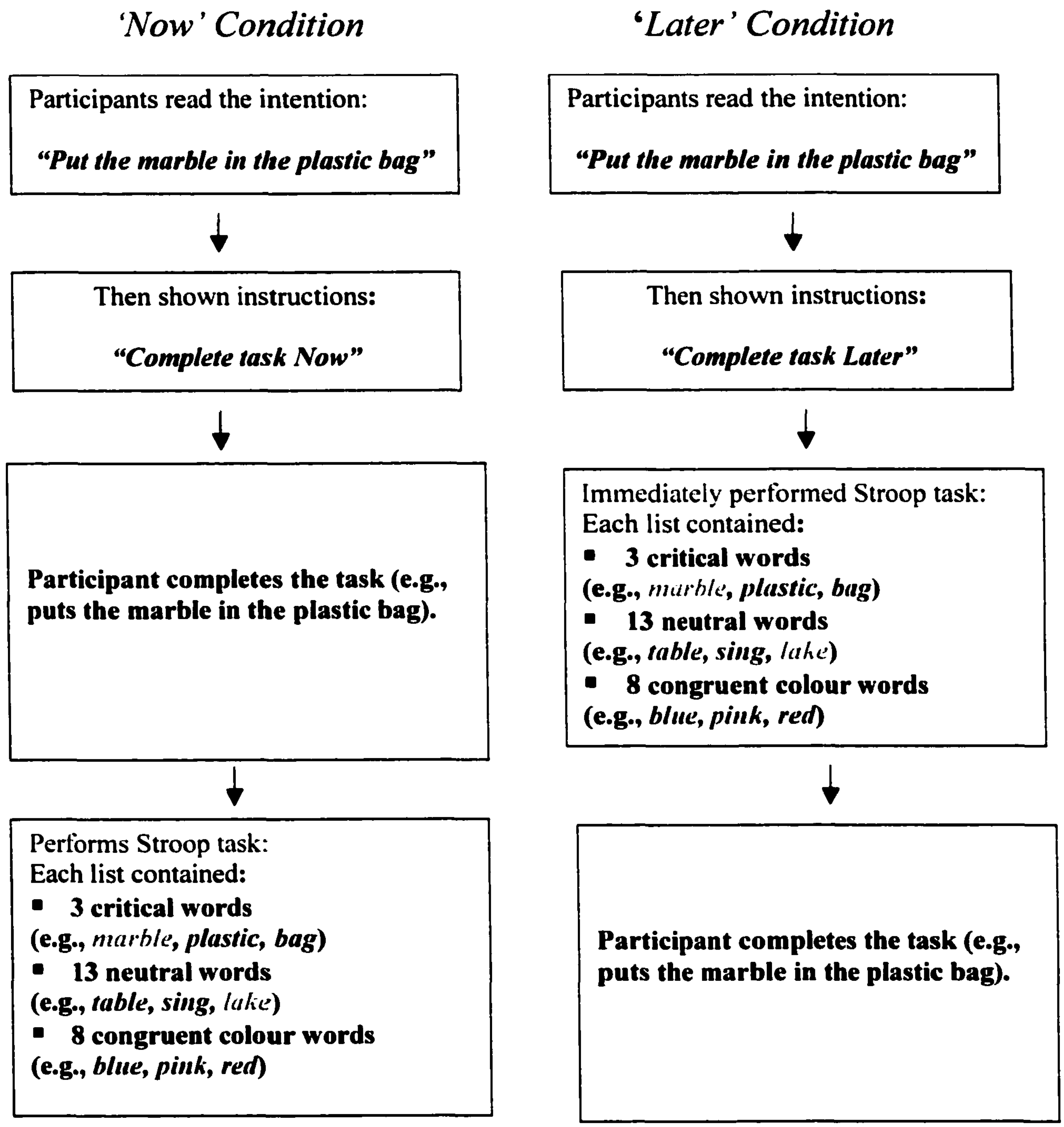

Figure 11. Schematic for 'Now' and 'Later' conditions in Experiment 4.

Results

All incorrect responses were removed from analyses of the Stroop data. Once again, accuracy was very high resulting in little data being removed. The result was the removal of on average .49% of all responses as errors (young = .37%, old = .61%). Latencies beyond 3 standard deviations of each participant's mean response or less than 300 ms were also deleted, which was true for less than .97% of the data (young = .63%, old = 1.31%). Response latencies were evaluated using a 2 (Age Group) × 2 (Instructions) × 3 (Word Type) mixed factorial analysis of variance (ANOVA) with repeated measures on the second and third factor.

Results yielded a main effect of Age Group, $F(1, 46) = 4.15$, $p < .05$, $\eta^2 = .08$, revealing that reaction time was significantly faster for younger ($M = 676.23$ ms, $SD = 93.50$) than for older adults ($M = 723.24$ ms, $SD = 81.54$). A main effect of Word Type was observed, $F(2, 92) = 221.94$, $p < .001$, $\eta^2 = .83$. Pairwise comparisons showed that colour naming was fastest for colour words ($M = 606.52$ ms, $SD = 78.14$), which were faster than neutral words ($M = 724.18$ ms, $SD = 82.57$), which were faster than critical words ($M = 768.52$ ms, $SD = 107.35$). There was a main effect of Instructions, $F(1, 46) = 32.20$, $p < .001$, $\eta^2 = .41$ showing that performance was slower in 'Later' ($M = 712.85$ ms, $SD = 95.07$) compared to 'Now' ($M = 686.62$ ms, $SD = 83.63$) trials. See Table 2 for mean response latencies for all cells.

