Studying the Relation of Reading Time Allocation Strategies and Working Memory Using a RSVP Text Presentation

by

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Abstract

Rapid Serial Visual Presentation (RSVP) is a useful method for controlling the timing of text presentations and studying how readers' characteristics, such as working memory (WM) and reading strategies for time allocation, influence text recall. In the current study a modified version of RSVP (Moving Window RSVP, MW-RSVP) was used to induce longer pauses at the ends of clauses and ends of sentences when reading texts with multiple embedded clauses. In two experiments we studied if WM relates to allocation of time at end of clauses or sentences (EOC/S) in a self-paced reading task and in two MW-RSVP reading conditions (Constant MW-RSVP and Paused MW-RSVP) in which pauses were induced or the reading rate was kept constant. In experiment 1, we found an additive effect of WM and reading condition (MW-RSVP vs. self-paced) on text recall, but no effect of WM on the length of EOC/S pauses. In experiment 2, WM and the length of EOC/S pauses were related in that high-WM span readers were more affected by the restriction of time allocation in the MW-RSVP conditions, and that the recall of both WM groups benefited from a Paused MW-RSVP presentation.

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List of Abbreviations

EOC	End of Clause
EOS	End of Sentence
EOC/S	End of Clause and End of Sentence
nonEOC	Not at the End of Clause
nonEOS	Not at the End of Sentence
nonEOC/S	Not at the End of Clause or End of Sentence
WM	Working Memory
RT	Reading Time
RSVP	Rapid Serial Visual Presentation
MW-RSVP	Moving Window – Rapid Serial Visual Presentation

Introduction

Reading and text comprehension involve complex mental operations. From a bottom-up perspective we have word identification, vocabulary access, proposition parsing, etc. On the other hand, from a top-down perspective we have the influence of background knowledge, inference generation, and mental model creation.

Among the models of reading comprehension, Kintsch's (1988) *construction-integration* (CI) model aimed to describe a system of mental operations underlying the processes occurring in text comprehension. The processing model by Kintsch and van Dijk (1978) combines a construction process in which a text base is constructed from the linguistic input as well as from the comprehender's knowledge base, with an integration phase, in which the text base is integrated into a coherent whole. In the CI model, bottom-up processes are generating several plausible meanings of propositions that will later be sifted through to find the correct construction once more contextual information becomes available. Selecting the correct construction is done by way of suppressing constructions that do not fit within the given context while solidifying relevant constructions; this is known as integration. The correct proposition will be apparent, especially, when it is connected to prior knowledge or a schema because both influence the integration process. Thus, the bottom-up construction phase leads to the development of a network of propositions that are then scoured through during the integration phase resulting in a coherent body of propositions for comprehension.

In addition to the bottom-up processes of the CI model, the body of propositions is used to create text bases, which are coherent, structured units. Text bases are the foundation of

operation for the process model because the local and global meaning of a text is represented within the text base. The formation of text bases includes microstructures, which are used to represent the local meaning of a text, and macrostructures, which are used to represent the gist of the text as a whole (Kintsch, 1988). Several factors can influence the construction-integration processes involved in constructing the representations in the text base such as word retrieval, proposition parsing, inference mechanisms, macro-operators for extracting the gist of a passage, and processes used to generate spatial imagery from a verbal description. All these processes can be subject to the readers' background knowledge about the topics presented in the text (Kintsch, 1988). In fact, Kintsch (1994) argues that prior knowledge aids the reader in making inferences when the text is not fully coherent, and also plays an important role in the activation of long-term memory when reading (Ericsson & Kintsch, 1995). Besides background knowledge, other individual differences such as breadth of vocabulary, ability to parse propositions, and working memory capacity can affect reading comprehension (Daneman & Merikle, 1996; Hirotani, Frazier, & Rayner, 2006; Marks, 2009; Potter, Kroll, & Harris, 1980).

Reading and End of Clause Pauses

Another variable that has been related to reading processes and comprehension is the time allocated to words when reading a passage. Reading research has assumed that the longer the time a reader observed a word, the more demanding is its processing. In studies using a self-paced moving window (MW) reading procedure in which the reader displays the text one word at a time, (Marcel A. Just, Carpenter, & Woolley, 1982) the assumption has been a fruitful one. Consistently longer reading times occurred with low-frequency words, with words that

introduced new topics in the text, and especially with words that occurred at the end of sentences or clauses (Daneman & Carpenter, 1983; Marcel A. Just et al., 1982). Furthermore, eye fixation and reading time studies suggested that readers pause at the ends of sentences (Marcel Adam Just & Carpenter, 1980) perhaps in effort to take additional time for integration.   Pausing at the end of a clause or sentence boundary could be indicative of a buffer strategy (Bouma & de Voogd, 1974; Kolers, 1976) in which readers buffer several words into working memory before processing them.   Ends of sentences can be thought of as linguistic cues that mark the end of one thought and the beginning of the next (Daneman & Carpenter, 1983). Those linguistic markers can be also located at the ends of embedded clauses within a sentence and can serve as places in which the reader adjusts information in working memory to appropriately accommodate connections to new information. Hirotani, Frazier, and Rayner (2006) coined the term *wrap-up effects* to describe what is occurring at linguistic markers such as sentences boundaries, which are signaled by periods, and clause boundaries which are generally signaled by a comma. During the wrap-up period, Rayner, Kambe, and Duffy (2000) posit that that information from a clause is being fully integrated and all within-clause problems are being resolved. This wrap-up time, in turn, causes a pause in reading to update the discourse representation. Similarly, Hirotani and others (2006) argue that wrap-up time could possibly be a strategy in reading to provide sufficient time for any problems in the clause to be detected and prevent the need to return to that clause. They called this notion the dwell-time hypothesis. In essence, end of clause (EOC) and end of sentence (EOS) pausing should strengthen the clause content in working memory and therefore facilitate reading performance. It could also be hypothesized that

during wrap-up time at the end of a clause or sentence (EOC/S), long-term memory is being accessed in order to make connections with background knowledge as evidenced by a mediated relationship of both WM and background knowledge with listening comprehension (Was & Woltz, 2007). Lazarte and Barry (2008) found that when reading texts with multiple embedded clauses, those participants exhibiting longer EOC/S pauses had better recall of essential text content.

