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Introduction

Memory problems have plagued humankind since time out of, well, memory. Don Norman, in *Things that make us smart* (Norman, 1993), has observed that one of the techniques that humans have used to improve their overall condition is the use of external aids and artifacts. These artifacts improve our ability to calculate, our ability to perform physical work, and our ability to remember.

Most people have used memory aids of one form or another. Some use mnemonics or visualization to aid recall. It is often said that ancient storytellers would visualize walking through rooms or scenes in order to recall sections of verse or story. Today we use external aids as well. Strings around the finger, sticky notes, pocket calendars and portable digital assistants (PDAs) all serve to keep information “at our fingertips.” These aids are extremely successful, but they require our attention. A calendar unchecked does little good. Many modern electronic memory aids have alerting devices. These alarms, bells, whistles and even synthesized vocalizations attempt to reach out and grab our attention so that we can attend to the memory item.

These alerts are excellent at grabbing and redirecting our attention. However, it is often overlooked that they grab our attention away from something else. If that something else were just daydreaming, this might be acceptable. Quite often the something else is more meaningful and substantial. This interruption can range from a nuisance to a disaster. For example, we walk down the hall to pick up an important document, we are interrupted by our PDA announcing that we have to make a phone call, we immediately proceed to make the call and forget about the document. While one could argue that this is simply a matter of setting priorities, I would counter that alerts are often extremely compelling, especially to certain personality types (e.g., those who cannot stand to let a telephone ring) and that even the distraction of hearing the alert can sometimes sufficiently interfere with the ongoing task. In other words, the alerts themselves can set the priorities.

We need to find ways to enhance our memory that do not interfere with ongoing tasks or other memory items. The overall goal of this research is to look at the efficacy of doing so using computers and other electronic devices to assist us. The assisting approach suggested here is called subliminal memory enhancement or, less controversially, Momentary Memory Priming (MMP). The concept of MMP is to briefly present material (target material) that we wish the person to remember on a display screen where that person is performing another activity. It is hypothesized that the brevity of the presentation will not disrupt the ongoing activity, but that the priming will be sufficiently perceptible as to reactivate, or refresh the memory trace of the target information in long-term memory. There are several application areas for this type of aid. One such application would be for prospective memory (remembering to do something in the future). A classic example of this problem is remembering to pick up an item at the store on the commute home from work. The task that the person is performing is driving and the target memory item that the person wishes to remember is to deviate from the current procedure (i.e., not go home but stop at the store). While prospective memory is perhaps the most intriguing application of such a memory aid, it can also be useful in remembering vital facts while performing another task – for example, remembering how to format a document while working on a word processor. This application would refresh procedural and declarative memory. Retrospective memory, that is, information that the person has already learned, could be refreshed just in time without having to

leave the current task to look it up. A mechanic who is troubleshooting a malfunctioning system could benefit from refreshing his or her memory of the functional connections of the system. A pilot programming a complicated flight management system could benefit by a brief refresher on how to input a new waypoint on the route. This type of memory (retrospective memory) is the type that will be explored in this research. Previous research has demonstrated that this technique (MMP) might be effective (Wallace, et al 1991). But if it is effective, how robust is the effect?

This study explored the boundaries of the effectiveness of MMP. MMP was used in a word recall task. The subject was asked to memorize a list of words presented sequentially on a video screen. This set of words was the target list. Then the subject was asked to memorize a second set of words presented in the same manner. This set of words was called the interference list. This interference task was designed to erase the target words from working memory so that they should only be present in long-term memory. For the treatment condition, the target list was momentarily primed (i.e., displayed for 33 msec.) during the presentation of the interference list. After assessing the recall of the interference list, the subject was requested to recall the target words (without seeing them again). Both recall measures were compared with a control condition where no priming occurred. This study represents a worst-case implementation for the MMP concept in that the secondary task (the interference task) is designed to directly interfere with memorizing the target words. It was thought that if the MMPs are effective, one would expect that the final recall of the target list would improve over the control condition whereas the recall of the interference list would be unaffected. If the recall for the interference list was poorer for the treatment condition, then the MMPs negatively affected the task of memorizing the interference list. If the recall of the target list was the same or worse in the treatment condition, then it would imply that the MMP does not have sufficient priming power to overcome the deleterious effects of the interference task.

Chapter 2 presents a literature review of relevant topics in the area of memory research and enhancement, and subliminal presentation of information. Chapter 3 discusses the concept of MMP in relation to the research described in the preceding chapters. Chapter 4 describes the experimental hypotheses tested in this study and the methods and procedures. Chapter 5 presents the experimental results of the study. Chapter 6 provides a discussion of these results and their implications. Chapter 7 summarizes the study and discusses future work.

Literature review

Memory

Memory is often considered a single thing. Someone with good memory would be thought of as being able to recall most of the things that he or she experiences. However, Tulving (Endel Tulving, 2000) has argued that the word memory is often used to mean many different things. People use the word, memory, to mean the neurological functions of encoding and storing an experience for recall, the notional store (apart from the physical neurology) for information in the mind, the actual contents of that information, the cognitive processes leading up to and including the retrieval of some experience, and the human phenomenon of being aware of remembering something. Tulving called for using the word memory as an adjective, as in memory store, memory encoding, memory capacity, and so on.

In this chapter, I will confine the discussion to the cognitive aspects of memory. While the exact definitions of the processes of memory are not shared by all researchers, there is a tentative consensus that the following processes are important to memory: attention to some event, encoding of the information about that event, storage/learning of that information, maintenance of that store, cueing for retrieval of the information, retrieval of the information, and expression of that information (Baddeley, 1998; Bower, 2000; Lezak, 1995; Lockhart, 2000; Shapiro & Eichenbaum, 1997). A person sees a phone number (attention), ‘memorizes’ that number by storing it in working memory as a auditory or visual item (encoding); attempts to transfer the item from working memory to long-term memory by developing a mnemonic for remembering it (storage); repeats it to himself over and over (maintenance), passes a phone (cueing), recalls the number using the mnemonic (retrieval), and dials the phone (expression). Failure in any one of these processes can result in the apparent failure of memory in general. It is often the case that a person may actually know the information but have difficulty recalling it or expressing it. Alzheimer’s disease often manifests itself in this way during the early stages. The patient knows the word, it is on the tip of her tongue, but she simply cannot bring it to mind. Cueing can sometimes assist these patients in recalling the word. In trying to recall the name of the current president, the cues ‘shrubbery’ (semantic) and ‘W’ (associative) might quickly enable the patient to say ‘Bush’ and to know that this is correct.

While forgetting commonplace information is a manifestation of diseases like Alzheimer’s, it is certainly not indicative. Virtually everyone forgets things. Schacter (Schacter, 2001) describes a memory expert who has virtual recall of incredibly long lists yet cannot remember to keep appointments. Cases like this have led researchers to not only categorize the processes involved in memory, but also the types of information that are remembered. These types are usually represented in dichotomies: auditory/verbal vs. visio/spatial (Baddeley, 2000; Bower, 2000), declarative vs. procedural (Lezak, 1995; Shapiro & Eichenbaum, 1997), semantic vs. episodic (Baddeley, 1998; Bower, 2000; Schacter, Wagner, & Buckner, 2000), cognitive vs. motor (Baddeley, 1998; Bower, 2000; Jonides & Smith, 1997; Lezak, 1995; Shapiro & Eichenbaum,

1997), implicit vs. explicit (Baddeley, 1998; Bower, 2000; Brown & Craik, 2000; Graf & Schacter, 1985), and retrospective vs. prospective (Baddeley, 1998; Nallan, Kennedy, & Kennedy, 1991). These dichotomies are generally determined by deficits in certain individuals. For example, a person may forget the names of all her friends, relatives, and places that she has lived (declarative and cognitive memory), but still be able to play the piano (procedural and motor memory). It is apparent that these different types of memory information are processed (encoded, stored, and retrieved) in different ways (perhaps using different areas of the brain or using different encoding, storage, and retrieval schemes).

This categorization of memory into six processes and six dichotomies allows researchers to specifically target their experiments to certain aspects of memory. There are 72 potential combinations of memory processes and information type (# of processes x 2# of dichotomies¹). The present study explores the following processes and types. The processes are memory storage, memory maintenance, memory cueing, and memory retrieval. The information type is auditory/verbal, declarative, semantic, cognitive, explicit, and retrospective.

Momentary Memory Primes

In an experiment designed to test the utility of subliminal information, Wallace, et al. (Wallace, Flanery, & Knezek, 1991) set out to determine if providing subliminal help messages could aid users of a text line editor. They created a new text editor, called PITA. It was similar to the Emacs text editor (Stallman, 1981), which is commonly used by computer programmers, in functionality yet all of the commands were different. Like Emacs, there was a help screen that could be called up that showed all of the commands and what they meant. Subjects (with previous experience with text editors like Emacs but not with PITA) were given a brief instruction regarding PITA and were then given a file to edit and make corrections. The study explored the effect of presenting the help screen periodically for an exposure of approximately 17 ms on the text-editing screen. The independent variables of the experiment were display content – the help screen, garbage text in the same format as the help screen, or a blank screen – and presentation schedule – fixed interval of 15 seconds or fixed ratio based on the keystrokes made by the subject. The results showed no difference in task performance, that is, there were no differences in errors or amount of text corrected. There were significant differences in number of times, the frequency, and the ratio (of keystrokes to help calls) of times the subject brought up the help screen based on screen content. For example, the mean number of times that the subjects called up the help screen was 3.954 for the subliminal help screen presentation, 6.95 for the blank screen presentation, and 7.767 for the garbage presentation. Means for the average time between help calls (286.2s – help screen; 244.6s – blank screen; and 149.6s – garbage) and the average number of commands between requests for help (17.5 – help screen; 10.6 – blank screen; and 7.7 – garbage) reflect similar trends. Differences were only significant ($p < .05$) between the help screen presentation and the garbage presentation. There were no significant findings for the schedule (fixed or ratio) treatment nor the interactions between schedule and screen content.

The results indicate that the subliminal presentation of the help screen assisted the subjects in remembering the system commands, so that they did not have to leave the current editing task to call up the help display. The results also indicate that the presentation of non-relevant information

¹ Not all combinations are valid.

(garbage) degraded memory performance in some way. There was no direct measure of memory (i.e., asking the subjects to list the command information after the test) so it is difficult to determine exactly how the displayed information improved or degraded the subjects' recollection of the help screen.

The term 'subliminal' usually evokes an affective response. Most people immediately think of the subliminal advertising and attempts to influence behavior (Dixon, 1971). The most compelling studies have been those involved with influencing the affect of an individual (Bornstein, Leone, & Galley, 1987; Krosnick, Betz, Jussim, & Lynn, 1992; Meyer & Walker, 1999). In these studies, subjects were given subliminal stimuli that had either positive or negative emotional content and then asked to react to secondary stimuli. For example, Krosnick, et al. (Krosnick, Betz, Jussim, & Lynn, 1992) found that subject's attitudes and beliefs about personality types regarding individuals whose pictures were shown as a secondary stimuli were affected by whether the subliminal stimuli, which were presented prior to the secondary stimuli, were emotionally positive or negative. Other studies have shown that when subjects are subliminally primed with geometric shapes, they rated those shapes as more likable or pleasant in a forced choice situation. In many ways, this resembles the false-fame effect (Jacoby, Woloshyn, & Kelley., 1989). An interesting study by Smith and Rogers (Smith & Rogers, 1994) that was designed to test whether subliminal messages affected selection behavior (that is, if a subliminal prime instructed the subject to choose one product over another, would the prime affect the subject's choice?) The answer was no; however they found that material that contained the subliminal primes (in this case, a commercial) was actually less memorable. This suggests that providing information subliminally may actually disrupt memory. The subjects were not explicitly instructed to remember the commercials so this falls under the category of implicit memory (see (Baddeley, 1998) for a definition of implicit memory).

What constitutes a subliminal presentation? The standard definition is perception without conscious awareness, that is, the prime has some effect on the subject's behavior, but the subject is never consciously aware of perceiving the prime (Bornstein & Pittman, 1992). Determining whether the subject is actually aware of the prime is controversial. The two basic methods of determining conscious perception are self-reports and discrimination measures based on conscious experience (Merikle & Reingold, 1992). Merikle states that self-report is often suspect as being unreliable (although it is regularly used in most all other fields of psychological, neurological, and medical research). Similarly, discrimination measures are often criticized as being incomplete, that is, as simply not testing the full range of conscious awareness and as thereby missing something. Merikle and Reingold (Merikle & Reingold, 1992) state that given these criticisms it would be virtually impossible to prove that anything was not subject to conscious awareness. They propose that a more useful metric would be the differences in sensitivities between direct and indirect measures. Direct measures are measures such as asking the subject to discriminate whether the prime was previously seen, and indirect measures are such as asking whether the subject favors or likes one prime over another (Merikle & Reingold, 1992). In this case you are not determining whether the stimulus is subject to conscious awareness, but the degree of conscious perception of the stimulus. Thus, a brief stimulus would rate a lower degree of conscious perception.