Table 2

Mean Response Latencies and Standard Deviations for Performance on the Stroop task as a function of Instructions and Word Type

	Now		Later	
	M	*SD*	*M*	*SD*
YOUNG				
Critical	722.27	(99.12)	770.76	(132.83)
Neutral	686.37	(83.84)	712.30	(91.42)
Colour	572.06	(63.48)	593.64	(70.36)
OLD				
Critical	770.61	(80.99)	810.45	(109.04)
Neutral	739.88	(70.59)	758.16	(70.08)
Colour	628.54	(79.71)	631.82	(84.87)

An interaction between Word Type and Instructions was observed, $F(2, 92) = 13.85, p < .001, \eta^2 = .23$ revealing a similar pattern of results as those found in Experiment 3. Inspection of the means show that there was a greater difference between latencies for critical items in the 'Now' and 'Later' conditions than for neutral or colour items (see Figure 12). There were no interactions with Age Group.

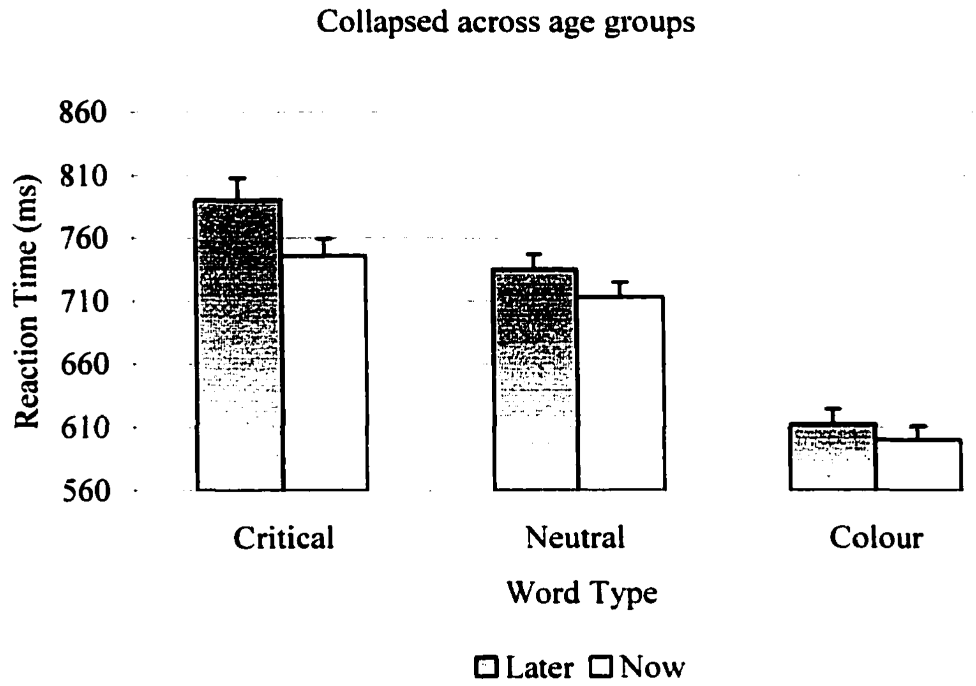

Figure 12. Reaction time performance on the Stroop task in Experiment 4 as a function of Word Type and Instructions. Bars represent standard error.

Additional analyses were conducted to examine whether a similar pattern of findings of critical item order would emerge as found in Experiment 3. Reaction time performance was evaluated using a 2 (Age Group: young, old) × 2 (Instructions: Now, Later) × 3 (Critical Item Order: first, second, third) mixed factorial analysis of variance (ANOVA) with repeated measures on the second and third factor. There was no main effect of Age Group (p = .14). However, there was a main effect of Instructions, $F(1, 46) = 28.24$, $p < .001$, $\eta^2 = .38$, showing that colour naming was slower in 'Later' (M = 790.62 ms, SD = 132.51) compared to 'Now' (M = 746.11 ms, SD = 102.54) trials. There was also a main effect of Critical Item Order, $F(2, 92) = 3.56$, $p < .05$, $\eta^2 = .07$. Pairwise comparisons revealed that latencies for critical items in the first position in the Stroop list (M = 754.35 ms, SD = 116.15) were significantly shorter than latencies for critical items in the second (M = 773.71 ms, SD = 118.71) and third positions (M = 777.02 ms, SD = 117.73) (see Figure 13). However, there was no significant difference between 2nd and 3rd position critical items. The interaction between Instructions and Order was not significant ($F < 1$) nor were there any interactions with Age Group ($F < 1$).