Working Memory and EOC Pauses

The aforementioned evidence that individuals pause at the EOC/S in order to integrate, encode, and update information begs the question of whether a relation exists between working memory and the allocation of time at the EOC/S. Is there a difference between high-working memory span and low-working memory span individuals in the length of their pausing at EOC/Ss? Working memory serves as a convenient construct that relates short-term mental storage, operations to retrieve and keep accessible long-term memory information (Was & Woltz, 2007), and a central executive that controls the allocation of cognitive resources (Baddeley, 1996) or attention (Engle & Kane, 2004; Mrazek, Franklin, Phillips, Baird, & Schooler, 2013). Daneman and Carpenter's (1980) reading span task (RST) has been widely used to assess the storage and processing functions of working memory during reading, and span scores correlate better with reading comprehension than scores from tasks measuring only storage or only processing components of working memory, even when some authors think the RST is mostly a measure of storage (Waters & Caplan, 1996). Daneman and Merickle's (1996) meta-analysis of 77 studies and 6,179 participants showed that measures tapping the combined

processing and storage capacity of working memory, such as the reading span and listening span

tasks, are better predictors of comprehension than measures that tap only storage capacity. The

analysis also supports the contention that working memory plays an important role in

comprehension as evidence by correlations ranging from .41 to .52 for Daneman and Carpenter's

(1980) reading span task with global and specific tests of comprehension ability.   Also,

Daneman and Carpenter (1983) posit the notion that working memory capacity may play a role

in text processing especially as new information is integrated with prior text.

   The trade-off between processing, storage, and the strategic allocation of time in working

memory as potential source of individual differences in reading comprehension was studied by

Engle, Cantor, and Carullo (1992). They tested four hypotheses about the relation between

individual differences in working memory and the Verbal Scholastic Aptitude Test (VSAT) as a

measure of reading comprehension. The first hypothesis was Daneman and Carpenter's (1980)

task-specific hypothesis which postulates that working memory, assessed by a reading-span task,

is related to reading comprehension because both measure differences in reading efficiency. The

more efficient the readers are the fewer resources required to process the text and the more

resources available to store content. The general-processing hypothesis attributes the

relationship between reading comprehension and working memory to differences in overall

capacity to process more information in a given period of time. The strategic allocation

hypothesis assumes that an effective use of strategies to allocate time and effort as a function of

the task demand accounts for the relation between working memory and reading comprehension.

Last, the general capacity hypothesis states that storage capacity general to a wide variety of verbal tasks accounts for the working memory and reading comprehension relationship. Although Engle et al.(1992) concluded that the general capacity theory is the most plausible explanation for the relation between working memory and reading comprehension, they did not totally discard parts of the strategic allocation hypothesis. According to Engle et al. (1992) the strategic allocation hypothesis implies that: (1) a better performance in the processing component of the span-task will lead to a lower span score, (2) the longer the time at the to-be-remembered end-of-sentence word, the higher the span score, and that (3) high-span readers will trade-off time on the processing component of the task for time on the to-be-remembered word as memory load increases. Engle et al. (1992) did not find any support for the first and third predictions; in fact, high-span readers actually increased their time on the processing component of the span task. However, they actually observed a systematic positive relation between the time on the to-be-remembered word and the span score in their experiment 1 (math-operation and word span-task) and experiment 2 (sentence and word span-task). High-span subjects spent more time on the to-be-remembered word and dwelled more on the to-be-remembered word with increasing loads in the span task. They finally ruled out the strategic allocation hypothesis because the correlation between span and VSAT scores was not affected when the viewing time allocated to every element in the span task was partialed out. Thus, the authors settled for a general capacity hypothesis to account for the span and comprehension relation.

High-WM span participants in Engel et al. (1992) did actually have a strategy to allocate more time to the to-be-remembered word, whereas the low-WM span subjects did not. The

decision to allocate more time to the to-be-remembered-word was a function of the memory load within each set of sentences: as memory load (words to remember) increased, the high-WM span subjects continuously increased the time on the to-be-remembered word. Thus, we can speculate that high-WM span readers in a memory-demanding task (such as free recall of text) will allocate more time than low-WM span readers to rehearse the text to be recalled. We postulate that places for allocating more time are at the EOC/S. Thus, a prediction is that WM span will be positively related to the pauses at EOC/S. On the other hand, it is well reported that in free-recall from self-paced reading tasks, pauses at EOC/Ss when reading complex texts are positively related to the propositional recall of the text. Therefore, we will predict that high-WM span readers will recall more text than low-WM span readers. Also, if WM is related to the strategic allocation of resources –in our case allocation of additional time to reading EOC/S words, any restriction of that allocation will affect the free recall of texts. Thus, high-WM span readers will be more affected than low-WM span readers when times for reading words are controlled.

Reading and RSVP

Working memory relates to reading comprehension, but differences in performance between high and low-WM span readers are also a function of how the text is presented and the purpose of reading (Chen, 1986; Lorch, Lorch, & Klusewitz, 1993). Chen (1986) found that high-WM span readers retained significantly more text meaning than low-WM span readers when the text was presented page by page. However, when using Rapid Serial Visual Presentation (RSVP) as a method for displaying paragraphs, no significant difference was found between high-WM span readers and low-WM span readers in the amount of text meaning

retained. In addition, RSVP reading led to better performance than page reading for low-WM

span subjects whereas no significant difference was present for high-WM span readers between

the page by page and RSVP reading. Thus, reading text through an RSVP procedure positively

impacted low-WM span readers and had a presumable adverse effect on high-WM span readers,

although the reduction was not significant. This interaction effect is attributed to the ability of

high-WM span readers to process text in the conventional page format more efficiently than low-

WM span readers. Accordingly, the author postulates that low-WM span readers place more

demands on working memory capacity in attempt to process conventionally displayed text and

therefore, have less capacity for storing information. The fact that low-WM span readers

significantly increased the amount of text recalled with the RSVP procedure indicates that RSVP

enhances the processing component of WM and allows more storage capacity. Not only was

there an interaction effect of text presentation mode and WM group, but another interaction was

present for text presentation mode and the location of the text in the paragraph.   Participants

retained more of the text from the second half of the paragraph when the text was presented

through RSVP and more from the first half of the paragraph when the text was presented in the

page format, which is in line with previous research (Potter et al., 1980).   In retrospect, Chen's

(1986) findings suggest RSVP as a potentially useful procedure for teaching reading skills to less

skilled readers. In the present studies we improve on the RSVP procedure by making it more

similar to conventional reading by introducing a variable reading rate per word in addition to a

constant reading rate.