If a subject is not consciously aware of subliminal priming, can it affect explicit memory, which by definition involves conscious effort? A study by Kamiya, et al. (Kamiya, Tajika, &

Takahashi, 1994) suggests that the answer is no. In these three experiments, subjects were exposed to masked word-stimuli for durations of 36 ms or 54 ms and asked to name the word if they could. After this segment of the experiment, they were given a word fragment completion test in which they were to fill in the first word that came to mind. Then they were given a recognition test where the subjects were given a list of words and asked to circle the words that were presented in the cueing segment. The authors felt that these tests were indirect measures of memory. However, the latter test is often used as a direct test of conscious perception (Kihlstrom, Barnhardt, & Tatarzyn, 1992). The reason that this measure was considered to measure indirect memory is that the subjects were not instructed that they would be tested on recalling these words later – but this is generally used when the subjects have consciously perceived the stimuli (Merikle & Reingold, 1991). The results indicated that only the words that were named (i.e., consciously recognized and therefore not subliminal) had a significantly positive memory effect. The average results for two such experiments are presented in Table 1. There was no statistical difference in the word fragment completion task between the failure to recognize group and the new group, indicating that the subliminal words did not prime the subjects.

Test	Naming		New
	Success	Failure	
Word-fragment completion	.68	.35	.32
Recognition	.72	.18	

Table 1 Average Proportion Correct for experiments 1 & 2 for Correctly Named Items, Incorrectly Named Items, and Nonstudied Items (Kamiya, Tajika, & Takahashi, 1994)

The authors found that there was a significant main effect ($p < .01$) for word naming. They also found that there was a significant interaction between test and word identification ($p < .05$). They performed separate one-way ANOVAs on the results of each test group and again found a main effect for word naming on each test (Kamiya, Tajika, & Takahashi, 1994). There are several pieces of data and analyses that are not included in this paper that would be enlightening to the interpretation of the results. There is no listing of the number of choices possible for the word-fragment completion task. If there were only two for the fragment completion, then .50 would be chance and the subjects would have scored less than chance (.35). If there were four, they would have performed better than chance. Similarly, the authors did not state how many words were on the recognition list. There is another important analysis that is missing – one-way ANOVAs for each of the Naming groups. If the numbers are comparable, it appears that the word-fragment completion is more sensitive to subliminal stimuli than more direct recognition tests, and this is what Merikle seems to call for (Merikle & Reingold, 1992). One important difference between the Kamiya study and the use of MMPs is that the words that were primed were not previously memorized. That is, it looked at placing the words in memory rather than reinforcing their trace in memory.

Ionescu & Erdelyi (1992) performed several experiments addressing the ability to recall subliminal cues. They found that both words and pictures that were presented using a tachistoscopic projector could be recalled at better than chance levels for durations as brief as 5 ms (the limit of their hardware setup). They argued that this was not truly subliminal since by their definition, subliminal meant not operating above chance. Using the 5 ms duration, they

reduced the illumination of the presentation by a factor of 3 and still found above chance levels. It was only when they reduced the illumination by a factor of 5 that statistically chance levels of recall were produced. In these experiments, the subjects were trying to read the words and pictures presented. In other experiments, such as (Merikle & Reingold, 1991), where subjects were not instructed to look at or recognize the stimuli, chance levels of recognition were obtained at much longer durations (430 ms in Merikle's study). Attentional focus is clearly critical regarding whether a presentation is available to conscious perception.

Attentional focus is also important to whether an item will be remembered. Simply being exposed to a stimulus, even at a high frequency and long duration, does not mean that the stimulus will be remembered. Berkerian and Baddeley (Bekerian & Baddeley, 1980) found that even though subjects had been passively exposed to a stimulus over 1,000 times, their recall was only 12 to 22% accurate. Similar results were obtained by Obermiller (Obermiller, 1985). This is consistent with the theory of levels of processing devised by Craik and Lockhart (Craik & Lockhart, 1972). This theory claims that the more deeply an item is processed, the better it is remembered. Thus, the memory of the word Dachshund will be more durable if the subject elaborates on the word by noting that it is a dog, and is often called a hot dog, and that he once knew of a Dachshund named Schnitzel, (i.e., semantic processing) than if he reasons that Dachshund rhymes with Datsun or 'That soon' (i.e. lexical processing). Transversely, the memory will be less durable if he simply repeats the word to himself over and over. The latter does not require a significant amount of processing where as the first requires the greatest amount of processing and elaboration. The former, deeper levels of processing are called elaborative rehearsal where as simply repeating the memory item over and over is called maintenance rehearsal. In the Wallace experiment, the participants supposedly did not recognize the presentations. Therefore, it is doubtful that the presentations provided any elaborative rehearsal. What is perhaps more likely is that the subjects' memory was perceptually reinforced, as discussed in the following paragraphs.

In the early stages of memory research, researchers held that there were two types of memory tests – a recall test and a recognition test – and that the latter was more sensitive than the former (Bower, 2000). However, Tulving and Thomson (E. Tulving & Thomson, 1973) showed that there were cases where information could be recalled but not recognized. In this experiment, subjects learned numerous word pairs. The words were common words that have a relatively high frequency of usage. Subjects were then given one of the two word pairs and asked to recall the other. Then they were asked to look through a list of common words and mark those that they recognized as having been presented earlier. If recognition is simply a more sensitive test of memory than recall, the subjects' performance on the recognition test should have been better than the recall test. However, the opposite was true. The subjects were better able to recall than recognize when there was a cue present.

Could the presentation of the HELP screen in the Wallace experiment have served this cueing purpose? Perhaps, however, the HELP screen contained far too many words to have been attended to in the brief presentation for a single word to cue the entire screen. What is more likely is that the perceptual form of the HELP screen cued the perceptual pattern, which in turn refreshed the memory trace of the PITA commands. (Since the garbage information in the Wallace experiment was presented in a similar format, it would appear that this cueing is highly sensitive and that errors in the cue (that is, differences from the actual cue) can actually reduce

memory performance rather than enhance it.) This form of priming draws on the Perceptual Representation System (PRS) as described by Tulving and Schacter (Endel Tulving & Schacter, 1990). In this system, the trace that is being reinforced is not a semantic or lexical trace but rather a pictorial or perceptual trace. Tulving and Osler (Endel Tulving & Osler, 1968) found that when two words were paired for memorization such as 'CITY-dirty', and subjects were cued with 'CITY', they would respond with 'dirty'. However, when cued with semantically equivalent words such as 'VILLAGE' or 'TOWN', they were not able to recall dirty.

Momentary Memory Primes: An approach to memory enhancement

The concept behind MMP is to reinforce the target memory trace of an individual while that individual is performing a secondary task. The theory of MMP depends on the following assumption – that the individual is attending to the visual channel and that the MMP can be presented on the visual channel. MMPs use the visual channel to present target information as opposed to other input channels. This is due to the fact that research in the effectiveness of auditory subliminal presentation of material has been inconclusive at best (Moore, 1995; Beyerstein & Eich, 1993).

There has been little research in the area of tactile, olfactory, or gustatory presentation of subliminal stimuli and it is uncertain as to how these presentations could effectively be made. Thus the visual channel was selected as the presentation channel for MMPs. The target memory items must be presentable in a visual form. If the reinforcement of the memory trace is due to perceptual cues rather than lexical or semantic cues (which is suspected) then the original presentation of the target memory items must be visual as well, and the MMP should faithfully represent that visual presentation. That is to say, perceptual qualities (such as shape and font) should be preserved in the MMP presentation. If the memory trace reinforced is perceptual, it would not be effective if the original memory item was a picture of a house and the MMP presentation was the word 'HOUSE'. Note that using the visual channel does not require that the MMPs are presented using the secondary task. It may be that the MMPs can be presented on the individual's eyeglasses or even projected directly on the retina.

Given this assumption, MMP may be a viable option for memory enhancement. The MMP would present target memory information in the subject's fovea for brief duration at certain intervals during the performance of the secondary task. There are several research questions that must be addressed to determine the efficacy of this concept.

Research Questions

Duration and Contrast.

As mentioned above, the presentation duration of so-called subliminal stimuli has varied greatly from experiment to experiment. In some experiments, the presentation duration has been specifically tailored to the individual subjects. Generally in these cases, presentations were given at shorter and shorter intervals until the subject could not name the presented item at levels better than chance. Durations at chance were considered subliminal. In other experiments, contrast against background was also manipulated. For contrast, the background shading was modified to make the presented item more or less readable. See figure 1 for an example of the contrast manipulation. Again, contrasts where recognition performance was at chance or below were considered subliminal.

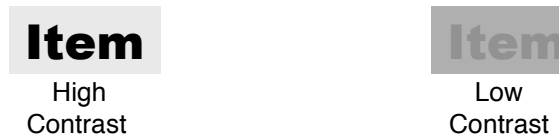


Figure 1: Examples of High and Low Contrast Presentations

The problem with tailoring duration and contrast to the individual is that there is no evidence that these levels are stable over time or variations in content. In the extreme case the levels would have to be reestablished frequently, which would be a time-consuming task in itself. The important attribute of MMP is not that it is subliminal or not consciously registered but that it does not interfere with the secondary task. This is potentially dependent on the relationship between the secondary task and the content of the MMP. Tailoring of the duration seems to be an uneconomical option. In this research I believe that a single, standard duration and contrast should be settled upon, rather than tailoring them to the individual, the secondary task, or the content. Thus, two of the main research questions of this area are: “what durations and contrasts are acceptable for enhancing memory of the target memory items for a varied population and information type?”; and “what durations and contrasts are acceptable for not degrading performance in a secondary task?” These answers will not likely be the same and a compromise will likely be necessary, trading off memory efficacy against task disruption.

Schedule.

Similar to duration and contrast, the frequency at which the MMPs are presented is an important issue. Too frequent presentations may distract from the secondary task, and too infrequent presentations may not be of benefit to the memory enhancement. While Wallace et al. found no influence of the schedule type (fixed interval or fixed ratio) on performance in their experiment; their results may not be generalizable. Therefore, two other important research questions are: “what schedules (both frequency and type) are acceptable for enhancing memory of target memory items?”; and “what schedules (both frequency and type) are acceptable for not degrading performance in a secondary task?”

Relevance.

The Wallace experiment demonstrated that while providing a meaningful cue improved performance over a control of a blank screen, a cue of irrelevant information could be detrimental to performance. This leads to an important question: “what do we mean by relevance?” In the Wallace experiment, the relevant information contained instructions on how to operate the text editor. But what about information that is only relevant to the user? What if information is important to the user but has nothing to do with the secondary task? Would it still be disruptive? For example, if a person is trying to remember a list of things to buy while driving, would this be a candidate for MMP in the driving task, or would the MMP have to have something to do with driving (for example, remembering to go to the store instead of going home)?

Recall.

In the Wallace experiment, recall was not explicitly measured, but inferred from the number of times the subject called up the HELP page. The subliminal cue was presented at (or near) the

time of recall (or so it was assumed). That is, when the subject needed the information, the subliminal cue was there. But will this kind of memory enhancement assist for future recall? As mentioned earlier, it would be interesting to test the subjects' ability to recall the contents of the HELP screen after the task. If not, then it might be inferred that the cues only assisted in knowledge retrieval from long-term memory into working memory and did not enhance the quality (e.g., retention, veridicality, ease of recall, ease of recognition) of long-term memory.

Retrospective and Prospective Memory.

The Wallace experiment tested retrospective memory, that is, recalling what one had already tried to remember. In retrospective memory, it is usually the case that the individual is seeking the information (e.g., how to delete a word in the PITA text editor.) The cues simply aided a search that had already begun. In prospective memory (i.e., remembering to remember) the key is the cue itself. Can MMPs provide such cues or will the individual have to remember to remember (e.g., "What was it that I was supposed to do")?

These represent just a few of the questions that must be explored in assessing the efficacy of MMPs. The conditions that could be addressed are as follows:

- Prospective Commission (e.g., does the subject remember to perform the task in the future?)
- Retrospective Content (e.g., can the subject recall, recognize, or be cued into recalling past information?)
- Recall During Secondary Task (e.g., can the subject multitask/hold two pieces of information?)
- Recall After Secondary Task (e.g., can subject recall information after an interference task?)
- Relevant to the Secondary Task (e.g., will the subject use the MMP information now?)
- Relevant to the 'target' Task (e.g., will the subject use the MMP information later?)
- Irrelevant to the Subject (e.g., will the subject remember MMP information that is not useful to him or her?)

The experiment described in this paper only addressed a subset of these questions. A portion of the experimental design space that is defined by these questions is portrayed in table 2. The shaded cells represent the conditions that were tested in the Wallace experiment. The cells with italicized text represent the conditions that were tested in this study.