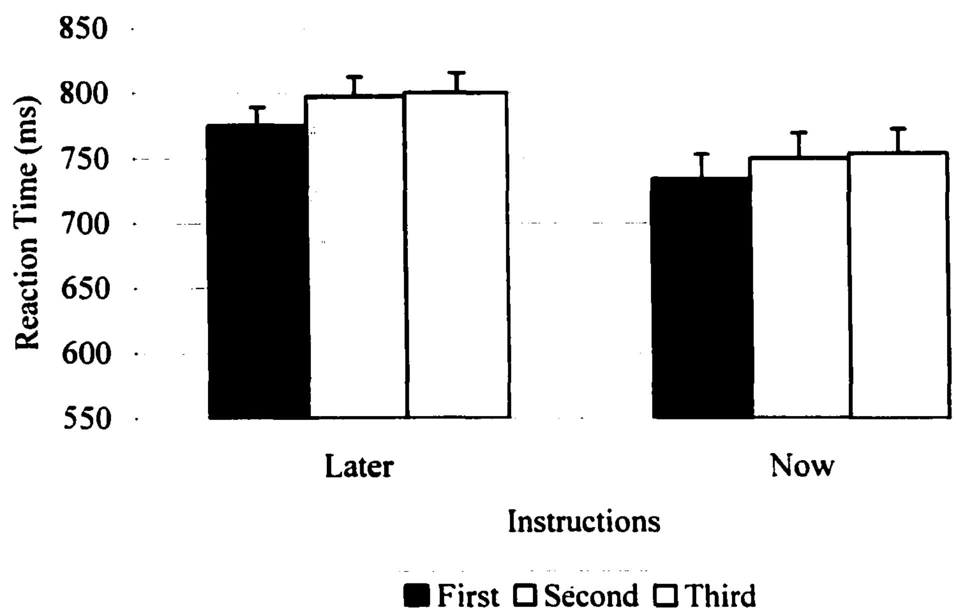

Figure 13. Reaction time performance on the Stroop task in Experiment 4 as a function of Critical Item Order and Instructions. Bars represent standard error.

Discussion

In this experiment, we demonstrated that interference decreased when participants completed the intention before the Stroop task relative to trials in which participants completed the intention after the Stroop list. In the study by Marsh et al. (1998), they found a similar effect such that before a script was carried out, latencies for the execute scripts were shorter than those for the neutral scripts and after the script was carried out, this effect reversed. They explained this effect by suggesting that completed intentions undergo a form of inhibition compared to intentions that have not been completed. An important difference between results obtained in this experiment and results that were obtained by Marsh et al. (1998) is that in our paradigm, performance in the 'now' condition did not go below the neutral baseline. That is, performance in the 'now' trials was characterized by a decrease in interference but response latencies did not go below the neutral baseline. In contrast, in the experiment conducted by Marsh et al. (1998), results showed that the latencies for the execute script were longer than those for the neutral script when the lexical decision task was administered after participants had already executed the scripts.

Marsh et al. (1998) explained their finding by suggesting that after an action has already been executed, the representation of the intention is inhibited and no longer in a heightened state. Thus, the representation loses its privileged status in memory leading to inhibition of this material. An explanation for the absence of this result in the present study can be found by examining our results from Experiment 2. In Experiment 2, we showed that an effect of repetition priming was obtained such that words that were simply read in a sentence, and subsequently encountered in a Stroop list, resulted in significantly longer response latencies (more interference) relative to neutral items. Therefore, this result shows that words that are processed in a sentence (regardless of the experimental manipulation) will show a degree of interference compared to items that are encountered for the first time in the Stroop list (e.g., neutral items). In sum, this implies that critical items from the 'now' trials in Experiment 4 may have gone below baseline if it were not for the effect of increased interference due to repetition priming. But most importantly, we cannot really compare our results to Marsh et al. (1998) because in our study the item sets were different and we did not counterbalance across critical and neutral items. Therefore, in order to really compare our results with Marsh et al. (1998) we would need to construct an experiment that was exactly the same as Experiment 4 except that participants would be exposed to neutral items on one additional occasion before they appeared in the Stroop list and items would be counterbalanced across critical and neutral words. This change would allow us to investigate whether critical words from the 'now' condition would show less interference than neutral items taking into account the effect of repetition priming.

No interactions with age group were observed showing that older adults exhibited a similar pattern of responding as younger adults. For both groups, completing an intention led to a decrease in interference in Stroop task performance. This result has implications for the inhibition deficit hypothesis. By this account, one would have expected that older adults would not have shown a decrease in interference after completing the intention before the Stroop list (Hasher et al., 1999). The reasoning is that proponents of this account would predict that older adults are unable to delete the contents of the intention from working memory even after they have completed it, therefore performance in the 'now' and 'later' trials should have shown a similar amount of interference for older adults. Indeed, Hasher et al. (1999) argue that one of the main functions of inhibition is to discard no-longer-relevant information from working memory. However, this prediction was not the case as both young and older adults showed equivalent levels of a decrease in colour-naming interference for critical words belonging to an intention that they had already carried out.