Rapid serial visual presentation (RSVP), as referenced above, is a word by word reading

paradigm in which words are displayed on the center of the screen serially one at a time or in

small groups (Forster, 1970). It has been shown that a RSVP presentation can lead to a faster

than normal reading rate of 12 words per second (wps), or 83ms per word, (Juola, Ward, &

McNamara, 1982; Potter et al., 1980) without a significant loss of text understanding. Juola,

Ward, and McNamara (1982) demonstrated that when reading short paragraphs through RSVP

in comparison to a conventional page format, no significant differences in comprehension scores

were present for RSVP speeds slower than twice the normal college student reading rate (86ms

per word). Paragraphs typed in conventional format and paragraphs formatted for RSVP were

given to participants with the same total time available to read each format and results showed

that conventional reading led to better recall than RSVP in the first half of the paragraph yet in

the second half of the paragraph, RSVP led to better recall than conventional exhibiting a

sequential effect (Chen, 1986; Potter et al., 1980). These results demonstrate the possibility that

RSVP helps keep readers more focused and on task for processing and storing paragraph

information than conventional reading as paragraph length increases. However, the RSVP

paradigm may interfere with normal processing whenever a word requires more processing time

than the programmed duration allows. In general, techniques that measure or control word

display times provide an assessment of encoding in real time during reading (Aaronson &

Ferres, 1984). In another comparison of RSVP versus full passage presentation, Masson (1983)

used varying word display times for the words at the ends of sentences and found a significant

improvement in comprehension of passages with RSVP when the RSVP procedure contained an

EOS pause of 500ms or 1000ms. The improvement in comprehension was for gist as well as detailed information. This implies that EOS pauses help manage the accumulation of concepts buffering in working memory.

In comparison with an RSVP presentation, in the word by word self-paced presentation, readers have control over the display time of each word, which allows the reader to move through words at a more natural pace and provides information about individual differences in word reading times. These individual word display times are used to study participant strategies for retaining or comprehending information for a recall task or comprehension task as well as measure speeds of integration. For example, participants exhibiting better recall may also be found to fixate longer at the EOC/S; thus, those participants could be using "dwell" time to integrate and rehearse decoded contents (Hirotani et al., 2006). Any discoverable strategies, such as the pausing strategy just described, can be implemented as a means of improving aspects of memory and comprehension which is a goal of the present study. We aim to shed light on the relation between text recall and the length of pauses at relevant locations in a paragraph.

Self or subject-paced approaches that display a single word in the center of the screen, are closer to a normal reading paradigm, but a self-paced moving window (MW) paradigm, as first developed by McConkie and Rayner (1975), is even more realistic. In MW paradigms, words move progressively across the screen rather than centrally located in a single window. Lazarte and Barry (2008), using such a self-paced MW reading paradigm to present words one at a time to Spanish and English bilinguals, found a positive relation between EOC/S pauses and text recall. Just and Carpenter (1980) also found that in traditional reading, readers make longer

pauses at points where processing loads are greater. Greater loads occur when encountering infrequent words, integrating information from important clauses, and making inferences at the ends of sentences.

Apparently inter-sentence pausing can be beneficial for recall, so a question to ask could be; is there a reading time per word or a pausing time at ends of clauses that becomes "optimal" for increasing recall? According to Potter (1984), in normal reading, people typically gaze at each word for over 200ms (or 5 words per sec) on average. In RSVP, a presentation of 6 words per second (167ms per word) is perceived as similar to a natural reading speed for most people. A presentation rate of 4 words per second (250ms per word) can be too slow for a typical college student.   In the other direction, at a rate of 12 words per second (83ms per word), twice the rate of normal reading, readers are able to read all or almost all words. Finally, readers appear to be unable to see all words or understand sentences presented at rates of 16-28 words per second (63ms to 36ms per word, respectively). Based on Potter's (1984) use of 200ms per word in traditional RSVP we chose 300ms in our moving window RSVP conditions (MW-RSVP). The 100ms increase for word display time is to help take into account the moving window aspect of the paradigm.

Potter, Kroll, and Harris (1980) found that when presenting paragraphs at a rate of 12 words per second (83ms per word), most of the text was understood and remembered. The introduction of longer pauses between sentences of a paragraph aids recall when reading through an RSVP procedure (Potter et al., 1980). Juola, Ward, and McNamara (1982) found that reading

paragraphs through RSVP, comprehension was generally equivalent to that of a normal paragraph reading format.

The usual RSVP procedure displays each word on a fixed central location or window, eliminating the gazing movements of natural reading. In effort to mimic natural reading through the RSVP procedure words should be displayed in a MW across the screen rather than a fixed location. This procedure is used in the present study and is called Moving Window – RSVP (MW-RSVP). The MW-RSVP procedure is used in order to make reading as conventional as possible in an effort to generalize results to non-electronic texts such as textbooks and other literary mediums. To test whether pausing strategies in reading could be induced in the laboratory two forms of MW-RSVP were constructed, Constant MW-RSVP and Paused MW-RSVP. In Constant MW-RSVP each word has the same exposure time (300ms) and in Paused MW-RSVP, words at the EOC/Ss are displayed for twice as long (600ms) as other words in order to assess a pausing strategy and its relation to reading comprehension.

We expect that inducing this pausing strategy will have a positive effect on text recall because EOC/S pausing will allow the reader to strengthen the clause content in working memory, in turn, facilitating reading performance. Given individuals pause at the EOC/S in order to integrate, encode, and update information in WM, individuals with different WM spans should benefit differentially from the pausing strategy induced by the MW-RSVP procedures. The extended EOC/S pauses in the Paused MW-RSVP condition are expected to improve text recall for low-WM span readers but not high-WM span readers because we predict that individuals with high-WM span scores are already using this strategic allocation of pauses at the

EOC/S. Also, if high-WM span readers are allocating additional reading time at the EOC/S words, any restriction of that allocation, such as in the Constant MW-RSVP condition, will negatively impact their text recall. Accordingly, individuals with high-WM span scores are expected to show a decrement in text recall for the Constant MW-RSVP condition and text recall for low-WM span readers is expected to increase in the Paused MW-RSVP.

Experiment 1

Methods

Participants

Sixty-one undergraduate students of varying majors at Auburn University participated in the study for extra credit in introductory level psychology courses or to fulfill a course requirement for research participation. All the participants were native English speakers except for two and those two participants were removed from any further analysis yielding a total of 59 participants. Of the 59 participants 43 were female (72.9%). Participants' ages ranged from 18 to 28 with a couple of participants of age 46 and 54. Almost half of the participants were classified as seniors ($n = 25$), followed by juniors ($n = 15$), freshmen ($n = 12$), and sophomores ($n = 6$). The GPAs of the participants ranged from 2.20 to 4.00 with an average GPA of 3.11 ($SD = .48$). All of the participants reported passing grades (i.e. grade of A, B, or C) for English courses taken except for 9 participants who failed to report an English grade due to not having taken a college English course prior to the time of study participation. Only 1.8% of the participants reported having prior knowledge of all four novels from which the text passages

were originally derived and 39.3% reported having no prior knowledge of any of the four novels (M = 1.2, SD = 1.2). Also, participants displayed 80.7% (SD = 9.4) accuracy on the RST.