Tense Retrospective/ Prospective	Type Commission/ Content	Task Recall/ Recognition/ Cued	Time During ST / After ST	Relevance Relevant-ST / Relevant-I / Irrelevant	Schedule Fixed Ratio / Fixed Interval / Variable Ratio / Variable Interval
Retrospective	Content	Recall	During	Relevant-ST	Ratio
Retrospective	Content	Recall	During	Relevant-ST	Interval
Retrospective	Content	Recall	During	Relevant-I	Ratio
Retrospective	Content	Recall	During	Relevant-I	Interval
Retrospective	Content	Recall	During	Irrelevant	Ratio
Retrospective	Content	Recall	During	Irrelevant	Interval
Retrospective	Content	Recall	After	Relevant-ST	Ratio
Retrospective	Content	Recall	After	Relevant-ST	Interval
Retrospective	Content	Recall	After	Relevant-I	Ratio
<i>Retrospective</i>	<i>Content</i>	<i>Recall</i>	<i>After</i>	<i>Relevant-I</i>	<i>Interval</i>
Retrospective	Content	Recall	After	Irrelevant	Ratio
Retrospective	Content	Recall	After	Irrelevant	Interval
Retrospective	Content	Recognition	During	Relevant-ST	Ratio
Retrospective	Content	Recognition	During	Relevant-ST	Interval
Retrospective	Content	Recognition	During	Relevant-I	Ratio
Retrospective	Content	Recognition	During	Relevant-I	Interval
Retrospective	Content	Recognition	During	Irrelevant	Ratio
Retrospective	Content	Recognition	During	Irrelevant	Interval
Retrospective	Content	Recognition	After	Relevant-ST	Ratio
Retrospective	Content	Recognition	After	Relevant-ST	Interval
Retrospective	Content	Recognition	After	Relevant-I	Ratio
<i>Retrospective</i>	<i>Content</i>	<i>Recognition</i>	<i>After</i>	<i>Relevant-I</i>	<i>Interval</i>
Retrospective	Content	Recognition	After	Irrelevant	Ratio
Retrospective	Content	Recognition	After	Irrelevant	Interval

Table 2 Partial Representation of Experiment Design Space

ST – Secondary Task, I – Individual

Shaded –Wallace Experiment, Italics – this study

For the experiment described in this paper, the retrospective content was the focus, but instead of recall during the task, recall of information after the task was addressed. In addition, rather than the target information being relevant to the secondary task, the MMPs provided information relevant to the individual but not relevant to the secondary task. In fact, it provided information that was potentially disruptive to the secondary task.

The experiment described here exposed subjects to a list of target memory items that they were asked to memorize. Then the subjects were shown a second list of memory items (i.e., the interference task). Subjects in the treatment condition saw a brief presentation of the target memory items presented for approximately 33ms (MMP) during the presentation of the interference items. These MMPs were relevant to the subject (because they were asked to remember them) but were irrelevant to the interference task (i.e., memorizing the second set of words). Subjects in the control condition were presented with at brief blank screen of approximately 33ms during the interference task. The subjects were tested on both memory lists

by asking them to recall each list and to select (i.e., recognize) those words from a larger list of words.

These conditions represent an extreme case for the use of MMPs. The information must be recalled after the secondary task (whereas the Wallace experiment used the information at the same time it was primed). This means that the MMP is strictly reinforcing long-term memory as opposed to retrieving information from long-term memory. Also, the secondary task is peculiar in that it is designed to deliberately stop attempts to reinforce long-term memory for the target items. This was not true in the Wallace experiment. In the Wallace experiment, the information was needed and used by the subject, which should have caused more elaborate processing regarding the target item. This elaborative processing should have also reinforced the memory trace in long-term memory. In this experiment, the information is not needed nor is it wanted at the time because the subject is trying to learn other words. If the MMPs were effective in this extreme case, then its effect is robust and therefore applicable to many applications.

The following hypotheses are used to test the effectiveness of the MMP in this experiment.

Hypothesis 1

Subjects receiving the MMPs will have better recall for the target memory items than those subjects in the control condition.

Hypothesis 2

Subjects receiving the MMPs will have better recognition of the target memory items than those subjects in the control condition.

Tentative Hypothesis

A desirable hypothesis to test is the null hypothesis, that is that the MMPs will not adversely affect the interference task performance; that is, there will be no statistical difference in interference memory item recall or recognition between subjects in the control condition and those in the treatment condition. However, this would require proving the null hypothesis and this is not a generally accepted test.

Method

Participants

A total of 143 students from Virginia Commonwealth University were used in this experiment. Subjects had 20/20 corrected vision based on self-report. The subjects were recruited using the VCU Experimentrix program, which allows students in Psychology 101 classes to earn extra credit by participating in experiments. The subjects earned credit for a 1.5 hour experiment. No attempt was made to balance gender in the experiment. 99 of the subjects were female. The number of subjects was selected to insure power. The pre-test power analysis is discussed in Appendix F. The need for high power comes from the potential support of the third, tentative hypothesis stated above.

Subjects participated in the experiments in groups of approximately 30.

Apparatus

The visual presentation was developed using Apple Computer's Final Cut Pro (V3.0) software and was recorded on DVD. The stimuli were projected onto a screen using a video projector with a resolution of 1024 x 768 pixels per inch.

Experimental Protocol

This experiment was approved by the VCU Institutional Review Board for human subject protection and assigned the experimental protocol number 3762. The memory tasks chosen for this experiment were modeled after the Rey Auditory Visual Learning Test (RAVLT) (Schmidt, 1996). The RAVLT is a memory test containing five learning trials for a list of 15 words, followed by an interference trial of 15 different words. The subject is then tested for recall of the 15 words from the original trials. While generally applied using verbal cues and recalls, it has been shown to be effective in visual learning tasks as well. Appendix A provides an overview of the RAVLT.

The subjects began by receiving a brief description of the experiment, followed by an opportunity to ask questions. They were then asked to sign a voluntary consent form (see Appendix C). The subjects were told that they were performing a memory experiment that was addressing the issue of screen distractions. They were told that during some segments of the test, the screen would flicker with different distractions. They were instructed that they were to ignore these distractions and concentrate on the memory task. This instruction was given to avoid biasing the subjects that the MMPs were present to aid their memory. It was considered to provide a conservative bias against the success of the MMPs since they were deliberately told to ignore them. After signing the consent form, they were given a brief format demonstration where they saw a typical presentation but did not have to remember the words. In place of actual words, sample words were used in this demonstration e.g., 'word1', 'word2', etc. This procedure was an attempt to avoid undesirable interference in the actual memory task.

All subject responses were made on a paper worksheet that was covered after each trial.

Each subject group received two mini-RAVLT sessions. Each session was either the treatment condition (MMP) or the control condition. The order in which the subjects saw each condition was counterbalanced (See Table 3a-f for counterbalance description). For the MMP condition, the subjects were presented a list of 15 words (i.e., target list), presented one at a time for a duration of one second with a one second presentation of a blank screen in between each word presentation. They were then given one minute to write down any of the fifteen words that they saw in any order. They were instructed to turn the paper over when they had finished. They were instructed not to use the time (that is, any time left over in the minute) remaining to continue memorizing the words. After the time was up, all papers were turned over. They then were shown the same presentation of 15 target words and given another minute to write down these words, again in any order. The subjects then received a third viewing of the target words and were asked to write them down again. The subjects were reminded that they would be tested on the target words later on in the experiment. This constituted the learning phase of the target memory items. The subjects were not presented with MMPs during this phase for either the control or treatment conditions. They were then given a new list of 15 different words (i.e., interference list) presented in the same format. However, for approximately 33 ms (i.e., one video frame) of each one-second interference word presentation, the screen displayed the target memory words (all 15 target words, one per interference word presentation) (figure 2). Thus in the MMP condition, the subjects saw each of the target words presented once again for approximately 33 ms. The subjects were given one minute in which to write down the interference memory words, again in any order. Finally, the subjects were given two minutes in which to write down the target memory words (without viewing them again). This completed the MMP session.

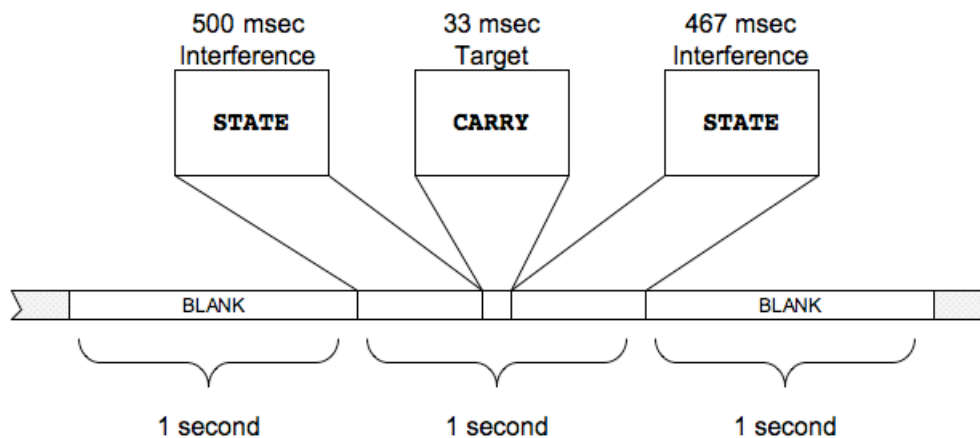


Figure 2: Interference presentation for Treatment Condition

In the control session, two new sets of words were used for target and interference sets. The

session proceeded for the three learning trials in the same way as the MMP session. During the interference learning trial, the 33ms gaps (where the MMP had been placed in the MMP condition) contained only a blank display (figure 3). Thus, in this case, the word on the display screen appeared to blink white for a moment. The subjects were then asked to recall the interference set of words and then asked to recall the target set (from this session).

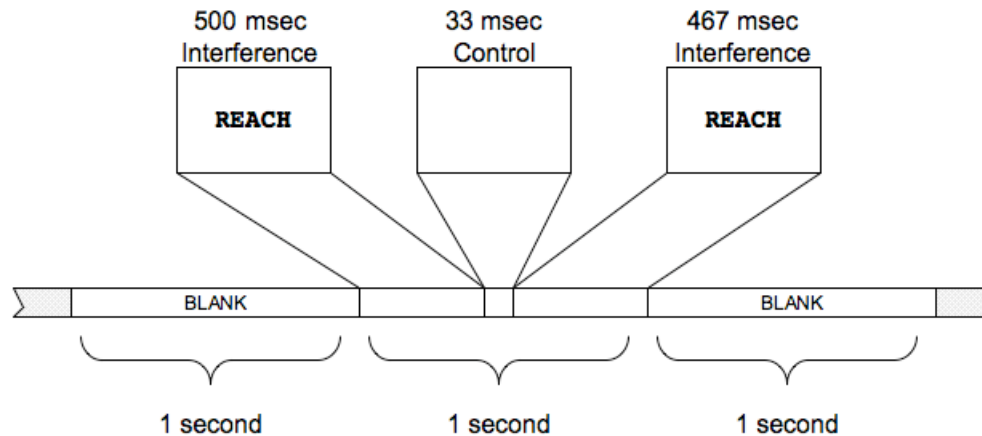


Figure 3: Interference presentation for Control Condition

With so many lists of words being presented, the lists were described to the subject as “List 1”, “List 2”, “List 3”, and “List 4”, which represented the target list for the first condition, the interference list for the first condition, the target list for the second condition, and the interference list for the second condition, respectively.

Finally, when both sessions were completed, each subject was presented with a paper list of 120 words (see appendix D), 60 of which had been viewed in the two sessions (15 target and 15 interference for the MMP condition, and 15 target, and 15 interference for the control condition.) The subjects were asked to place an X by any word that they had seen during any of the presentations. They were given five minutes for this task.

At the end of the experiment, the subjects were given a questionnaire (see appendix E) to fill out regarding subjective aspects of the experiment and then were excused. Figure 4 presents a chronological flow diagram of the experimental tasks that the each subject performed.

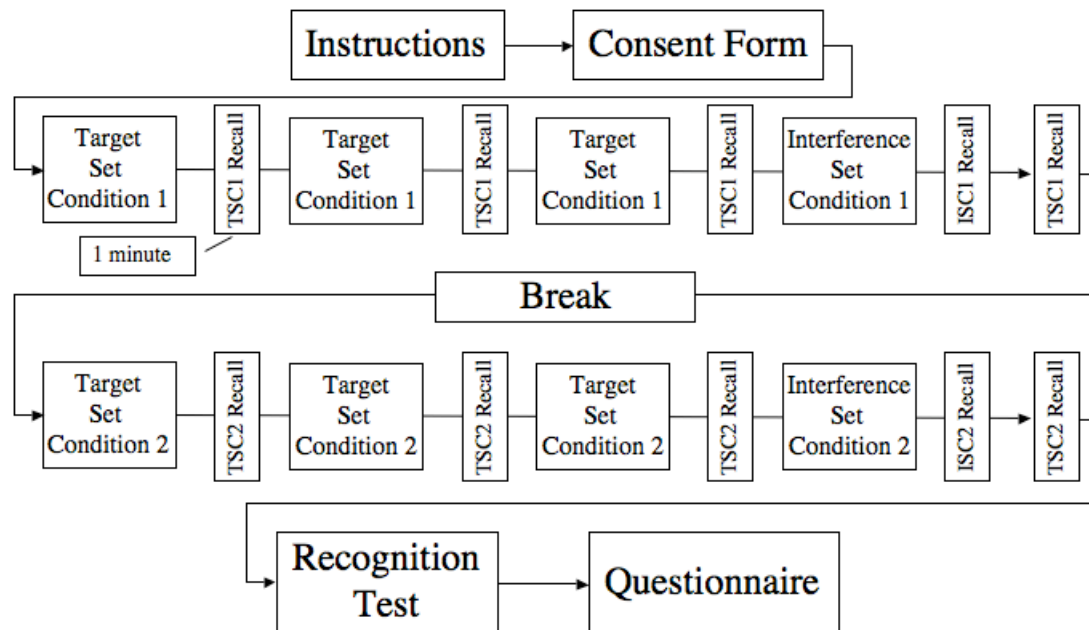


Figure 4: Experiment flow

Experimental Conditions and Run Definitions

The words used in this study were selected from the list of 116 five-letter words having a Thorndike-Lorge frequency (Thorndike & Lorge, 1972) of at least 50 per million, and were at a third-grade reading level. Appendix B provides the list of these words. The words were presented in all capitals and in Courier font (a non-kerned font) so that they took up the same horizontal and vertical screen space.