An important point to address from Experiment 4 is the absence of an interaction between Critical Item Order and Instructions. In contrast to findings from Experiments 1 and 3, results showed that there was a similar graduated pattern in response latencies for 'now' and 'later' conditions for critical item order. In Experiments 1 and 3, this differential pattern of interference was only present for the 'do the task' trials but not for the 'forget the task' trials. The absence of this interaction in Experiment 4 may be due to the fact that participants executed the intention in the 'now' trial before completing the Stroop task. It may be that having physically interacted with the materials in this condition led to a higher association among critical items leading to the observed pattern of response latencies.

General Discussion

In the current set of experiments, results revealed that enhanced awareness of the need to carry out an intention made it more likely that words related to that intention interfered with colour naming when the words were later encountered in a Stroop task. Our results imply that information that is held in mind with the intention to be carried out has an advantage over information that is neutral or not future-oriented. The magnitude of this effect (typically around 40 ms) in the current experiments was similar to the intention superiority effect found by other researchers (e.g., Goschke & Kuhl, 1993; Marsh et al., 1998). Previous studies used facilitation paradigms and demonstrated that encoding an intended action leads to information being processed more easily or efficiently if it is related to that action. If one applies the assumption that response latencies and accessibility of information is inversely related, then results from experiments by Goschke and Kuhl (1993) and Marsh et al. (1998) can be taken as evidence for the presence of an intention superiority effect. A potential limitation to our paradigm is the fact that the critical words were always located between the 6th and 19th items within the Stroop list. Therefore, some could argue that our results would provide stronger evidence if critical items were separated by more intervening items. Future studies will benefit by exploring the limitations of this effect by separating critical items by a larger number of intervening items. If an intention superiority effect is still found under such conditions, it will provide even stronger support. However, an obvious contribution of the current study is simply that an intention superiority effect was found within the context of an interference task. However, the question could be asked: Do our findings contribute anything to our understanding of the intention superiority effect that facilitation paradigms cannot? And if so, the nature of that contribution must be examined and integrated with the findings that preceded it.

A major contribution is simply that an intention superiority effect was found within the context of an interference paradigm because it provides a stronger demonstration of this effect. The strength of using an interference paradigm lies in the fact that word reading is not required for colour naming. Therefore, the observed effects in our paradigm can be assumed to be less contaminated by strategies directed toward identification of the word itself (Burt, 1999). Goschke and Kuhl (1993) used a recognition memory measure and Marsh et al. (1998) used a lexical decision task. In both of these facilitation paradigms word identification may have contributed to the intention superiority effect. In contrast, using the Stroop task as a tool to examine the intention superiority effect is a significant advantage because it can be used to investigate lexical access to specific concepts without being affected by strategies directed toward identification of the word. As Burt (1999) states, there are a number of task-specific strategies that can qualify or influence the interpretation of data from recognition memory or lexical decision tasks. It should be noted, however, that our Stroop lists contained only congruent colour words. To provide an even stronger demonstration of our results, future studies would require that we include incongruent colour words within our Stroop list along with congruent colour words because this would discourage participants to a greater degree from reading words during the Stroop task. Our results indicate that awareness of the need to carry out an intention makes it more likely that any words related to that intention interfere with colour naming, however, the explanatory burden still remains in terms of explaining the underlying mechanisms of this phenomenon.

Structuralist and Proceduralist Explanations of the ISE

Hunt and Smith (1996) make a distinction between a structuralist and a proceduralist explanation of the intention superiority effect. In the structuralist explanation, a link is made between the intention superiority effect and priming. They suggest that the intention superiority effect can be conceptualized as an "energized representation" and that the activation level of the representation is thought to exceed some theoretical base rate. This elevated activation level leads to the representation being more easily reactivated into full awareness by appropriate cues. Therefore, in this structuralist account a representation of an intention must already exist in mind in order for it to be primed (Hunt & Smith, 1996). This explanation is in line with Anderson's ACT (adaptive control of thought) theory. In this model, goal nodes possess constant amounts of activation that do not need rehearsal to sustain their activation. Intentions are thought to decay more slowly than other memory contents due to their representation as subthreshold nodes in long-term memory (Anderson, 1983). The time it takes to match a probe item with its match in long-term memory is inversely related to the level of activation of that representation. Based on Anderson's model, Goschke and Kuhl (1996) suggested that an intention is represented in declarative memory as a proposition and this proposition contains a related node that corresponds to its intentional status. The intentional status can be thought of as the 'to-be-done' aspect of the intention. It is reasonable to assume that retrospective memory could be described in a similar way. If one intends to remember a person's name, the representation of the name would include a to-be-remembered node. Therefore, the only difference in the representations of prospective and retrospective memory is the intent to remember to act (prospective memory) and the intent to remember to remember (retrospective memory). The difference is memory for intended action and memory for content. In this account, the only distinction between these two forms of memory is the idea that intent to act involves more detailed processing (Hunt & Smith, 1996).

An alternative explanation is termed the 'proceduralist explanation' and in this account, the initial processing corresponding to the encoding of the intention is provoked by some cue situation (Hunt & Smith, 1996). Therefore, cues may be anything that correspond to all or part of the original processing. When an intention is formed, it may involve more detailed processing and this detailed processing offers more opportunities for future processing to overlap. So, rather than basing an intention superiority effect explanation on the presence or absence of nodes (or activation levels), the effect can be explained in terms of the reinstatement of prior processing.