Design

There were two phases to this study. Phase 1 consisted of acquiring participants' working memory scores through a reading span task (RST) and participants' word reading times for types of word (EOC, EOS, non-EOC, non-EOS), through a self-paced MW reading task. In addition, text recall was measured for the self-paced MW reading task by asking participants to write down immediately after each reading everything they could remember from the text. In phase 2 participants produced a similar text recall when texts were presented under two conditions: Constant MW-RSVP condition in which all of the words were displayed for a constant amount of time and Paused MW-RSVP condition in which words at the EOC/S were displayed for twice as long as the non-EOC/S words.

Stimuli

Participants' WM capacity was assessed using a variant of the standard reading span task (RST) by Daneman and Carpenter (1980). Instead of reading aloud sentences and determining if the sentences made sense, in the modified RST used in the present study, participants silently read sentences and determined if each sentence was true or false. During the reading process participants were also challenged to retain the last word of each sentence for later recall when the sentence set had been completed. The sets of sentences ranged from 2 to 5 sentences each. Once all the sentences in a set were displayed, the participants typed the last word of each sentence on a recall screen. Participants read 3 sets of each sentence set size (2, 3, 4, and 5) for a

total of 42 sentences. The correctness of the response was recorded for each sentence. Half of

the sentences contained subject-extracted relative clauses such as sentence 1 below whereas the

other half contained object-extracted clauses such as sentence 2 below. Please see Appendix A

for a full list of the sentences used in the adapted RST.

Old vinyl records that are still available through e-bay are collector's items.

The academic semester that most colleges follow is sixteen weeks long.

Because the responses for both types of sentences were not significantly different, the score for

both were combined into a single RST score.

A total of 12 four-sentence narrative passages were used for the two phases of the study.

Adaptations were made from six passages from XIX and XVIII century English novels

(Gulliver's Travels, Robinson Crusoe, Ivanhoe, and Oliver Twist). All the four-sentence

narrative passages describe actions, events, and interactions of the main characters. The original

passages were selected because they contained sentences with several non-essential embedded

clauses. Each passage was adapted by modernizing vocabulary and arranging the structure of the

four sentences to make them as similar as possible across passages. For the purpose of the

present study, syntactic complexity is being defined as the number of embedded clauses, i.e. the

more embedded clauses present in the passage the more complex the passage becomes. From

each passage, two versions with different syntactic complexity levels were obtained by varying

the number of embedded clauses within each sentence. The original adapted passage was

defined as Level-II (L-II) syntactic complexity. The Level I (L-I) versions were obtained by

subtracting non-essential embedded clauses from the L-II passages. The four sentences in L-II readings took the form of K-Y-Z-K or K-Y-Z-K-Y-Z, where K represents the kernel or essential clauses of the sentence, and both Y and Z represent the non-essential clauses in the sentence. For L-II texts the number of words per passage varied from 102 to 132 with an average of 118.5 (SD = 9.47). The following passage is an example of a L-II text:

S1:   Nothing angered and mortified me, not even my diminutive size, nor the continual hassle in the palace, so much as the Queen's dwarf.

S2:   This same creature, being of the lowest stature that was ever in that county, for I verily think that he was not fully thirty feet high, became very insolent, affecting to swagger, and looking up as he passed by me.

S3:   He, when passing by the Queen, which was frequent, seldom failed a smart word or two upon my littleness.

S4:   This malicious little cub, one day at dinner, while I was sitting down at my table, took me up by the middle and dropped me into a bowl of cream, that was a very large one, and full to the rim.

Readings at the L-I of syntactic complexity, or kernel readings, were obtained by dropping all the non-essential embedded clauses from the original text. These readings are called kernel because they contain all the essential information to develop the topic. The 6 L-I or

kernel readings contain between 32 and 54 words per passage, with an average of 44.5 (SD = 6.37). The kernel version of the above passage becomes:

S1: Nothing angered and mortified me so much as the Queen's dwarf.

S2: This same creature became very insolent.

S3: He seldom failed a smart word or two upon my littleness.

S4: This malicious little cub took me up by the middle and dropped me into a bowl of cream.

Materials

The reading span task and the text presentation occurred on an ACER computer screen monitor with screen resolution 1280 x 1024. All reading tasks and RST were displayed through EPrime 2.0 with text font of Times New Roman size 12. For the self-paced MW and both the Constant and Paused MW-RSVP reading tasks, margin lines were placed on the top and bottom boundaries of the screen two inches from display edge as reference points for the text display area which began at the top left portion of the screen and progressed in the form of a conventional paragraph. There were four lines each containing seven words within the text display area and a reference screen was shown prior to reading each passage that resembled the screen presented in Appendix B. In addition, for the self-paced word-by-word reading condition, the participants were required to press a designated key (SPACEBAR) to extinguish the current

word and display the next word. In the MW-RSVP conditions the presentation time of each word was controlled by the experimenter.

In the RST, the full sentences were displayed in the center of the screen and participants were required to press designated keys (0 = False, 1 = True) to indicate whether the sentence was true or false. When the recall prompt appeared on the screen indicating the time to recall the words from the ends of the experimental sentences, participants typed in each word on the screen in the order in which it was presented and typed an X in place of any forgotten word. Participants were able to see the words as they were typing.

Procedure

Phase 1: Phase 1 consisted of obtaining measures of WM span scores, self-paced word reading times (RTs), and text recall for each participant. Upon arrival participants were asked to read and sign the IRB approved informed consent and complete a general background questionnaire (see Appendix C). Afterwards, participants completed the RST followed by the self-paced MW reading task. For the RST, participants completed three practice trials containing sentence sets of 2, 3, and 5 prior to the experimental sentence sets. Participants were asked to judge if the sentence was true or not by pressing the corresponding key (0 = False, 1 = True) to enter their response with the knowledge that they had only 10 seconds to respond. Participants' time to press the key was recorded by the computer, as well as their true-false responses. If there was not a response within ten seconds, the computer displayed the next sentence in the set. Within each set there was no delay in presenting the next sentence once the participants produced a response for the current sentence on the screen. After the last sentence in a set, the

screen displayed a prompt to type-in the last word of each one of the sentences previously

presented on the screen. The RST portion of the study lasted between 15-25 minutes.