In an attempt to avoid potential confounding issues from specific word lists (i.e., that one list of words was more memorable than another), two complete sets of words were randomly selected from the Thorndike-Lorge list. Table 3a-f shows the word lists and the counterbalancing that was used for the subject pool. Thus, order and word list were counterbalanced between subjects. Unfortunately, as will be described in the results sections below, the number of subjects that volunteered for the word list counterbalance (sessions 3 and 4) was nearly half of the original set (sessions 1 and 2). Order and word list were between-subject variables. Since each subject received each of the two conditions, treatment is a within-subject design.

Session 1 – 26 Subjects			
Control First		Treatment (MMP) Second	
Target	Secondary (Interference)	Target	Secondary (Interference)
List 1	List 2	List 3	List 4
AGAIN	REACH	CARRY	STATE
BEING	MONEY	SLEEP	CLOSE
MONTH	STAND	ROUND	WOMAN
THANK	THERE	BRING	THREE
SOUND	LIGHT	HEAVY	BEGIN
WHICH	SINCE	PLAIN	EVERY
COLOR	LARGE	SWEET	BLACK
FRONT	DEATH	CROSS	LEARN
VOICE	DRIVE	SERVE	THINK
LEAVE	QUICK	OFTEN	THOSE
FRESH	PLANT	FLOOR	RIGHT
ALONG	WOULD	WATCH	RAISE
FOUND	TODAY	DRINK	HEART
NEVER	LAUGH	WHILE	STONE
START	NIGHT	SHALL	EARTH

Table 3 (a) Session 1 words and order

Session 2 – 23 Subjects			
Treatment (MMP) First		Control Second	
Target	Secondary (Interference)	Target	Secondary (Interference)
List 3	List 4	List 1	List 2
CARRY	STATE	AGAIN	REACH
SLEEP	CLOSE	BEING	MONEY
ROUND	WOMAN	MONTH	STAND
BRING	THREE	THANK	THERE
HEAVY	BEGIN	SOUND	LIGHT
PLAIN	EVERY	WHICH	SINCE
SWEET	BLACK	COLOR	LARGE
CROSS	LEARN	FRONT	DEATH
SERVE	THINK	VOICE	DRIVE
OFTEN	THOSE	LEAVE	QUICK
FLOOR	RIGHT	FRESH	PLANT
WATCH	RAISE	ALONG	WOULD
DRINK	HEART	FOUND	TODAY
WHILE	STONE	NEVER	LAUGH
SHALL	EARTH	START	NIGHT

Table 3 (b) Session 2 words and order

Session 3 – 14 Subjects			
Control First		Treatment (MMP) Second	
Target	Secondary (Interference)	Target	Secondary (Interference)
List 3	List 4	List 1	List 2
CARRY	STATE	AGAIN	REACH
SLEEP	CLOSE	BEING	MONEY
ROUND	WOMAN	MONTH	STAND
BRING	THREE	THANK	THERE
HEAVY	BEGIN	SOUND	LIGHT
PLAIN	EVERY	WHICH	SINCE
SWEET	BLACK	COLOR	LARGE
CROSS	LEARN	FRONT	DEATH
SERVE	THINK	VOICE	DRIVE
OFTEN	THOSE	LEAVE	QUICK
FLOOR	RIGHT	FRESH	PLANT
WATCH	RAISE	ALONG	WOULD
DRINK	HEART	FOUND	TODAY
WHILE	STONE	NEVER	LAUGH
SHALL	EARTH	START	NIGHT

Table 3 (c) Session 3 words and order

Session 4 – 16 Subjects			
Treatment (MMP) First		Control Second	
Target	Secondary (Interference)	Target	Secondary (Interference)
List 1	List 2	List 3	List 4
AGAIN	REACH	CARRY	STATE
BEING	MONEY	SLEEP	CLOSE
MONTH	STAND	ROUND	WOMAN
THANK	THERE	BRING	THREE
SOUND	LIGHT	HEAVY	BEGIN
WHICH	SINCE	PLAIN	EVERY
COLOR	LARGE	SWEET	BLACK
FRONT	DEATH	CROSS	LEARN
VOICE	DRIVE	SERVE	THINK
LEAVE	QUICK	OFTEN	THOSE
FRESH	PLANT	FLOOR	RIGHT
ALONG	WOULD	WATCH	RAISE
FOUND	TODAY	DRINK	HEART
NEVER	LAUGH	WHILE	STONE
START	NIGHT	SHALL	EARTH

Table 3 (d) Session 4 words and order

Session 5 – 33 Subjects			
Control First		Treatment (MMP) Second	
Target	Secondary (Interference)	Target	Secondary (Interference)
List 5	List 6	List 7	List 8
SMALL	EARLY	UNDER	WOMAN
PAPER	FRESH	SOUTH	HEAVY
REACH	THOSE	COULD	BLACK
LAUGH	SWEET	CAUSE	WORLD
BUILD	THANK	RIVER	BEING
TABLE	READY	STAND	DRINK
ABOUT	AGAIN	PIECE	RIGHT
WHERE	MONEY	HOUSE	WATER
EARTH	PLAIN	VOICE	UNTIL
THERE	THREE	NIGHT	ORDER
CARRY	FIRST	EVERY	SHORT
FLOOR	ROUND	POWER	DEATH
MONTH	COVER	WATCH	SIGHT
AFTER	VISIT	FOUND	QUICK
STONE	ABOVE	TODAY	POINT

Table 3 (e) Session 5 words and order

Session 6 – 31 Subjects			
Treatment (MMP) First		Control Second	
Target	Secondary (Interference)	Target	Secondary (Interference)
List 7	List 8	List 5	List 6
UNDER	WOMAN	SMALL	EARLY
SOUTH	HEAVY	PAPER	FRESH
COULD	BLACK	REACH	THOSE
CAUSE	WORLD	LAUGH	SWEET
RIVER	BEING	BUILD	THANK
STAND	DRINK	TABLE	READY
PIECE	RIGHT	ABOUT	AGAIN
HOUSE	WATER	WHERE	MONEY
VOICE	UNTIL	EARTH	PLAIN
NIGHT	ORDER	THERE	THREE
EVERY	SHORT	CARRY	FIRST
POWER	DEATH	FLOOR	ROUND
WATCH	SIGHT	MONTH	COVER
FOUND	QUICK	AFTER	VISIT
TODAY	POINT	STONE	ABOVE

Table 3 (f) Session 6 words and order

Dependent measures

The following dependent variables were analyzed based on the answers provided by the subjects. The differences between the number of words recalled on the third trial of the target memory list and the fourth trial (after the interference list trial) were computed. These differences represent the amount of memory loss over the interference trial. They reflect how many words the subject forgot over the interference task and is the primary determinant of the effectiveness of the MMP. The absolute number of words recalled from the target memory list on the last (fourth) trial represents a weaker measure but was, nonetheless recorded and analyzed. The number of words recalled from the interference memory list during that trial was used to compare the two conditions for interference and distraction due to the MMPs for the target words. For the recognition task, the mark made by the subject (i.e., X for recognized, blank for not presented) was recorded for each word and compared with whether the word was presented. The questionnaire items were also recorded.

Analyses

Hypothesis 1.

Subjects receiving the treatment (MMP) for the target memory items will have better recall for the target memory items than those subjects in the control condition (i.e., that did not receive the treatment (MMP)). To test this hypothesis, a paired t-test was conducted on the differences between trials 3 and 4 for the target memory word list for the treatment (MMP) condition and the control condition. Also, a paired t-test was conducted on the absolute number of target words recalled at the end of each condition (i.e., the fourth recall of the target words).

Hypothesis 2.

Subjects receiving the treatment (MMP) will have better recognition of the target memory items than those subjects that did not receive the treatment (MMP). For this hypothesis, a paired t-test was conducted comparing the number of target words recognized in the recognition trial for the two conditions.

Tentative Hypothesis.

The treatment (MMP) will not adversely affect the interference task performance; that is, there will be no statistical difference in interference memory item recall or recognition between subjects in the control condition and those in the treatment condition. Paired t-tests on both the recall (i.e., recall trial in the interference task) and recognition tests were conducted between the two conditions of interference words.

Experimental Results

All descriptive statistics and paired samples T-test analyses were performed using SPSS Standard Version 11.0.2 (15 April 2003) for the Macintosh. The significance level was set at 95%. 14 subjects were removed from the data due to abnormal memory loss (>7 or <-2), or abnormal pattern of improvement (nonmonotonic progressions greater than 2). Thus the n for the analysis was 129.

Hypothesis 1 – Treatment (MMP) improved recall over Control

There was no significant difference between treatment ($M = 1.77$ words, $SD = 1.75$) and control ($M = 2.06$ words, $SD = 1.82$) conditions for the memory loss measure (that is, the number of words correctly recalled in the fourth recall of the target words of the session subtracted from the number of words correctly recalled in the third recall). There was a statistically significant difference ($p < .01$) between the treatment and control conditions for absolute number of words correctly recalled in the fourth recall. This difference favored the treatment condition ($M = 10.81$ words, $SD = 2.80$) over the control condition ($M = 10.07$ words, $SD = 2.83$).

Hypothesis 2 – Treatment (MMP) improved recognition over Control

There was no significant difference between treatment ($M = 12.51$ words, $SD = 2.29$) and control ($M = 12.31$ words, $SD = 2.23$) conditions for the number of words recognized at the end of the study.

Tentative Hypothesis – Treatment (MMP) did not affect with interference task recall and recognition over control.

There was no significant difference between recall of interference words for treatment ($M = 6.73$ words, $SD = 2.18$) and recall of interference words for control ($M = 6.76$ words, $SD = 2.02$) conditions. Similarly, there was no significant difference between recognition of secondary (interference) words for treatment ($M = 6.91$ words, $SD = 2.53$) and recognition of secondary (interference) words for control ($M = 7.12$ words, $SD = 2.87$) conditions.

However, questionnaire results indicate that many of the subjects felt that the MMPs or the Blank flickers (control condition) were annoying (see figure 5) and that they impaired memory (see figure 6).

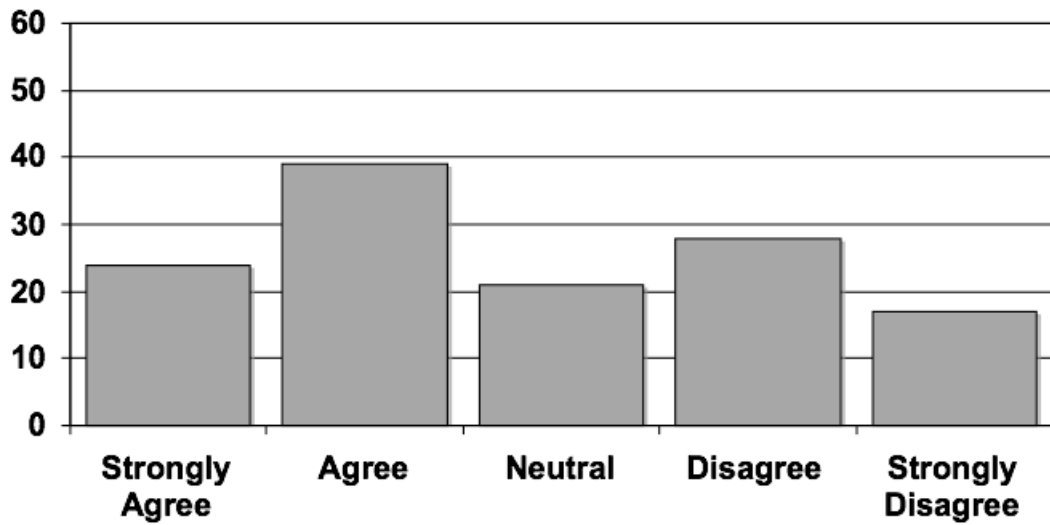


Figure 5: Frequency of responses to the statement “The distractions were annoying.”