Proceduralist Approach and the Effect of Critical Item Order

The proceduralist account may be more appropriate as an explanation of the results found in the current set of experiments. Most specifically, the proceduralist explanation accounts for the results from analyses of the critical item order. As described earlier, analyses from Experiments 1 and 3 revealed a pattern of results in which the first critical item in the Stroop list acted as a cue leading to greater interference for the second and third critical words. Therefore, this effect could be interpreted as showing that the first critical word acts as a cue for the remaining elements of the intention. During the planning stages, participants may engage in encoding processes that lead to more sensitivity to the task environment. Therefore, once the first critical word in the Stroop list is processed it may overlap more easily with processing that was done at encoding triggering the notion that an intention needs to be executed and this results in the second and third critical items being retrieved from long-term memory and transferred to working memory which leads to increased interference for these words. It may be that the notion that there is 'something to do' is brought to awareness after the first critical word acts as a cue and causes a reinstatement of processing that had occurred at encoding. Therefore, rather than thinking in terms of nodes of activation as in the Anderson (1983) model, the intention superiority effect may be better explained as a phenomenon in which intended information is reprocessed more quickly because an internal or external marker has been associated with that intention. The fact that the first critical item in the Stroop list did not show elevated levels of interference supports this explanation. So, it is not the activation level of the intention per se but rather that intentions are reprocessed more quickly compared to neutral information because of the strength of association between the encoded intention and the retrieval context.

In line with this idea, Marsh et al. (1998) argued that intended information might be reprocessed more efficiently as a consequence of an internal marker. Marsh's intentional marker account differs from that of Goschke and Kuhl's (1993) heightened activation account. For example, Marsh et al. (1998) suggested that it is not intuitive that multiple intentions throughout the day all have a heightened activation because this would be too cumbersome for working memory. Marsh's account of the intention superiority effect appears to correspond more closely to a proceduralist explanation and Goschke and Kuhl's explanation of this effect appears to correspond more to a structuralist account. In terms of the best explanation for findings in the current study, a structuralist explanation may be less useful in explaining our effect of critical item order for the following reason: If the entire intention (including all three critical words) was in a more 'activated state' compared to neutral items, then one would expect that the amount of interference for all three critical words would be approximately equivalent. However, in nearly every experiment, the latency of the first critical word differed significantly from the latencies of the second and third critical words. According to a structuralist account one would expect that all parts of the intention (including the first critical word) should have been characterized by a heightened and activated state. Therefore, the proceduralist explanation may be a better explanation for the results of critical item order in the current experiments because this explanation can account for more differential patterns of response latencies. It may be that our pattern of results from analyses of critical item order reflects the sensitivity of the system to information that cues or triggers the intention that there is something to do. It would be informative to decompose results obtained by Goschke and Kuhl (1993) and Marsh et al. (1998) to examine whether they found a corresponding pattern of results. It may be that they found little or no facilitation for the first items and that facilitation increased with the presentation of later items.

Explanation of the Intention Superiority Effect and Aging

As discussed earlier, there are several known features that are required for prospective memory performance and that distinguish prospective memory tasks from traditional studies of retrospective memory. First, prospective memory tasks lack an explicit prompt to perform the previously encoded intention. Thus, when a cue appears that was previously associated with the need to execute an intention, the participant must recognize the cue and retrieve the correct action. Second, prospective memory involves a delay between encoding the intention and executing the response. Third, prospective memory tasks involve concurrent task performance. Therefore, the participant must retrieve and execute the intention in the midst of some other ongoing activity. These three characteristics place demands on working memory (Stone, Dismukes, & Remington, 2001). Furthermore, Maylor (1996) argues that the retention interval is susceptible to age-related disruption because older adults are particularly susceptible to age-related deficits in: working memory capacity, vulnerability to interfering information, and vulnerability in handling dual task requirements.

Based on the evidence stated above, one would expect that older adults might be particularly vulnerable to age-related deficits. All three characteristics of a typical prospective memory task involve elements known to become vulnerable as age increases.

However, our results showed no interactions with age and older adults exhibited similar patterns of performance to that of young adults albeit slower overall. This lack of observed interactions with age in the current experiments may be understood in the context of retention intervals and the idea that performance may be influenced to the extent that the retention intervals vary in length. Researchers often make a distinction between short and longer retention intervals (Baddeley & Wilkins, 1984). For example, an intention that needs to be carried out in one minute is qualitatively very different from an intention that must be carried out in one hour. In our paradigm, the retention interval was relatively short because we wanted to avoid the possibility that participants would rehearse the material before they began the Stroop task and we wished to closely reproduce aspects of the paradigms used by Goschke and Kuhl (1993) and Marsh et al. (1998). Thus, it may be the case that the cognitive processes necessary to support maintaining intentions in mind across shorter delays (such as in our paradigm) are less vulnerable to age-related disruption. An important direction for future research is to test older adults on an intention superiority effect paradigm that varies the length of retention intervals. It may be that age differences and interactions would emerge depending on the length of the interval. Another valuable future project would be to test young and older adults on an intention superiority effect task and a corresponding prospective memory task. Then one could examine whether the presence or absence of an intention superiority effect predicted prospective memory performance.