For the self-paced MW reading task participants were instructed to read a passage on the

screen using a self-paced word-by-word MW presentation procedure. In this procedure, the

computer displayed one word of the passage at a time, and the participant could only move to the

next word by pressing the spacebar on the keyboard. No backward movements were allowed.

Four practice readings were presented, followed by six experimental readings: three Level-I

passages and three Level-II passages. The reading topic and level of difficulty were selected at

random from the twelve available readings. Immediately after the participants finished an

experimental reading, a prompt was given to write down in a booklet "all the information from

the reading that they can remember".   Reading times for each word were recorded by the

computer. This portion of the study took between 30mins to 45mins, and participants were

asked to return for phase 2 in a second session.

Phase 2: Participants returned to the lab for a second session.   Participants read six new

experimental readings, only of Level-II difficulty, under two MW-RSVP conditions: Constant

MW-RSVP and Paused MW-RSVP. Four short practice readings were presented using both

MW-RSVP conditions before the actual six experimental readings. In the Constant MW-RSVP

condition all the words in the reading were presented at the same rate of 300ms which is about

50ms longer, to account for conventional reading saccades, than the average fixation times in

reading presented in other reading and RSVP literature (Just & Carpenter, 1980; Rayner, 1978;

Rayner & McConkie, 1976). In the Paused MW-RSVP condition, the display time of the words

at the EOC/Ss were twice the display time for non-EOC/S words, similar to Potter, Kroll, and Harris (1980) who used an intersentence pause rate of twice the average word reading time. Thus, in the present experiment the EOC/S words were displayed for 600ms. The sequence of presentation of the six readings was determined at random. As in phase 1, immediately after the presentation of a reading, the participants were prompted to write down in a booklet "all the information from the reading that they can remember."

Analysis and Scoring

The RST task was scored using the partial credit unit scoring suggestions from Conway et al. (2005), where the proportion of correctly recalled last words within each set is averaged across all sets. In other words, each item can have a decimal score between 0 (no element was recalled) to 1 (all elements were recalled). Participants were classified into high- vs. low-WM span groups based on a tertiary-split. For the high-WM span group we had 20 (33.9%) participants and for the low-WM span group we had 19 (32.2%) participants. In addition, the average reading times per word at the EOC/Ss and non-EOC/Ss were obtained from the self-paced MW, word-by-word presentation of the experimental readings. We created templates representing the content of each passage as a list of propositions following the propositional analysis procedure by Bovair and Kieras (1985) to score participants' written recalls, and a percentage of clauses recalled from the texts was computed. The average number of propositions per text was 22 (SD = 1.0) for Level-I versions and 58 (SD = 2.4) for Level-II. Propositions not mentioned in the written recall received a score of 0. If only a fragment of the

proposition was mentioned, the proposition received a score of 1 and if the gist of the propositions was recalled the proposition received 2 points.

Data from phase 1 was analyzed using a 2 x 2 mixed repeated measures design, with high- versus low-WM span groups as the between-subjects factor and text difficulty as the within-subjects factor. As response variable we have the reading times for EOC/S words, the reading times for non-EOC/S words, and the percentage text recall of propositions. In phase 2 the data was analyzed using a 2 x 2 mixed repeated measures design with WM span group as the between-subjects factor and type of MW-RSVP condition as the within-subjects factor. As response variable we have the percentage of text recall of propositions which were scored following the same procedure as in Phase 1. Finally, we used a 2 x 3 mixed repeated measures design to compare the proposition text recall of the high- and low-WM span readers in the three reading conditions: self-paced MW *(*from phase 1), Constant MW-RSVP, and Paused MW-RSVP conditions *(*from phase 2) for readings at level-II of difficulty only.

Results

Reading Span Task – Recall - Pausing

Table 1 summarizes the means and standard deviations of the RST span scores, the percentage of total text recall from the self-paced MW reading task by level of text complexity, and the percentage of text recall from both the Constant MW-RSVP and Paused MW-RSVP reading conditions. Table 2 displays the correlations among the span scores and the text recall variables for the whole sample. Span scores were not significantly correlated with the average percentage of text recall on the self-paced MW reading task ($r = .227$, $p = .084$); however, the

span scores were significantly correlated with average percentage of text recall for both of the Constant MW-RSVP ($r = .303, p = .019$) and Paused MW-RSVP ($r = .261, p = .046$) conditions. Span scores ranged from .25 to 1.00 (M = .756, SD = .146). When categorizing participants into high- and low-WM span groups based on a tertiary split using the RST, participants with a span score of .7139 or less were classified as individuals in the low-WM span group ($N = 19$) and those with spans of .8397 or higher were classified as individuals in the high-WM span group ($N = 20$). Table 3 displays the means and standard deviations for the average percentage of text recall for the self-paced MW, the Constant MW-RSVP and Paused MW-RSVP reading conditions based on membership in either the high- or low-WM span groups.

Recall – Phase 1

Table 4 displays the means and standard deviations for both the high- and low-WM span groups for the percentage of text recall for Level-I texts and Level-II texts. A significant main effect of WM group was found for text recall, $F(1, 37) = 12.230, p = .001, \eta_p^2 = .248$, (see Table 5 for the corresponding ANOVA table). When testing the within subjects effects we found a significant main effect of text complexity, $F(1, 37) = 112.256, p = <.001, \eta_p^2 = .752$. However, the interaction of WM span group and text complexity was significant, $F(1, 37) = 15.100, p = <.001, \eta_p^2 = .290$, due to a significant difference in text recall between WM groups for Level-I texts but not for Level-II texts (see Figure 1). This was an unexpected finding.

Reading Times

In the whole sample, span scores and EOC/S pauses were not significantly correlated ($r = .191, p = .147$) which was inconsistent with our hypothesis that high-WM span individuals

would exhibit significantly longer RTs on words at the EOC/S than low-WM span individuals, see Table 6. In addition, RTs for EOC/S words were not significantly correlated with text recall on the self-paced MW reading task ($r = .193$, $p = .143$), see Table 6. Longer pauses at the EOC/S were not related to better text recall and span scores were not related to better text recall or longer pauses at EOC/Ss.