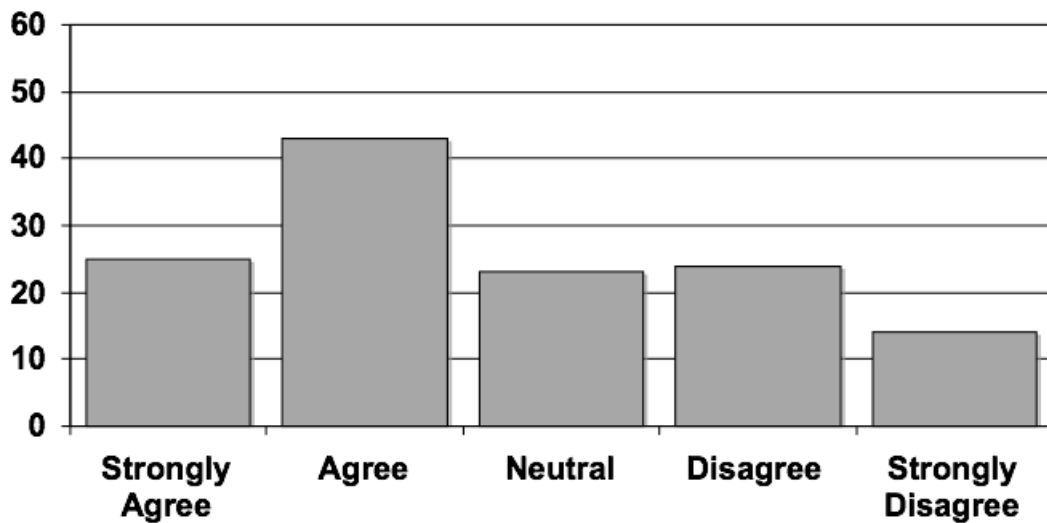


Figure 6: Frequency of responses to the statement “The distractions made it harder to remember the second set of words.”

Additional Observations

Several ad hoc analyses were conducted to try to understand the findings above and prepare for future research.

Order effect.

A one-way analysis of variance was performed on all of the dependent variables using order as the factor. The following variables were found to differ significantly based on order: The fourth recall of the target in the control condition $F(1, 128) = 4.14, p < .05$; the memory loss (difference between third and fourth recall) in the control condition $F(1, 128) = 12.73, p < .01$; recognition of the target words in the treatment condition $F(1, 128) = 6.42, p < .05$; and recognition of the interference words in the treatment condition $F(1, 128) = 9.04, p < .01$. Paired sample T-tests were performed comparing session order (first and second) regardless of wordlist.

For the treatment first – control second order, significant differences were found in the fourth recall for the target words – $p < .01$, with $M = 10.74$ for the treatment condition ($SD = 2.46$) and $M = 9.54$ for the control condition ($SD = 2.81$); the memory loss over the interference task – $p < .01$, with $M = 1.82$ for the treatment condition ($SD = 1.62$) and $M = 2.64$ for the control condition ($SD = 1.74$); and the recognition of the interference words – $p < .01$, with $M = 6.23$ for the treatment condition ($SD = 2.83$) and $M = 7.39$ for the control condition ($SD = 3.23$).

For the control first – treatment second order, significant differences were found in the second recall for the target words – $p < .05$, with $M = 10.97$ for the treatment condition ($SD = 2.39$) and $M = 10.43$ for the control condition ($SD = 2.00$); and the recognition of the target words – $p < .01$, with $M = 12.99$ for the treatment condition ($SD = 1.92$) and $M = 12.22$ for the control condition ($SD = 2.34$).

The combined assessment of these data suggest the differences in fourth target word recall and the memory loss over the interference trials are likely to be due to decrements in the control condition (due to being near the end of the experiment) rather than improvements in the treatment condition. Similarly, the difference in the increase in the treatment target recognition where the treatment words are shown last is most likely attributable to the recency effect (Baddeley, 2000). The fact that the treatment negatively affected the interference recognition in the treatment first condition may be indicative of the novelty of the MMP.

Word lists.

For the target memory tasks, there were three sets of 15 words used for the treatment condition– the CARRY set, the AGAIN set, and the UNDER set (see tables 3 a – f). Respectively, there were three sets used for the control condition – the AGAIN set, the CARRY set, and the SMALL set. A one-way analysis of variance was conducted over the three word lists used for the treatment condition. The analysis showed that the choice of word list did have a significant effect on memory performance. Specifically, the first recall of the target words in the treatment condition – $F(1, 128) = 6.94, p < .01$; the second recall of the target words in the treatment condition – $F(1, 128) = 7.81, p < .01$; the third recall of the target words in the treatment condition – $F(1, 128) = 3.34, p < .05$; the first recall of the target words in the control condition – $F(1, 128) = 6.43, p < .01$; the second recall of the target words in the control condition – $F(1, 128) = 8.38, p < .01$; the third recall of the target words in the control condition – $F(1, 128) = 11.11, p < .01$; the fourth recall of the target words in the control condition – $F(1, 128) = 11.85, p < .01$; recognition of the target words in the treatment condition $F(1, 128) = 4.12, p < .05$; recognition of the target words in the control condition $F(1, 128) = 19.56, p < .01$; and recognition of the

interference words in the control condition $F(1, 128) = 8.27, p < .01$.

Comparisons of the individual word list groups were performed using paired sample t-tests. For the treatment = CARRY – control = AGAIN group ($n = 47$), significant differences were found in the second recall for the target words – $p < .05$, with $M = 10.51$ for the treatment condition ($SD = 2.08$) and $M = 9.79$ for the control condition ($SD = 1.85$); the third recall for the target words – $p < .01$, with $M = 12.28$ for the treatment condition ($SD = 1.95$) and $M = 11.15$ for the control condition ($SD = 2.56$); the fourth recall for the target words – $p < .01$, with $M = 10.47$ for the treatment condition ($SD = 2.77$) and $M = 8.62$ for the control condition ($SD = 2.88$); the memory loss over the interference task – $p < .05$, with $M = 1.81$ for the treatment condition ($SD = 1.77$) and $M = 2.53$ for the control condition ($SD = 2.00$); the recognition of the target words – $p < .05$, with $M = 11.77$ for the treatment condition ($SD = 2.59$) and $M = 11.09$ for the control condition ($SD = 2.66$); and the recognition of the interference words – $p < .01$, with $M = 6.74$ for the treatment condition ($SD = 2.34$) and $M = 5.94$ for the control condition ($SD = 2.52$). In all cases, (statistically significant or not) the mean favored the treatment condition.

For the treatment = AGAIN – control = CARRY group, which was the counterbalance to the previous group ($n = 26$), significant differences were found in the recognition of the target words – $p < .01$, with $M = 12.96$ for the treatment condition ($SD = 1.66$) and $M = 14.04$ for the control condition ($SD = 1.55$); and the recognition of the interference words – $p < .01$, with $M = 6.46$ for the treatment condition ($SD = 3.06$) and $M = 8.50$ for the control condition ($SD = 2.37$). In all cases, (statistically significant or not) the mean favored the control condition. The reader should note that the results of these two groups seems to indicate that the Carry word list is more memorable.

For the treatment = UNDER – control = SMALL group ($n = 56$), there were no significant differences between the treatment and control conditions. The means for all cases (statistically significant or not) were mixed between favoring the treatment and control conditions.

As a further exploration, a one-way analysis of variance was performed on the recalls without regard to treatment (i.e., first recall = first recall treatment + first recall control) with word list as the factor. Results were significant for all of the data except the interference words and the memory loss. The results are as follows: first recall $F(3, 257) = 8.94, p < .01$, second recall $F(3, 257) = 11.86, p < .01$, third recall $F(3, 257) = 9.41, p < .01$, fourth recall $F(3, 257) = 9.19, p < .01$, target recognition $F(3, 257) = 3.32, p < .05$, and interference recognition $F(3, 257) = 3.89, p < .05$. Table 4 shows the sample number, the means and the standard deviations for each of the recalls. Figures 7 through 11 show the plots of the means for the four recalls of the target set and the recognition of the target set.

Recall	Word List	Subject Number (N)	Mean	Standard Deviation
First	Carry	73	6.96	1.55
	Again	73	6.89	1.55
	Under	56	8.16	1.85
	Small	56	7.79	1.73
Second	Carry	73	10.37	1.99
	Again	73	9.89	1.90
	Under	56	11.75	2.00
	Small	56	11.20	1.76
Third	Carry	73	12.25	1.72
	Again	73	11.48	2.16
	Under	56	13.07	1.80
	Small	56	12.93	1.94
Fourth	Carry	73	10.48	1.87
	Again	73	9.14	2.26
	Under	56	11.45	2.23
	Small	56	11.09	2.03
Target Recognition	Carry	73	12.58	2.44
	Again	73	11.75	2.51
	Under	56	12.93	2.14
	Small	56	12.54	1.53
Interference Recognition	Carry	73	7.37	2.48
	Again	73	6.12	2.72
	Under	56	7.27	2.41
	Small	56	7.46	3.00

Table 4 Means and Standard Deviations of each recall and recognition based on word list.

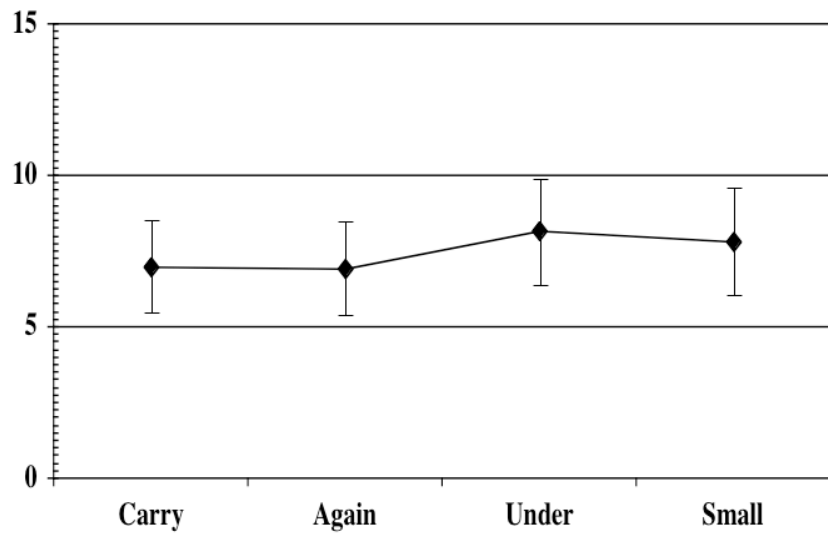


Figure 7: Means for the first recall of the target set for each word list (n=258)

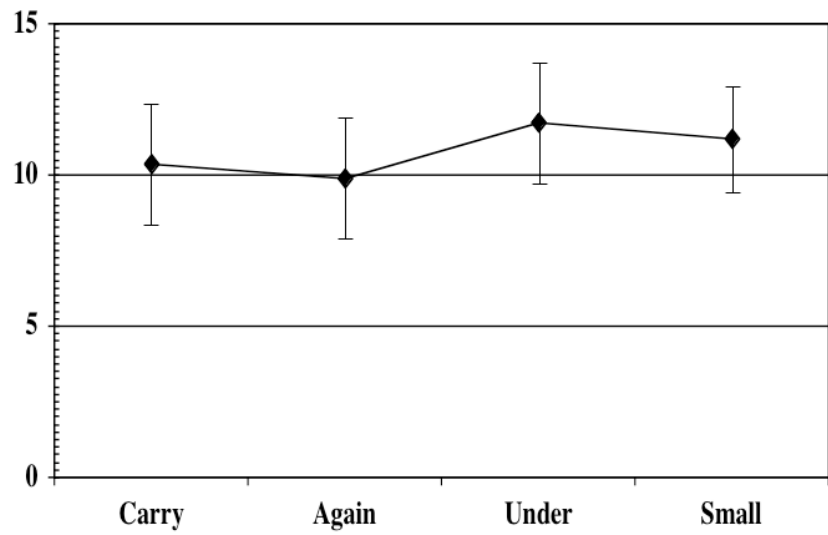


Figure 8: Means for the second recall of the target set for each word list (n=258)

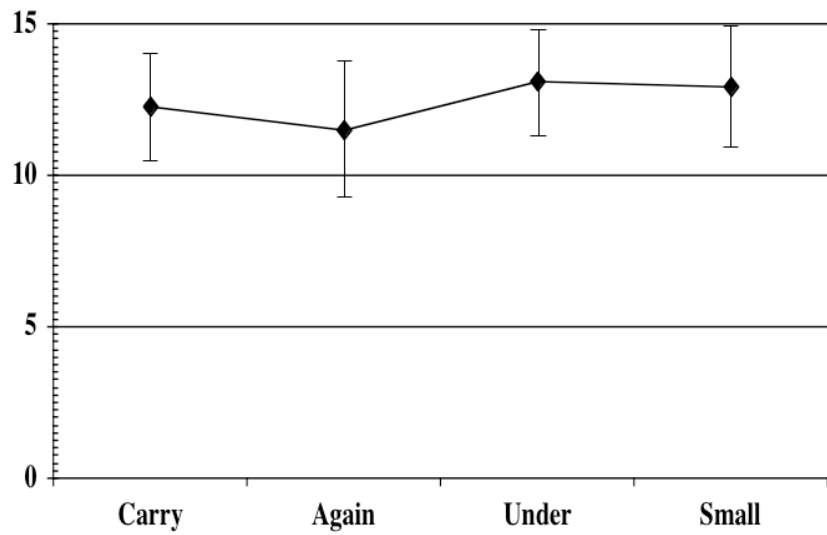


Figure 9: Means for the third recall of the target set for each word list (n=258)