Furthermore, Verhaeghen, Marcoen, & Goossens (1993) conducted a meta-analysis of adult age differences in speed of search in short-term memory, memory span, list recall, paired-associate recall, and prose recall. Relevant to the current study was their finding that showed a lack of age sensitivity for either semantic processing or association strategies. Therefore, these abilities appear to be maintained into later adulthood. In the current study, it is likely that both semantic processing and association strategies were necessary components in remembering and carrying out intentions. The fact that these cognitive competencies are maintained into old age could help explain the lack of age interactions that were observed in the present study.

In order to further understand the results of older adults' performance on our paradigm, it may be necessary to consider research on age-related performance on the Stroop task. The Stroop test is widely used in batteries of tests to examine older adults' proneness to interference. Some studies have found age-related differences on the Stroop task (e.g., Daigneault, Braun, & Whitaker, 1992) while others have failed to show a difference (e.g., Libon et al., 1994). There is wide variability in the forms of this test and Lezak (1995) suggests that age differences emerge with longer versions of the test as this increases the sensitivity of the measure. Therefore, the longer the version, the more sensitive it will be to age differences. In the current set of experiments, the Stroop lists were relatively short in length and there were no incongruent colour words included in the Stroop lists. As mentioned earlier, another factor that may have contributed to the absence of any age interactions is that the retention interval was relatively short between encoding and execution of the intention. Therefore, it may be that interactions with age would have been observed had the duration of the retention interval been lengthened and the number of items in the Stroop task been increased. Furthermore, the Stroop test is typically used to examine older adults' proneness to interference and if older adults are inherently more prone to interference than younger adults it may be that they were especially sensitive to our manipulation. Therefore, older adults may show the same magnitude of an intention superiority effect as young adults because they were especially prone to interference for colour naming.

In a chapter by Hunt and Smith (1996) they suggest that a link can be made between the intention superiority effect and priming. Other researchers (e.g., Einstein & McDaniel, 1996; Mäntylä, 1993) have also made the observation that there are striking similarities between prospective memory and implicit memory. For example, Mäntylä (1993) provided support for the idea that increased activation at the time of planning an intention, facilitated memory for that future action. In his study, the level of activation was manipulated through giving participants a category fluency task that increased participants' sensitivity to a primed target cue. Later when that cue was encountered, participants experienced increased facilitation in executing the intention. Results from Mäntylä illustrate the point that there may be a conceptual link between prospective memory functioning and implicit memory. For this reason, it is useful to consider our current results in terms of findings from research on implicit memory because our paradigm can be viewed as a type of implicit priming task. The term implicit memory refers to a phenomenon in which memory for a prior event is revealed on subsequent performance in the absence of deliberate recollection (Graf, Squire, & Mandler, 1984). In our task, similar to implicit memory paradigms, colour naming is in opposition to word reading. Thus, a participant is attending selectively to stating the colour of a word and not to the semantic meaning of the words. Therefore, the effect of words' semantic meaning on performance can be viewed as a form of implicit influence because colour-naming latencies are thought to be uncontaminated by strategies directed toward identification of the word itself (Burt, 1999). In light of this idea, the effect of words' semantic meaning on performance can be viewed as implicit because participants are attending to colour naming in the Stroop task and not to processing the words semantically. The fact that we find no interactions with age group and older adults show comparable patterns and magnitude of priming as young adults may not be surprising given the typical findings across a wide variety of implicit tasks. For example, a vast amount of research shows that older adults show comparable repetition priming to that of younger adults (Zacks, Hasher, & Li, 2000). More specifically, research conducted on item priming shows that older adults exhibit equivalent priming to that of young adults. Item priming refers to facilitation that occurs when there is repetition of familiar individual stimuli. Therefore, our paradigm can be conceived as a demonstration of item priming. The fact that older adults exhibit an intention superiority effect at the same magnitude as that of the younger adults makes a contribution to what is currently known about both the intention superiority effect and item priming in an older adult age group.

General or Specific Effect?

Another interesting theoretical issue to pursue is whether the intention superiority effect represents a specific phenomenon or whether it is can be explained by a more general broadly outlined explanation. Hunt and Smith (1996) favor the latter explanation and suggest that it may be that encoding is more detailed for information that we intend to execute in the future and that this aspect of encoding accounts for the observed intention superiority effect. However, it should be noted that in the current set of experiments and those conducted by Goschke and Kuhl (1993) and Marsh et al. (1998), encoding strategies were controlled by administering instructions to execute or not execute the intention after participants had already encoded the material. Therefore, it seems unlikely that more detailed or elaborate encoding would fully explain the intention superiority effect. However, it may be the case that at the precise moment that the instructions to execute an intention are administered to the participant, the content of that intention that was previously encoded may be revisited and experience a sudden boost in activation. This type of re-encoding may lead to its superiority in memory compared to material that is not to be executed. This suggestion was made by Altmann and Trafton (2002).