For each participant we obtained the overall average RT per word, the average RT per EOC/S word, and the average RT per non-EOC/S word. Overall, the average RT per word was 649ms (SD = 242). Table 7 shows the means and standard deviations for the RT variables based on membership in either the high- or low-WM span groups. We did not find a significant main effect of WM span group $F(1, 37) = .858$, $p = .360$), see Figure 2. Participants in either the high- or low-WM span groups were performing similarly in their RTs for EOC/S words and non-EOC/S words. A significant main effect of word type (EOC/S versus non-EOC/S) was significant, $F(1, 37) = 9.530$, $p = .00$; $\eta_p^2 = .205$. Post hoc analyses showed that non-EOC/S words were read more quickly than EOC/S words.   The interaction or WM span group and RTs for EOC/S and non-EOC/S words was not significant $F(1, 37) = .849$, $p = .363$, see Table 8. When incorporating overall RTs into the design we still do not see a significant main effect of WM span group, $F(1, 37) = .821$, $p = .371$, or a significant interaction, $F(2, 74) = .848$, $p = .432$, see Figure 2. On the other hand, we do still have a significant main effect of RTs, $F(2, 74) = 9.507$, $p = <.001$; $\eta_p^2 = .204$, see Table 9. Words at the EOC/S had the longest RTs, followed by the overall RTs, and then non-EOC/S words RTs.

Text Recall – Phase 2

Analysis of the data in the RSVP conditions showed a significant main effect of working memory group on text recall, using Level-II texts only, $F(1, 37) = 6.307$, $p = .017$; $\eta_p^2 = .146$; see Table 10. In both conditions of MW-RSVP, readers with a high-WM span recalled significantly more than readers with low-WM span scores, (see Figure 3). The induction of pauses at the EOC/S did not play a significant role in increasing recall for either the low- or high-WM span participants as shown by an insignificant main effect of condition $F(1, 37) = 1.325$, $p = .257$. The interaction between span scores and text recall for the Paused MW-RSVP condition was not significant, $F(1, 37) = .422$, $p = .520$; thus, pausing at the EOC/S is not significantly related to working memory. For the Constant MW-RSVP condition we expected to find a reduction in text recall for the high-WM span group. Our expectation was not confirmed as evidenced by lack of interaction, the high-WM span group always scored higher than the low-WM span group regardless of condition. In addition, our hypothesis that text recall for the low-WM span group would increase was also not supported due to lack of interaction.

When comparing percentage of recall across all reading conditions (self-paced MW, Paused MW-RSVP, and Constant MW-RSVP) we found a significant main effect of working memory span, $F(1, 37) = 6.030$, $p = .019$; $\eta_p^2 = .140$. High working memory span readers recalled significantly more than low-WM span readers across all reading paradigms. We also found a significant main effect of condition, $F(2, 74) = 4.376$, $p = .016$; $\eta_p^2 = .106$, in that all participants recalled significantly more information in the self-paced MW reading task in comparison to the Constant MW-RSVP reading condition, but text recall for the self-paced MW reading task was not significantly different from the Paused MW-RSVP, see Figure 4. Again,

interaction of WM group and text recall for all reading tasks was not significant, $F(2, 74) = .354$, $p = .703$, see Table 9.

Discussion

The correlational analyses among span scores and text recall on the self-paced MW reading task did not support our premise that reader's WM was related to a pausing strategy in reading texts with multiple embedded clauses. Also, participants pausing longer at EOC/S words did not have a better propositional text recall in the self-paced MW reading task. Therefore, pausing at opportune locations (EOC/S) did not emerge as a beneficial reading strategy for the purpose of recalling text. Readers with high-WM span scores did not dwell longer at the EOC/S than readers with low-WM spans scores yet high-WM span readers recalled more text.

These results contradict the notion that the EOC/S is a location for integration, encoding, rehearsal, or reinstatement of the propositions previously read into memory as was posited by Rayner and others (2000). Similarly, our data seems to deviate from the dwell-time hypothesis (Hirotani et al., 2006) in which wrap-up time could be occurring at the EOC/S in effort to provide sufficient time for any problems in the clause to be detected and prevent the need to return to that clause. The reason behind the divergence in our data set is possibly due to the fact that high-WM span readers recalled more text than low-WM span readers only when reading Level-I texts but both groups performed equally well in recalling Level-II texts. All subsequent text recall analyses were conducted using Level-II texts, which essentially means, that we compared WM groups whose text recall was indistinguishable. The modified version of the RST used in the present study could be responsible for the lack of group distinction because its

difficulty level has not been assessed compared to other commonly used reading span tasks. We address this problem in experiment two.

Although, we did not find evidence of pauses relating to an increase in text recall in the self-paced MW reading task, we wanted to see if inducing a pausing strategy in reading at the EOC/S, as in the Paused MW-RSVP, would prove beneficial. We did not find that pausing at the EOC/S produces better text recall when compared to a constant reading rate. Interestingly, when we compared working memory groups and their performance on both MW-RSVP conditions we found that the high-WM span group recalled more than the low-WM span group. In this case WM does serve as a distinguishing factor in text recall contrary to the self-paced MW reading task. Due to the fact that induced pauses did not aid recall but a WM effect was present, we again support that individual differences in WM are largely a matter of capacity.

Our expectation that high-WM span readers would have an advantage over low-WM span readers with what we called a "pausing" strategy in their reading was not met and leads us to agree with Engle, Cantor, and Carullo (1992) that working memory capacity alone is responsible for high-WM span individuals having better recall than low-WM span individuals. Even though Engle, Cantor, and Carullo (1992) did not entirely rule out all components of the *strategic allocation hypothesis* for individual differences in working memory, our evidence suggest that the notion of EOC/S pauses as an example of strategic allocation of resources is not responsible for high-WM span readers producing better text recall of complex texts, in turn, strategic pausing operates independently of the individual's WM capacity.

Experiment 2

Experiment two was conducted as a replication of experiment 1 with the exception that we introduced another reading span task (RSPAN) in order to compensate for the difficulty level of the RST used in experiment 1.

Methods

Participants

Forty-one undergraduate students of varying majors at Auburn University participated in the study for extra credit in introductory level psychology courses or to fulfill a course requirement for research participation. All the participants were native English speakers except for two and those two participants were removed from any further analysis yielding a total of 39 participants. Of the 39 participants 31 were female (79.5%). Participants' ages ranged from 18 to 23 with one participant who failed to report their age. Eighteen participants reported being classified as freshmen followed by seven sophomores, eight seniors, and five juniors with one participant failing to report their classification. The GPAs of the participants ranged from 2.00 to 4.00 with an average GPA of 3.26 (SD = .52). All of the participants reported passing grades (i.e. grade of A, B, or C) for English courses taken except for seven participants who failed to report an English grade due to not having taken a college English course prior to the time of study participation. Only 2.6% of the participants reported having prior knowledge of all four novels from which the text passages were originally derived and 38.5% reported having no prior knowledge of all four novels (M = .92, SD = 1.0). Also, participants displayed 82.6% (SD = 10.5) accuracy on the RST.