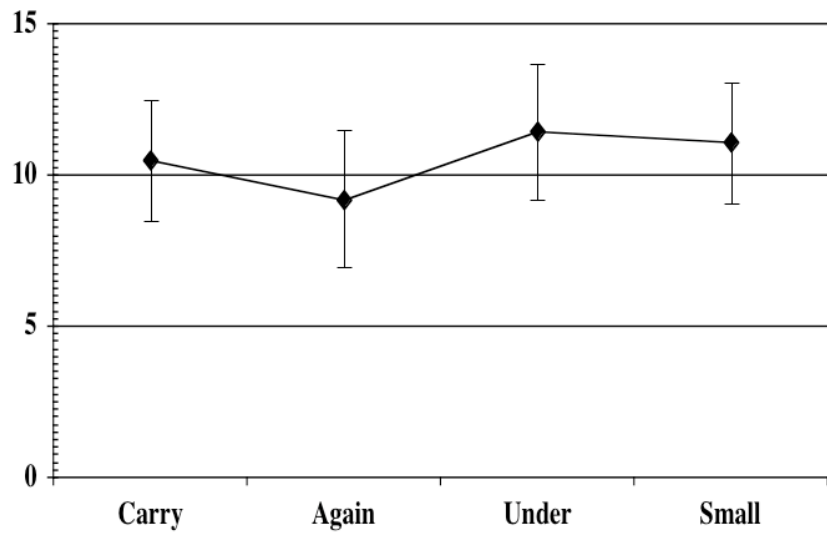


Figure 10: Means for the fourth (after the interference task) recall the target set for each word list (n=258)

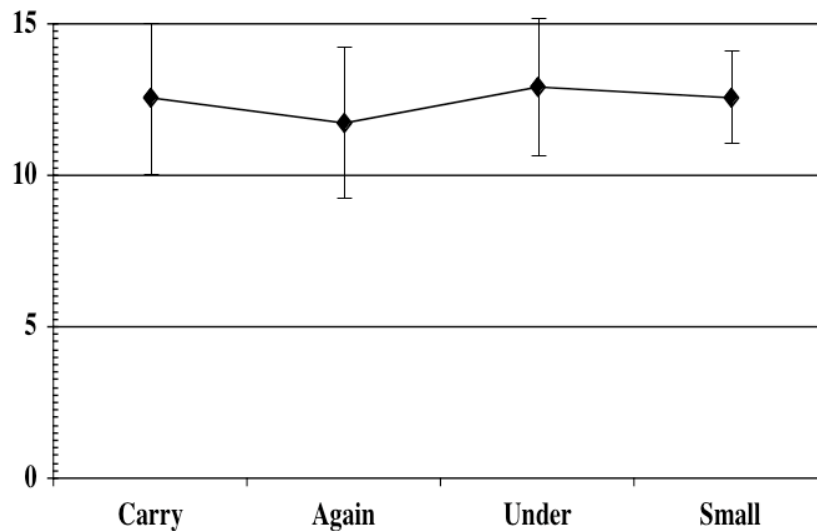


Figure 11: Means for recognition of the target set for each word list (n=258)

Questionnaire Data.

The questions dealt with the MMPs and the blanks that were presented during the interference word list presentation. The means for each question tended to be to the right of the midpoint (that is, towards disagree). The mode data was very interesting. The mode values for the statements “The distractions were annoying” and “The distractions made it harder to remember the second set of words” were both 2, indicating Agree. The mode values for “I tried to read the distractions,” “I was able to read the distractions,” “I noticed that some of the distractions were previous words,” and “The repetition of previous words in the distractions helped me remember them” were all 5, indicating strong disagreement. In hindsight, these answers may have been biased by the negative connotation of the word ‘distraction’ and by the fact the subjects were instructed not to pay attention to the distractors (MMPs). The histograms for the first two questions are presented in figures 5 and 6 above. The histograms for the remaining 4 questions are found below in figures 12 through 15.

	Distractions were Annoying	Interfered with Memorizing Interference	Tried to read distractions	Able to read distractions	Noticed distractions were previous words	Distractions helped target memory
Mean	2.8	2.7	3.2	3.1	3.3	3.9
Mode	2	2	5	5	5	5
St. Dev	1.33	1.28	1.49	1.45	1.57	1.24

Table 5
Descriptives for Questionnaire Data
1 = Strongly Agree 5 = Strongly Disagree

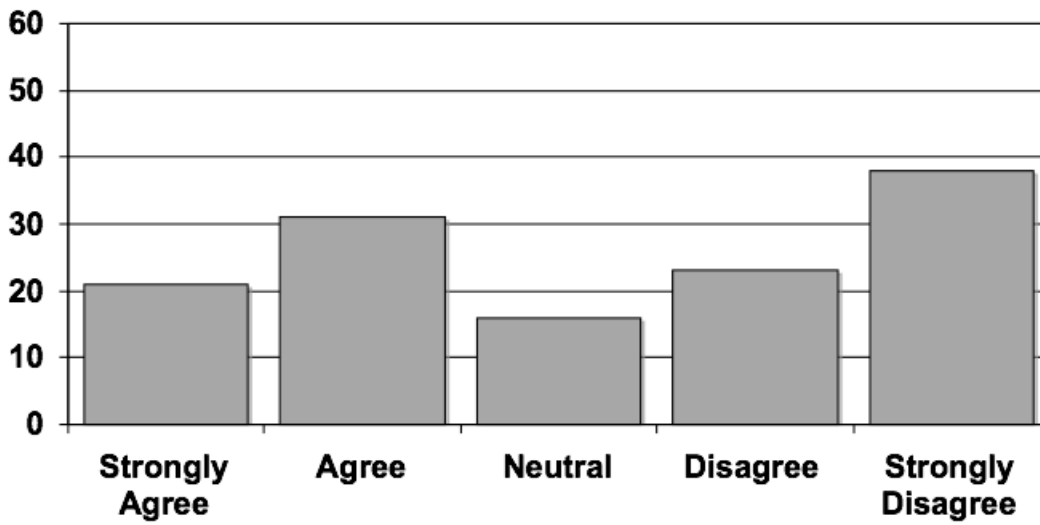


Figure 12: Frequency of responses to the statement "I tried to read the distractions."

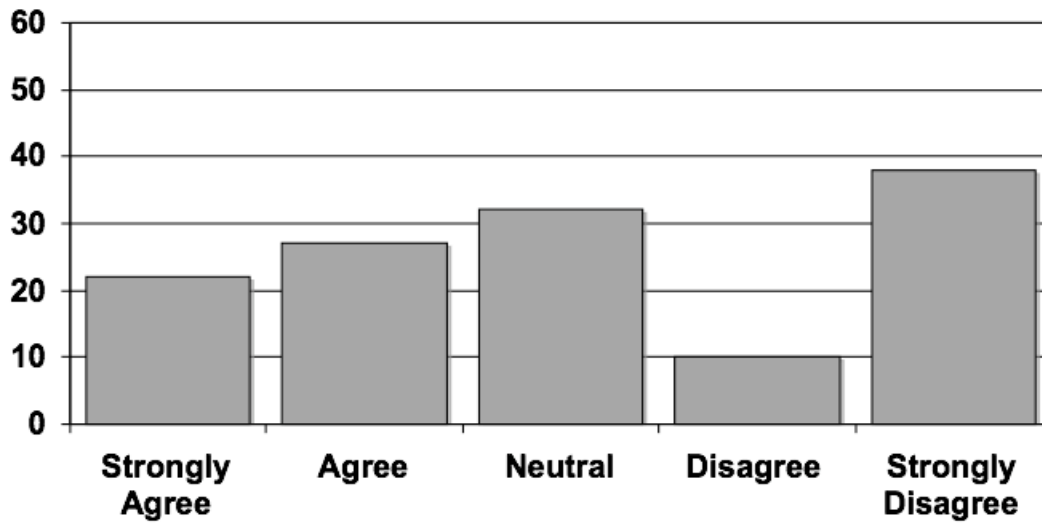


Figure 13: Frequency of responses to the statement “I was able to read the distractions.”

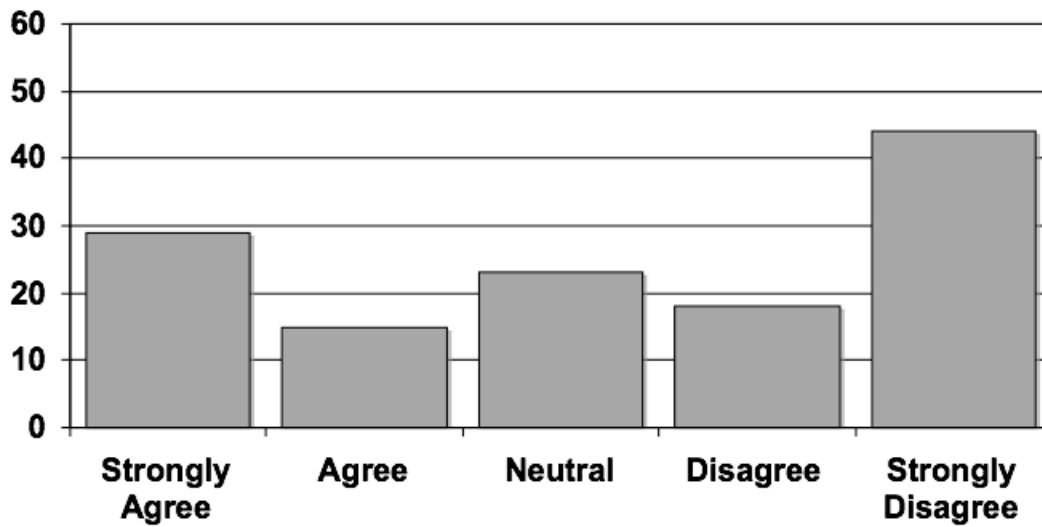


Figure 14: Frequency of responses to the statement “I noticed that some of the distractions were previous words.”

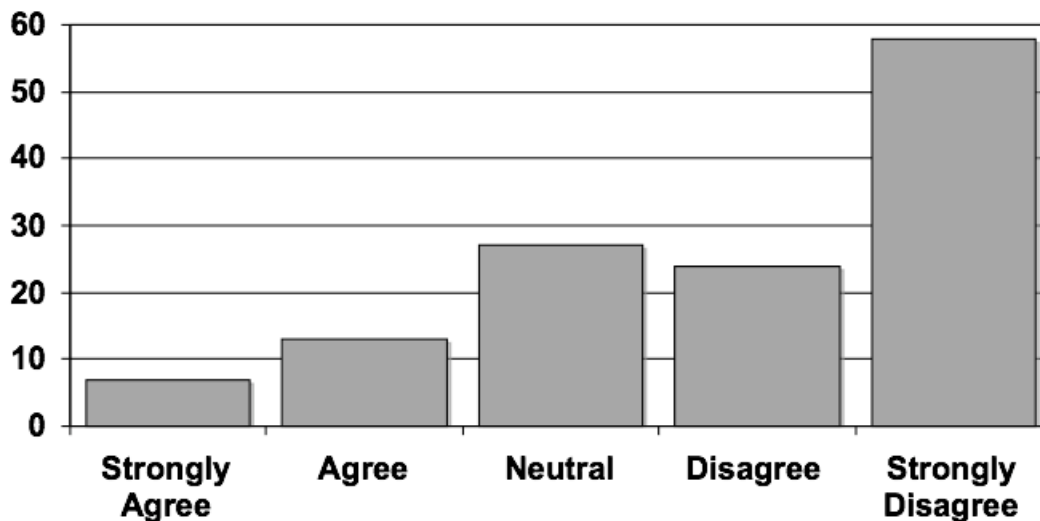


Figure 15: Frequency of responses to the statement “The repetition of previous words in the distractions helped me remember them.”

The final part of the questionnaire asked the subjects to share any memorization strategy that they used. 77 subjects stated that they used some form of story or sentence making. 39 of the subjects stated that they used some sort of word association. 25 of the subjects stated that they used repetition. 16 of the subjects stated that they used to order of the words to help them remember. 9 stated that they chunked words into groups. 7 said that they used rhyming strategies. 4 subjects stated that they used visualization or imagery to help them remember. 1 subject stated that he keyed on odd words and another stated that she translated the words into another language. Note that many of the subjects listed two or more strategies. 21 subjects did not answer the strategy question.

Comparisons with the meta-norms for the RAVLT.

One reason for using the RAVLT as a model for the experimental tasks in this experiment is the existence of established norms. The meta-norms for the first three trials in the RAVLT for ages 20 – 29 are listed in Table 6 and are taken from (Schmidt, 1996). While no age data was recorded for the subjects, most were ‘college age’, which generally ranges from 19 to 25.

Trial	Mean	Standard Deviation
1	7.0	1.8
2	9.9	2.2
3	11.5	2.1

Table 6 Meta-norms for the age group of 20 to 29 year-olds for the RAVLT

One-sample t tests were performed to compare these norms to the data for both the control and treatment conditions. In all but one case (control words for the first trial) the means for the recalls in this study were significantly higher ($p < .05$ for the comparison of the third trial for the

control, and $p < .01$ for the remainder) than the meta-norms. A possible explanation for these differences could be the fact that the words were visually displayed and were written down when recalled whereas the traditional RAVLT is generally oral in both presentation and recall. In seeing the words the subjects may have utilized both the visuo-spatial sketchpad and the phonological loop (as they said the words to themselves) for encoding the words (Baddeley, 2000) whereas the RAVLT would only utilize the phonological loop. In writing down the words, they utilized more aspects of the brain (e.g., motor cortex). This more elaborative processing (Brown & Craik, 2000) may have reinforced the memory traces of the target words more than in the traditional RAVLT. Another possible explanation is that the demographics for the subjects in this test were substantially different from the ones used in the meta-norms. Finally, again it may be that the word lists used in this study were more memorable because they were all five-letter words where the number of letters in the words for the traditional RAVLT varies from 4 to 6 letter words.