Altmann and Trafton (2002) share the opinion that a re-encoding of previously encoded intentions leads to the superiority of that material in memory. In their paper, they present a goal-activation model that analyzes goal-directed cognition in terms of the memory constructs of activation and associative priming. They attempt to identify cognitive and environmental constraints that explain how we store goals and then successfully retrieve them later. They make the strong statement that goal memory is not structurally different from and/or superior to memory for other types of non-goal material. The authors argue that in most studies of the intention superiority effect the distinction between cognitive constraints and task constraints is not clear. Task constraints can be observed directly by examining the performance of an individual, however cognitive constraints can only be observed indirectly. Altmann and Trafton (2002) claim that this distinction gets confused and leads to psychologists making an argument that special goal structures exist because the individual needs them. But they argue that this explanation is not sufficient and it is necessary to update our assumptions because the notion of a specialized memory for goals in the psychological literature has 'taken on a life of its own' and acquired the status of a theoretical construct. The authors note that Anderson's ACT (adaptive control of thought) model is often recruited to support the idea that goals have special status in memory. In this model, goals are sources of activation that do not require active maintenance. Therefore, because goals are stored in this activated state, when a new goal is formed active inhibition is required to remove them from working memory (Altmann & Trafton, 2002).

As discussed before, Altmann and Trafton's (2002) model identifies three constraints on goal-directed behavior: (a) the interference level, (b) the strengthening constraint and, (c) the priming constraint. Altmann and Trafton (2002) depart from previous explanations on the intention superiority effect mainly because they do not acknowledge a structural difference between memory for goals and memory for other facts and events. They observe that in Goschke and Kuhl's paradigm there is enough time between encoding and the intention superiority measure for the kinds of strengthening processes to take effect as described in the goal-activation model. Even if there is only one or two seconds available for rehearsal, the cognitive system will take advantage and strengthen material that needs to be executed. The idea is that the intention superiority effect could simply reflect this strategic memory processing. However, their reasoning may not fully address Experiment 3 of Goschke and Kuhl's (1993) study. In this experiment, both groups were told that they should expect a free recall test of the material from both the execute and observe scripts. One would expect that participants who were expecting a free recall test (whether they were or were not executing an intention) would generate the same amount of strategic processing and strengthening of the material. Yet Goschke and Kuhl's results demonstrated an intention superiority effect solely for material from the execute condition. If Altmann and Trafton (2002) wish to conclude that there is nothing 'special' about memory for goals, then they need to demonstrate that memory for other types of non-goal material can also exhibit a similar superiority in memory. Furthermore, it is interesting to reflect on the results from the current set of experiments because our paradigm used an interference measure. In the Stroop task, a strategy is evoked in which participants attempt to ignore the influence of the semantic meaning of words so that they can successfully name the colour. Would the strengthening constraint described by Altmann and Trafton account for the interference that was observed in our paradigm? It may be that Altmann and Trafton (2002) would argue that when participants were instructed to do/forget the task, the intention-related material from the 'do the task' condition experienced a strengthening that caused it to interfere with colour naming compared to material from the 'forget the task' condition. Therefore, even though participants were attempting to attend only to colour naming in the Stroop task, it may be that the effect of the previous strengthening of the intention-related information led to an increase in interference in colour naming. It may be informative to consider research in another cognitive domain that shows similar effects of goals on behavior.

There is relevant work in another research domain that may be related to discussions of intention superiority. For example, research on situation models in reading comprehension studies show that after a goal or intention of a story protagonist has been introduced, readers keep that part of the situation model more available or active in memory and information related to that goal is processed more efficiently compared to non-goal information. It may be that goals whether they belong to a story protagonist or one's self are processed more easily and therefore are more accessible during retrieval. There is considerable evidence showing that in on-line lexical decision or recognition tasks, subjects process goal information more quickly after reading about events related to the goal (Suh & Trabasso, 1993). For example, research on narrative comprehension and the fate of completed goal information shows that after a goal or intention of the story protagonist has been introduced, readers keep that part of the situation model more available or active in memory so that it can be used to make inferences to help them interpret the subsequent actions of the story protagonist (e.g., Suh & Trabasso, 1993). Thus, later concepts require less processing time because they can be mapped onto the developing structure of the text (Miller-Soederberg & Stine-Morrow, 1998). Integration of propositions is achieved by making causal inferences that relate different pieces of information together based on the knowledge of a goal or plan.

Suh and Trabasso (1993) suggest that goals are "a major source of global coherence" (p. 279) because they serve to organize concepts that are spread over large amounts of narrative text. Research on the situation model shows that the maintenance of goal-related information only occurs until the character's goal has been satisfied. When a goal has been completed, that part of the situation model is no longer kept in a state of heightened activity. This idea was tested by administering stories to participants and then giving them memory probes later in the story to assess availability of goal-related information (Lutz & Radvansky, 1997). The idea that a goal in a narrative may be characterized by a heightened activation may be related to the research on the intention superiority effect (e.g., Goschke and Kuhl, 1993, 1996; Marsh et al., 1998, 1999). It may be that the processing of goals is qualitatively different from the processing of other types of information in a variety of research domains. When uncompleted goals of a story protagonist or intentions of one's own are encoded, the associated cues or material processed along with them are highly associated and therefore retrieved more easily. Thus, it may be that encoding a goal leads to increased facilitation for information that is related to that goal whether the goal belongs to a story protagonist (situation model research) or in an individual's daily life (prospective memory).