Materials

All of the materials are exactly the same as in experiment 1 with the exception of the automated RST (RSPAN) from Unsworth and others (2005). The addition of the RSPAN task serves to correlate the RST task used in experiment 1 with the RSPAN that has been widely used and published in effort to determine the equivalence of the modified RST used in the current study. The RSPAN task only requires the participant to respond by clicking the mouse. The task is broken down into two sections. First, participants receive practice sessions and second, the participants perform that actual experiment. The practice sessions are further broken down into three sections. The first practice is simple letter span. Participants see letters appear on the screen one at a time, and then must recall these letters in the same order they saw them. In all experimental conditions, letters remain on-screen for 800ms. Recall consists of clicking the box next to the appropriate letters (no verbal response is required). After each recall, the computer provides feedback about the number of letters correctly recalled. Next, participants practice the sentence portion of the experiment. Participants first see a sentence (e.g., "Andy was stopped by the policeman because he crossed the yellow heaven.") Once the participant has read the sentence they click the mouse to advance to the next screen. Participants then see a prompt ("This sentence makes sense") and are required to click on "True" or "False." After each sentence sense-verification participants are given feedback. The reading practice serves to familiarize participants with the sentence portion of the experiment as well as calculate how long it takes a given person to solve the sentence problems. Thus, it attempts to account for individual differences in the time it takes to solve reading problems. After the reading practice, the program calculates the individual's mean time required to solve the problems. This time (plus 2.5 standard

deviations) is then used as a time limit for the reading portion of the experimental session. The

final practice session has participants perform both the letter recall and reading portions together,

just as they will do in the experimental block. Participants first see the sentence and after

verifying that it makes sense or not, they see the letter to be recalled. If participants take more

time to verify the sentence than their average time plus 2.5 SD, then the program automatically

moves on. This serves to prevent participants from rehearsing the letters when they should be

verifying the sense of the sentences. After the participant completes all of the practice sessions,

the program moves them on to the real trials. The real trials consist of 3 sets of each set-size,

with the set-sizes ranging from 3 - 7. This makes for a total of 75 letters and 75 sentence

problems. Subjects are instructed to keep their reading accuracy at or above 85% at all times.

During recall, a percentage in red is presented in the upper right-hand corner. Subjects are

instructed to keep a careful watch on the percentage in order to keep it above 85%.

The program reports five values at the conclusion of the experiment: RSPAN score, total

number correct, and sentence errors. The first, RSPAN score, uses "absolute RSPAN" scoring

method. It is the sum of all perfectly recalled sets. So, for example, if an individual recalled

correctly 2 letters in a set size of 2, 3 letters in a set size of 3, and 3 letters in a set size of 4, their

RSPAN score would be 5 (2 + 3 + 0) or All or Nothing Load scoring according to Conway et al.

(2005) that was used in experiment 1. Total number correct is the total number of letters (out of

75) recalled in the correct position, which is related to the partial credit load scoring of Conway

et al. (2005). Errors are reported as total number of errors, accuracy errors where the subject

verified the sense of the sentence incorrectly, and speed errors in which the subject ran out of time in attempting to verify a given sentence.

Procedure

Experiment 2 was very similar in procedure as experiment 1 and consisted of two phases. Phase 1: Phase 1 consisted of acquiring measures of working memory capacity, self-paced word reading times, and text recall for each participant. Upon arrival participants were asked to read and sign the IRB approved informed consent and complete a brief general background questionnaire (see Appendix B). Afterwards, participants completed either the RST or the RSPAN task followed by the self-paced MW reading task. The two reading span tasks were counterbalanced for each participant between phase 1 and phase 2. All participants took both reading span task procedures but one task was taken in the first session whereas the remaining reading span task procedure was taken in the second session. The RST from experiment 1 was conducted in the same manner as previously mention and participants completed the RSPAN as described above. The self-paced MW reading task was conducted in the same manner as experiment 1. For phase 2, participants returned to the lab for a second session in which they completed the reading span task that was not completed in phase 1 and then proceeded to complete the MW-RSVP reading conditions as in experiment 1.

Analysis and Scoring

As in the first experiment, the RST task was scored using the partial credit unit scoring suggestions from Conway et al. (2005) and the RSPAN used a similar scoring procedure, where the proportion of correctly recalled last words within each set is averaged across all sets. To

classify participants into high- and low-WM span groups based on a tertiary-split we used both

reading span tasks. In the classification process, 85% of the participants were consistently

classified as high- or low-WM group whereas three participants were incorrectly classified

between the two reading span tasks and were subsequently dropped from any further analysis.

Classification in this manner yielded 12 (30.8%) participants in the high-WM span group and 13

(33.3%) in low-WM span group. Propositional scoring was performed using the same analysis

as experiment 1. In addition, the average reading times per EOC/S word and non-EOC/S word

were obtained from the self-paced MW word-by-word presentation of the experimental readings

as in experiment 1. Further data analysis followed the same procedures as in experiment 1 with

the exception of a correlational analysis between the RST and the RSPAN tasks.

<div align="center">**Results**</div>

Reading Span Task – Recall - Pausing

Table 12 summarizes the means and standard deviations among the span scores on the

RSPAN, span scores for the RST, percentage of text recall from the self-paced MW reading task

by level of text complexity, and the percentage of text recall from both the Constant MW-RSVP

and Paused MW-RSVP conditions. Table 13 displays the correlations among both the RSPAN

and RST tasks and the recall variables. We obtained a significant strong correlation between the

RSPAN and the RST ($r = .535, p = <.001$), thereby to assign participants to high- and low-WM

span groups would produce similar classification. As mentioned in the Methods section, we

constructed the WM groups by selecting the upper third and the lower third using both the RST

and RSPAN tasks. Consistent with experiment 1, span scores for the RST were not significantly

<div align="center">31</div>

correlated with the average percentage of text recall in the self-paced MW procedure ($r = .262$, $p = .107$); contrary to experiment 1, the span scores were not significantly correlated with average percentage of text recall for either the Constant MW-RSVP ($r = .115$, $p = .485$) or the Paused MW-RSVP ($r = .088$, $p = .595$) conditions. Span scores for the RST ranged from .00 to 1.00 ($M = .737$, $SD = .203$). In addition, the correlation between WM span scores based on the RSPAN task and the percentage of text recall on the self-paced MW reading task was not significant ($r = .167$, $p = .308$), and neither were those span scores significantly correlated with either the Constant MW-RSVP ($r = .011$, $p = .949$) or Paused MW-RSVP ($r = .009$, $p = .957$) conditions. Span scores for the RSPAN ranged from 26 to 73 ($M = 56.7$, $SD = 9.5$).