Discussion of Experimental Results

The results do not find any evidence that the use of MMPs assists in recall or recognition of the target words after an interference task. The one finding that was significant – namely that subjects recalled a greater number of words for the fourth recall in the treatment condition compared to the control condition – is better explained by the apparent confounding of the word lists used themselves. If the word lists were equally memorable, one would expect that the third recall for all word lists to be statistically the same since the treatment had not been administered at that point. However, the post hoc analysis of the word lists demonstrate that this is not the case and that some lists were more memorable than others. The smaller number of subjects in the counterbalanced conditions (sessions 3 and 4) apparently caused the counterbalance to be ineffective. This was further confirmed by the fact that there was no significant difference in sessions 5 and 6 where entirely new word lists were used.

Why didn't the MMPs work to assist memory? To answer this we need to examine the differences between this study and the Wallace experiment. As mentioned in section 4 above, the conditions in this experiment were conservatively biased against the success of the MMPs in order to determine the robustness of effect. There are a number of possible explanations for their failure. One explanation is that mere exposure to the words does not enhance memory – regardless of the exposure time. As mentioned earlier, studies by Berkerian and Baddeley (1980) and Obermiller (1985) would suggest that mere exposure does not aid memory. In the Wallace experiment, the subjects were not only exposed to the presentation, it is inferred that they were seeking this information. Another explanation is that the interference task did its interfering quite well. Since the MMPs are subtle by design, the interference task may have overwhelmed any positive value. The secondary task in the Wallace experiment (the editing task) was not at odds with the primes. Yet another reason for these results is that in the Wallace experiment, the primed information was used at the time of priming. The results of this experiment would tend to suggest that the value of that prime is extremely short lived. Finally, the MMPs were in direct opposition to the secondary task and the subject was actively (per instructions and by trying to concentrate on the interference words) trying to ignore the MMPs.

In hindsight, the assumption that the MMPs might be equivalent to a fourth session using the RAVLT (as discussed in the Appendix F: Preliminary Power Analysis) was inappropriate. In the fourth session of the RAVLT, the subject is deliberately trying to remember the words when they are exposed to them and then tries to recall the words. Both of these acts can tend to reinforce memory through elaborative processing (Craik and Lockhart 1972). Therefore expectations that the MMP exposure would be similar to the fourth presentation of the RAVLT were unrealistic.

It is likely that these factors – 1) that mere exposure does not necessarily reinforce memory, 2) that the secondary task was designed to disrupt the very memory that the MMPs were trying to reinforce, 3) that the half-life of the MMP value is very short, 4) that the primed information was not needed at the time of priming, and 5) that the primed information was not only irrelevant to the secondary task, it was in opposition to it – contributed to the failure of the MMPs to assist in remembering the target words. In addition, since many of the subjects reported that the MMPs

(and their blank control equivalents) were annoying and since many of the subjects claimed that were able to read the words presented, it may be that the single video frame (33ms) may be too long or insufficiently masked to provide a an unobtrusive prime.

Conclusion

“I have not failed 700 times. I have not failed once. I have succeeded in proving that those 700 ways will not work.”

--Thomas Edison

The Wallace experiment results indicate that there is potential value in using briefly displayed reminders of previously studied information to assist memory. The study described in this thesis indicates that this method of memory enhancement is not helpful across all types of memorization and recall tasks. This study also demonstrated that the disruption of one task by the MMP could be subjectively annoying to the participant (although there was no difference in performance). The Wallace experiment primed information that was useful to the subject while it was being presented and which the subject both desired and used at the time of presentation. The study described here primed information that was not useful to the subject when it was being presented and was not used at the time of presentation. It may be the MMPs do not refresh a memory trace but instead cue the recall of a previous memory (E. Tulving & Thomson, 1973). Thus the brief exposure to the MMP would only serve as a cue — what Tulving and Schacter (Endel Tulving & Schacter, 1990) call the Perceptual Representation System.

Future studies in the area of MMPs might look at the use of information at the time of priming and information that is either relevant to the secondary task or not. I propose two such experiments. Both would involve negotiating a maze from a first person perspective. The map of the maze would be shown to the subject prior to moving in the maze and the subject would negotiate the maze a number of times on paper (the learning phase). Then the subject would be placed in a virtual first-person perspective (similar to many video games). As in the Wallace experiment, the subject could switch screen modes bring up the map (hiding the perspective view). However in the treatment condition, the subject would be primed with the map using MMPs while negotiating in the perspective mode. Anticipated benefits are the reduction of time to negotiate the maze, fewer wrong turns, and fewer calls for the map. This differs from the Wallace experiment in that the information presented is more directly related to the task – an analogous study using the Wallace paradigm would prime the editing directions, not the help screen. The second experiment would be similar to the first but would provide information that is not relevant to the secondary task. The information that would be primed would be similar to the memory words used in this task. The user would have to recall the words while negotiating the maze. At the end of each test sessions the subject would try to recall / recreate either the maze or the word list.

Another set of experiments could look at the possibility of MMPs being used for prospective memory. Again, the maze scenario could be used. In this case, the subject would be given a task to remember to perform either after a particular time or after a particular juncture in the maze.

The prospective task would not be critical (otherwise, if it were critical then the reminder would be a more salient – supraliminal – presentation). The expected benefits would be that the MMPs would aid the subjects in remembering to perform the task but would be less disruptive to the maze-negotiating task than traditional alerts.

The experiment described in the thesis demonstrates that the MMP concept has its limits and is not brutally robust. Having established a lower bound, it is time to explore less extreme and more amenable uses for MMPs. Information technology has great potential for helping humans remember information as long as designers remember to use it effectively. Less subtle methods than MMPs can lead to critical disruptions of ongoing tasks. There needs to be an effective balance in between salience and subtlety. I hope that these studies will lead to the discovery of that balance.

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Appendix A

Overview of the Rey Auditory and Verbal Learning Test

Title: Rey Auditory and Verbal Learning Test (RAVLT)

Author: André Rey (original French version); Edith Meyer Taylor (English adaptation)

Publisher: Western Psychological Services, 12031 Wilshire Blvd. Los Angeles, CA 90025-1251

Copyright Information: The test itself carries no copyright or trademark and administration of the test is not restricted. There are handbooks and administration sheets that are provided by the publisher which hold a copyright. There are no qualification restrictions on the materials.

Intended Audience: The RAVLT and variations of it have been administered to people of ages 7 to the elderly. It has been used in various languages and cultures. Variations have been administered to individuals with hearing disabilities. Individuals must be alert and able to follow the test directions. They must have sufficient language skills to indicate their responses.

Forms Available: The RAVLT has been modified extensively over the 40 years of widespread use. The most numerous modifications involve the memory items used in the test. The test was originally constructed in French and has been adapted for English, Hebrew, German, Italian, and Dutch. Many of these adaptations involved word changes rather than simple translations because of changes in syllable count. Another aspect that has been modified is the measurement methodology. The original method was memory recognition where the subjects were given a story and asked to identify the memory items (words) in the story. This was varied to use simple recognition from a list of words (either 30 or 50 words), or recognition from a three item forced choice task. RAVLT's most common measurement method is free recall of memory items. Other variations include visual presentation where the subject must read the word aloud rather than have the word read to him or her, and variations in the feedback given to the subject (e.g., encouragement or identification of correct responses or repeated responses.)

Other Tests by Rey: Rey Complex Figure Test and Recognition Trial (RCFT) A measurement tool for visiospatial ability and memory.

Purpose and Recommended Use: The RAVLT is a simple memory assessment test. It can be used to test several aspects of memory such as working memory, long-term memory and learning ability. It has been used as a diagnostic tool to identify neurological, cognitive, and age-related disorders as well as a research tool to identify the manifestations of such disorders. In the process of establishing norms it has identified and quantified normal learning ability and memory ability as it changes with age. It was originally conceived for use with children but has more recently been used extensively with elderly populations. Its recommended use is in the assessment of memory capability with an emphasis on identifying memory deficits. It is recommended to be used as part of an overall assessment ensemble that can provide a comprehensive picture of the subject.

Dimensions or Areas Measured: RAVLT can be used to measure working memory recall (Trials I-V

and Trial B), long-term memory recall (Trial VI and delayed trial), long-term memory recognition (recognition test – story or list) and word learning ability (progress over Trials I-V). These measures combine to provide discriminative capability that is greater than the individual measures by themselves. For example, a lower than normal short-term and long-term memory score combined with a flat learning curve is an indicator of amnesia whereas low scores combined with a positive learning curve tend to indicate head trauma.

Administration: The peculiar aspects of the test (i.e., those not included in most psychometric tests such as informed consent) include five consecutive learning trials of 15 words (Trials I-V). This is followed by one learning trial of an interference set of 15 different words (Trial B). A learning trial consists of the subject being presented 15 words at a rate of one per second. This presentation is normally provided by the test administrator reading the words aloud. Then the subject is asked to recall as many of the 15 words as they can remember in any order. Immediately following Trial B, the subject is asked to recall the original 15 words (Trial VI). Following this the subject is either presented with a list of words (e.g., 30 words where 15 are the original words and 15 are foils that may have semantic or phonemic similarity) or a story containing the 15 words and asked to identify the words from the original list. This is the recognition test. A variation of the test includes a delay (20, 30, or 60 minutes) and another recall test. Subjects are not generally timed on any of the tests.

Scoring Procedure: For each of the trials, the subjects responses can be scored as correct, repeated, repeated corrected (where the subject remembers that he or she has repeated the word), repeated questioned (where the subject asks if he or she has said that word before), error, error from the interference set, a frank confabulation, or phonemically or semantically similar error. These distinctions are not represented in the norm data however they can be useful in a more thorough assessment of the subject's performance with regard to proactive and retroactive interference and malingering. If the subject constantly repeats a word without recognition of having done so or repeatedly asks if he or she has already mentioned a word, this could be a further indicator of memory deficits. For the recognition tests, a similar scoring can be used, namely correct, missed, error, or phonemically or semantically similar error.

Description of Items: The memory items are all one or two syllable words that have a Thorndike-Lorge frequency (Thorndike & Lorge, 1972) of at least 50 per million, high imagery and are at a third-grade reading level. Phonemic and semantic similarities are avoided. As mentioned above, there are several variations of the word lists. Many of these additional word lists were generated for test-retest assessment. Others were primarily for culture or language differences.

Statistical Item Analysis: There has been no item analysis regarding the individual words in the RAVLT. I have not found any information regarding a more common occurrence of one word over another or the particular descriptive value of one word over another. However, there have been statistical comparisons of the different word lists that have been developed for the alternate forms of the test. I will discuss these between group analyses in the section on reliability.

Method of Validation: Content validity is considered to be intuitively obvious given the nature of the test (its face validity) and it is not specifically addressed. What is more thoroughly addressed is concurrent validity both with other measures of memory and with discriminative tests on patients with known neurological disorders. Factor analyses have been used to confirm construct validity.

Norm Groups: The norm data for the RAVLT is quite extensive, as it has been used for more than 40 years. However, it is largely derived from a number of somewhat disparate studies. Schmidt (Schmidt,

1996) provides excellent tables of meta-norms based on these various studies. These meta-norms are based on n-weighted averages and standard deviations. They are stratified based on age. He provides 10 categories of meta-norms: Age 13 (1 study, N=51), Ages 14-15 (2 studies, N=177), Ages 16-19 (3 studies, N=78), Ages 20-29 (4 studies, N=498), Ages 30-39 (4 studies, N=1081), Ages 40-49 (5 studies, N=522), Ages 50-59 (4 studies, N=161), Ages 57-69 (4 studies, N=166), Ages 70-79 (4 studies, N=143) and Ages 76-89 (2 studies, N=50). In addition, he provides two general categories: Adult (4 studies, N=1989) and Elderly (2 studies, N=52). He provides a breakdown of each meta-norm that shows how each individual study compares to the meta-norm.

The norm data includes means and standard deviations for responses for Trials I-VI, Trial B, the Delayed Recall Trial, the Recognition Memory Trial, and the sum score of Trials I-V. Since not all studies included the delayed recall and some studies used different methods for the recognition memory trial, Trials I-VI and Trial B are the most robust.

Interpretation of Scores: While no cut off has been established for determining that a person's memory is impaired, Schmidt (1996) suggests that a recall score of 8 or less on Trial V should arouse suspicion. The stratified norms show that the average recall on Trial V consistently decreases as age increases and the standard deviation consistently increases with age. The meta-norm mean for ages 76-89 is 10 (SD=2.3). The meta-norm mean for ages 20-29 is 12.9 (SD=21.8). Therefore a score of 8 for Trial V for a 25 year old would be more suspicious than the same score for an 85 year old. While age is the dominant modifier, gender has also been shown to affect scores with females tending to have better scores than males. Some studies have shown effects from education and intelligence but not consistently.

When interpreting the scores it is best to be specific if possible regarding the norm that is used. Many of the tests used to create the meta-norms used different procedures or word lists. The greater the similarity of the study used in the norm with the current study, the more comparable the data is to the norm. Schmidt (1996) provides the RAVLT performance data from several clinical groups such as patients with head injuries, learning disabilities, and Alzheimer's disease. These can be used for comparison.