Results from the research on the intention superiority effect and situation model research involve several key elements: (a) information that is relevant to some future goal that is unresolved shows facilitation compared to a neutral baseline, (b) when the goal is completed, the information loses its superiority in memory. It may be that in both research domains, associative links are the critical component for goal-oriented material having superiority in memory. This idea is underscored by Altmann and Trafton (2002) who state that the priming constraint of their goal activation model predicts that successful performance depends on associative links between environmental cues and the target goal. Therefore, in order for a goal to direct behavior it must take precedent over other goals or material that are active in memory. Activation is described by Altmann and Trafton as an assumption in which the memory system integrates prior experience with current evidence to predict current need for a memory element. And it is this predicted need that is the item's activation level therefore active items are those whose history and context are relevant at the present moment. The goal activation model presented by Altmann and Trafton can sufficiently explain results obtained by research on the intention superiority effect as well as research on situation model research. Therefore, it may be that holding a goal in mind (whether it belongs to one's self or a story protagonist) directs behavior and facilitates the integration of information that supports the attainment of that goal. Therefore, it may be that the intention superiority effect is a part of a larger phenomenon that relates to a general effect of goals on cognition and behavior. In this case, the intention superiority effect phenomenon may be closer to ideas investigated by Zeigarnik who showed that there is 'something about interrupted actions' that leads to their superiority in memory. It may be that goals provide an organizing coherence to our cognitive system which leads to information that is related to that goal being processed more easily.

Conclusions

Overall, the present set of experiments support the idea that information that is to be carried out in the future has a superiority in mind compared to information that is not future oriented. There were three principle contributions from the current line of experiments. First, our paradigm provided a more rigorous exploration of this phenomenon by exhibiting an intention superiority effect within an interference paradigm. We demonstrated that participants are influenced by the presence of the embedded words from an intention even when they are attempting to ignore their influence and attend solely to colour naming. It provides converging evidence of a different variety to the work previously conducted by Goschke and Kuhl (1993), Marsh et al. (1998) (1999), and Dockree and Ellis (2001).

Second, these experiments were the first to exhibit an intention superiority effect within an older adult age group. This finding has important implications for how intentions and goals are held in mind with increased age. It may be that the cognitive processes necessary to support maintaining intentions in mind across shorter delays are less vulnerable to age-related disruption. As mentioned previously, an important future study is one that tests older adults on an intention superiority effect paradigm that varies the length of retention intervals. It may be that age interactions would emerge depending on the length of the interval.

Third, our analyses of critical item order imply that an intention is not held in mind as an indivisible and intact representation. Our findings of step-wise response latencies from the first critical item to the second can be interpreted to mean that the various components of an intention are highly associated. When the first critical item is encountered, it appears to serve as a cue bringing the rest of the intention from long-term memory into working memory where these items cause increased interference for colour naming performance. This finding has implications for theory building because it offers evidence against a vigilance account. Some researchers have likened memory for intentions to a simple vigilance task. In vigilance tasks, individuals monitor a source for the infrequent occurrence of some event. Therefore, the infrequent event is always in mind. However, our data suggest that the first critical cue is not being 'held in mind' because the increased interference occurs only for the second and third critical item. Furthermore, the effect of critical item order is not easily supported by an account such as that of Anderson's ACT explanation. By Anderson's explanation, one would expect that the level of interference for the first critical item appearing in the Stroop list would be equivalent to the third critical item. The reason is that in the ACT model all goal nodes possess constant amounts of activation and they do not need rehearsal to sustain their activation. Therefore, based on this account, one would expect that the first critical item appearing in the Stroop list would show an elevated activation reflected by increased interference similar to the second and third critical items. An explanation for the intention superiority effect offered by Marsh et al. (1998) may better describe our results. They suggested that it is not intuitive that multiple intentions throughout the day all have an elevated and heightened activation because this would be too cumbersome for working memory. They argue that it is not the activation level of the intention per se but rather that intentions are reprocessed more quickly compared to neutral information because of the strength of association between the encoded intention and the retrieval context. It would seem that our results are more easily explained by such an account.

Of course, explanations for the underlying mechanisms of the intention superiority effect have yet to be completely understood or collectively agreed upon. Studies that further examine the relation between the intention superiority effect and prospective memory performance will help to elucidate the conceptual link between them. Furthermore, if older adults exhibit an intention superiority effect as they do in this study, it will be important to investigate whether this effect is predictive of performance on various types of prospective memory tasks. Future experiments will benefit by examining whether the intention superiority effect is a unique phenomenon or whether it is related to other forms of research (e.g., situation model research) that also show a facilitatory effect of goals on the cognitive system.

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Appendix

Example of Stroop list

blue
pink
beauty
good
pursuit
yellow
supper
car
blue
marble
green
chief

Critical items

pitcher
plastic
cellar
bag
pink
red
white
chapter
harvest
lack
party
form

Note: Actual words from Stroop lists were displayed in seven colours: red, blue, green, yellow, pink, white, and black on a grey background.