Validity as Determined by Authors: Neither Rey nor Taylor appear to have produced significant validity studies.

Validity as Determined by Others: Validity data from other researchers is plentiful. The various scores derived from the RAVLT (e.g., Trial VI and Trial I-V Total) have a strong and significant concurrence with Wechsler Memory Scale, the Wechsler Adult Intelligence Scale-R (WAIS-R) digit span, the Benton Visual Retention Test, the Visual Spatial Learning Test, and the California Verbal Learning Test. Factor analyses have show high single factor loadings on many of these tests when compared with RAVLT. RAVLT has been shown to discriminate between neurologically impaired individuals and normal individuals as well as being able to discriminate reliably on age. Factor analyses have shown 2 factor solutions interpreted as short-term (Trials I, II, and B) and long-term memory (Trials III, IV, V, and VI) and 3 factor solutions interpreted as acquisition (Trials I and B), storage (recognition memory trial), and recall (Trials V, VI, and delayed recall).

Reliability: Reliability testing for memory tests can be difficult as there is a strong practice effect. One would want to use the exact same test for both test and retest. However, this would not be a valid descriptor of temporal reliability. One possible solution is to wait a sufficiently long period between test and retest to reduce practice effects. However, the practice effects in this case are rather robust and long time intervals can confound the reliability test, as memory scores will change with age. Alternate word

lists have been used to reduce this practice effect, however, it is not clear that the test is the same as the retest. Indeed, alternate word lists have been shown to have differences in difficulty according to average scores. However, it is generally agreed that these differences in difficulty, when appropriately counterbalanced, are so small that they do not provide any substantial reliability problems.

Major Assumptions and Questions: The major assumption for this test is that memory span for words represents more general memory functions. The ability to use this test to discriminate between normal individuals and impaired individuals with diseases such as Alzheimer's seems to bear this out. However, research in memory seems to indicate that there are several different types of memory processes (e.g., working memory, long-term memory, and primed memory (Endel Tulving, 2000)) and the amount of coverage provided by the RAVLT for working memory and priming remain to be seen.

Distinguishing Characteristics: Perhaps the most distinguishing characteristic is the legacy of this test. It is tried and true and as with many standards, even if it did not measure what it purports to (which I believe it does) it would still be significant because it provides a reference for comparison.

Desirable Features: The test is easy to administer, it is relatively fast, and it requires no special equipment. The norms that are available are excellent as are the instructions and the possibilities of alternate forms. Both reliability and validity have been demonstrated by those who do not have a vested interest in the test.

Undesirable Features: While the norms are excellent, they have been compiled from several studies using different techniques. These variations may influence the outcome of the studies. This is probably so as some of the studies are in disagreement with each other. The RAVLT appears to have ceiling effects with some groups such as bright individuals, thus you cannot see the full range of the population. The samples used for most of the studies have higher than average education and IQ levels, which means that the norms may be too high for the population. There are no norms for many of the alternate forms. There has been no cross-cultural or cross-ethnic research using this test.

Appendix B

Word list used for the experiment

Five-letter words

ABOUT	COULD	HEAVY	PLACE	SOUTH	UNDER
ABOVE	COVER	HORSE	PLAIN	SPEAK	UNTIL
AFTER	CROSS	HOUSE	PLANT	STAND	VISIT
AGAIN	DEATH	KNOWN	POINT	START	VOICE
ALONE	DRESS	LARGE	POWER	STATE	WATCH
ALONG	DRINK	LAUGH	QUICK	STONE	WATER
AMONG	DRIVE	LEARN	RAISE	STORY	WHERE
APPLE	EARLY	LEAVE	REACH	SWEET	WHICH
BEGIN	EARTH	LIGHT	READY	TABLE	WHILE
BEING	EVERY	MIGHT	RIGHT	THANK	WHITE
BLACK	FIELD	MONEY	RIVER	THEIR	WHOLE
BREAD	FIRST	MONTH	ROUND	THERE	WOMAN
BRING	FLOOR	NEVER	SERVE	THESE	WORLD
BUILD	FOUND	NIGHT	SHALL	THING	WOULD
CARRY	FRESH	NORTH	SHORT	THINK	WRITE
CAUSE	FRONT	OFTEN	SIGHT	THIRD	YOUNG
CHILD	GREAT	ORDER	SINCE	THOSE	
CLEAR	GREEN	OTHER	SLEEP	THREE	
CLOSE	HAPPY	PAPER	SMALL	TODAY	
COLOR	HEART	PIECE	SOUND	TRAIN	

Appendix C

Subject Consent Form

RESEARCH SUBJECT INFORMATION AND CONSENT FORM

TITLE: Assessing the effects of momentary distractions on memory retention.

PROTOCOL NR: VCU IRB PROTOCOL NUMBER: **3762**

SPONSOR: Virginia Commonwealth University

INVESTIGATOR: Paul C. Schutte

This consent form may contain words that you do not understand. Please ask the investigator to explain any words or information that you do not clearly understand. You may take home an unsigned copy of this consent form to think about or discuss with family or friends before making your decision.

PURPOSE OF THE STUDY:

The purpose of this research study is to examine the effects of presenting briefly displayed words during memory retention task. The words are presented by briefly flashing them on the screen where you are currently viewing a list of words to be memorized. If you notice the word presentation, you should try to ignore it and concentrate on memorizing the words presented.

You are being asked to participate in this study to help assess these effects. Your skills are not being tested. You should perform to the best of your abilities but you should not consider yourself to be under any pressure to perform.

DESCRIPTION OF THE STUDY

Your participation in this study will last up to 60 minutes. Approximately 80 subjects will participate in this study.

PROCEDURES

This study will consist of two sessions. For each session, you will be asked to view and recall two lists of words (Lists 1 and 2 for the first session, Lists 3 and 4 for the second session.) There are 15 words in each list. These will be presented to you on a projection screen.

You will be shown the first list of 15 words (List 1) on the screen one at a time at one-second intervals. You will then be asked to recall these words and write them down on a provided piece of paper that will be collected when you are finished. If you cannot remember a word, feel free to guess. The order of the words is not important. Once you have finished writing the words down you will turn the paper over. You will be shown these words in the same manner for two more trials. You will try to recall these words after each trial. Then you will be shown another set of 15 different words (List 2). During the presentation of the second set of words, you may notice a flicker of words on the screen. Please try to ignore them and concentrate on the new memory task (List 2). You will have to recall these new words (List 2) after they are presented to you. Finally you will be asked to recall the original set of 15 words (List 1).

There will be a five-minute break. Then you will have another session with two new word sets. List 3 will be presented three times with a recall of the words after each presentation. Then List 4 will be presented followed by recall for List 4. Finally, you will be asked to recall List 3.

After this session, there will be another five-minute break. Then you will be shown a list of 120 words. You will be asked to write a '1' if the word was presented in List 1, '2' if the word was presented in List 2, '3' if the word was presented in List 3, or '4' if the word was presented in List 4. Leave the space blank if you do not think that the word was previously presented.

At the end of the test, you will be asked a number of questions regarding the test and words used in the test.

In summary, your test will proceed in this order:

Presentation of List 1	-	Recall of List 1
Presentation of List 1	-	Recall of List 1
Presentation of List 1	-	Recall of List 1
Presentation of List 2	-	Recall of List 2
Recall of List 1		

Break

Presentation of List 3	-	Recall of List 3
Presentation of List 3	-	Recall of List 3
Presentation of List 3	-	Recall of List 3
Presentation of List 4	-	Recall of List 4
Recall of List 3		

Break

Recognition test of 120 words.

Final Questionnaire

RISKS AND DISCOMFORTS

There are no known side effects.

BENEFITS

There are no benefits offered to you by your participation in this experiment other than the compensation offered by your instructor.

COSTS

There are no costs associated with this experiment.

CONFIDENTIALITY

Information from this study will be given to the sponsor. It may be given to other governmental agencies that are interested in this research. Records that identify you and the consent form signed by you may be looked at and/or copied for research or regulatory purposes by:

- Virginia Commonwealth University

Absolute confidentiality cannot be guaranteed because of the need to give information to these parties. The results of this research study may be presented at meetings or in publications. Your identity will not be disclosed in those presentations.

COMPENSATION FOR INJURY

In the event of physical and/or mental injury resulting from your participation in this research study, Virginia Commonwealth University and MCV Hospitals will not provide compensation.

If you are injured or become ill as a result of participation in this study, contact the investigator immediately.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

Your participation in this study is voluntary. You may decide to not participate in this study. If you do participate, you may freely withdraw from the study at any time. Your decision will not affect your standing or relationship with VCU.

Your participation in this study may be stopped at any time by the investigator or the sponsor without your consent. The reasons might include:

- the investigator thinks it necessary for your health or safety;
- you have not followed study instructions;
- there is an equipment malfunction
- the sponsor has stopped the study; or
- administrative reasons require your withdrawal.

QUESTIONS

In the future, you may have questions about your study participation. If you have any questions, contact:

Paul C. Schutte

Phone: 757-864-2019

Email: s2pcschu@vcu.edu

If you have questions about your rights as a research subject, you may contact:

Office for Research Subjects Protection

Biotech One

800 East Leigh Street, Suite 114

Richmond VA 23219

Phone: (804) 828-0868

Do not sign this consent form unless you have had a chance to ask questions and have received satisfactory answers to all of your questions.

CONSENT

I have read this consent form. I understand the information about this study. All my questions about the study and my participation in it have been answered. I freely consent to participate in this research study.

I understand that I will receive a signed and dated copy of this consent form for my records.

By signing this consent form I have not waived any of the legal rights, which I otherwise would have as a subject in a research study.

Subject Name, printed

Subject Signature

Date

Signature of Person Conducting Consent Discussion

Date

Investigator Signature (if different from above)

Date

Appendix E

Post Test Questionnaire

Subject #:

Please circle the answer that best reflects your experience during this study.

1. The distractions were annoying

1	2	3	4	5
Strongly Agree		Uncertain		Strongly Disagree

2. The distractions made it harder to remember the second set of words

1	2	3	4	5
Strongly Agree		Uncertain		Strongly Disagree

3. I tried to read the distractions

1	2	3	4	5
Strongly Agree		Uncertain		Strongly Disagree

4. I was able to read the distractions

1	2	3	4	5
Strongly Agree		Uncertain		Strongly Disagree

5. I noticed that some of the distractions were previous words.

1	2	3	4	5
Strongly Agree		Uncertain		Strongly Disagree

6. The repetition of previous words in the distractions helped me remember them.

1	2	3	4	5
Strongly Agree		Uncertain		Strongly Disagree

7. On the back, please write down any memorization strategies you used during the experiment.

Thank you for your participation!

Appendix F

Preliminary Power Analysis

One reason for using the RAVLT as a model for the experimental tasks in this experiment is the existence of established norms. These norms provide a predictive basis for estimating power in the experiment. The Meta-norms for ages 20 – 29 are listed in Table F1 and are taken from (Schmidt, 1996). These represent the average number of words recalled out of 15 words. The RAVLT has five learning trials instead of three as in this experiment. Three was chosen for this experiment to reduce the likelihood of a ceiling effect (e.g., a large proportion of subjects remembering all 15 words).

Trial	Mean	Standard Deviation
1	7.0	1.8
2	9.9	2.2
3	11.5	2.1
4	12.4	1.9
5	12.9	1.8
6	11.5	2.3
Delayed Trial	11.3	2.5

Table 7 Meta norms for the age group of 20 to 29 year-olds for the RAVLT

After three learning trials, one would expect 95% of the subjects to fall between 7.3 (11.5 - 4.2) and 15 (11.5 + 4.2) words recalled. After the secondary task, one might expect a reduction of about 1.5 in the mean. In this case, one would expect to see a mean of 10, with a span of 5 to 15. The standard deviation seems to increase after delay or interference and this is probably due to individual differences in memory ability. Hypothesis 1 predicts that the MMP session will not show as much of a decrease between trials 3 and 4 as the other session. For the sake of the analysis, assume that the mean and standard deviation for the control-distraction session is 10 and 2.5, and that the MMP session is 11.5 and 2.1. How many subjects would be needed to achieve sufficient power of .80?

Using the point biserial regression method:

$$r_{pb} = \frac{(11.5 - 10) \times .5}{2.5} = .3$$

$$f^2 = \frac{.09}{.91} \approx .1$$

$$n^* = \frac{7.85}{.1} + 1 + 1 = 78.5 + 2 \approx 81$$

Thus the number of trials (that is, total sessions) required would be 81. Since each subject receives two sessions this requires a minimum number of subjects to be 41. The number of subjects was increased based on the results of a pretest.

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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14. ABSTRACT A memory aid, that used brief (33ms) presentations of previously learned information (target words), was assessed on its ability to reinforce memory for target words while the subject was performing an interference task. The interference task required subjects to learn new words and thus interfered with their memory of the target words. The brief presentation (momentary memory priming) was hypothesized to refresh the subjects' memory of the target words. 143 subjects, in a within subject design, were given a 33ms presentation of the target memory words during the interference task in a treatment condition and a blank 33ms presentation in the control condition. The primary dependent measure, memory loss over the interference trial, was not significantly different between the two conditions. The memory prime did not appear to hinder the subjects' performance on the interference task. This paper describes the experiment and the results along with suggestions for future research.					
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