When creating groups for distinguishing between high- and low-WM span individuals based on a tertiary split using the RST, participants with a span score of .6856 or less were classified as individuals in the low-WM span group (n = 12), and those with spans scores of .8542 or higher were classified as individuals in the high-WM span group (n = 13). When using the RSPAN to create groups for distinguishing between high- and low-WM span individuals based on a tertiary split, participants with a span score of 54.3 or less were classified as individuals with low-WM span scores, and those with spans scores of 61.7 or higher were classified as individuals with high-WM span scores. A cross tabulation between the two working memory span tasks showed that 85% of the participants were consistently classified into high- and low-WM span groups. Three participants were inconsistently classified into a WM span group; therefore, we decided to only use individuals that were consistently classified by both the RSPAN and the RST for our analyses. Table 14 displays the means and standard

deviations for the average percentage of recall on the self-paced MW reading task, and Constant and Paused MW-RSVP reading tasks based on membership in either the high- or low-WM span groups.

Recall – Phase 1

Table 15 displays the means and standard deviations for both the high- and low-WM span groups for the percentage of text recall for Level-I texts and Level-II texts. When testing the within subjects effects we found a significant main effect of text complexity, $F(1, 23) = 62.210$, $p = <.001$; $\eta_p^2 = .730$, similar to experiment 1. In contrast to experiment 1, a significant main effect of WM group for text recall, $F(1, 23) = 2.274$, $p = .145$, was not found. Also in contrast to experiment 1, the interaction of WM span group and text complexity was not significant $F(1, 23) = 1.687$, $p = .207$, see Table 16. All participants exhibited better text recall with Level-I texts, see Figure 5.

Reading Times

Similar to experiment 1, scores on the RST and RT for EOC/S words did not result in a significant correlation ($r = .290$, $p = .074$) which was inconsistent with our hypothesis that that high-working memory span individuals would exhibit significantly longer RTs on words at the EOC/S than low-WM span individuals, see Table 17. However, RTs for EOC/S words was significantly correlated with text recall on the self-paced MW reading task ($r = .614$, $p = <.001$) which is inconsistent with experiment one, see Table 17. Here, the longer pauses at the EOC/S were related to better text recall but span scores were not related to better text recall or longer pauses at EOC/Ss.

For each participant we obtained the overall average RT per word, the average RT per EOC/S word, and the average RT per non-EOC/S word. Overall, the average RT per word was 1066ms (SD = 883). Table 18 shows the means and standard deviations for the RT variables based on membership in either the high- or low-WM span groups. Contrary to experiment 1, a significant main effect of WM span group was found, $F(1, 23) = 4.816$, $p = .039$, $\eta_p^2 = .173$. Consistent with experiment 1, a significant main effect of RTs based on word types was found, $F(1, 23) = 15.266$, $p = .001$, $\eta_p^2 = .399$, indicating that non-EOC/S words were read more quickly than EOC/S words. The interaction between WM span group and RTs for EOC/S words versus words non-EOC/S words was significant $F(1, 23) = 4.491$, $p = .045$, $\eta_p^2 = .163$, see Table 19. These results indicate that participants in the high-WM span group exhibited longer pauses at the EOC/Ss. When incorporating overall RTs into the design we still see a significant main effect of WM span group, $F(1, 23) = 5.174$, $p = .033$, $\eta_p^2 = .184$, a significant main effect of RTs for word types, $F(2, 46) = 14.674$, $p = <.001$, $\eta_p^2 = .389$, and a significant interaction, $F(2, 46) = 4.316$, $p = .019$; $\eta_p^2 = .158$, see Table 20. Like experiment 1, words at the EOC/S had the longest RTs, followed by the overall RTs, and then non-EOC/S words RTs, see Figure 6.

Text Recall – Phase 2

In Phase 2, just as in experiment 1, we decided to induce pauses by manipulating the RT of each word in two MW-RSVP reading paradigms. The same parameters as experiment 1 were used. In contrast to experiment 1, analysis of the MW-RSVP text recall data did not show a significant main effect of working memory group on text recall $F(1, 23) = .260$, $p = .615$, see Figure 7. However, we did find a significant main effect of MW-RSVP conditions $F(1, 23) =$

4.922, $p = .037$, $\eta_p^2 = .176$.   The induction of pauses at the EOC/S did seem to play a significant role in increasing text recall for the low- and high-WM span participants. The interaction between span scores and text recall for the MW-RSVP conditions was not significant $F(1, 23) = .217$, $p = .646$, see Table 21. For the Constant MW-RSVP condition we expected to find a reduction or elimination of the difference between WM groups, due to a worse performance of the high-WM participants. Our expectation was not confirmed as evidenced by lack of interaction. However, the advantage of the high-WM span group over the low-WM group in the self-paced condition seems to disappear in the MW-RSVP condition.

When comparing percentage of recall across all three reading conditions (self-paced MW, Paused MW-RSVP, and Constant MW-RSVP), there is a significant interaction between WM groups and reading condition, F(2, 46)=6.712, p =.003, $\eta_p^2 = .226$, (see table 22). The effect of WM is conditioned on the task. In the MW-RSVP conditions high and low-WM groups did not differ in their text recall, but the high-WM group outperformed the low-WM group in the self-paced task. On the other hand, the significant main effect of condition on working memory groups $F(2, 46) = 12.588$, $p = <.001$, $\eta_p^2 = .354$) is due to the fact that all participants recalled significantly more information in the self-paced MW reading task in comparison to the Constant MW-RSVP and Paused MW-RSVP reading conditions. Also, participants recalled significantly more in the Paused MW-RSVP condition in comparison to the Constant MW-RSVP reading condition, see Figure 8.

Discussion

Unlike experiment one, the correlation analyses between span scores and text recall on self-paced MW reading task did support our premise that reader's WM was related to a pausing strategy in reading texts with multiple embedded clauses. In addition, participants pausing longer at the EOC/S exhibited better propositional text recall for the self-paced MW reading task. Therefore, in contrast to experiment one, pausing at opportune locations (EOC/S) emerged as a beneficial reading strategy for the purpose of recalling text. Readers with high-WM span scores recalled more text and spent longer time at the EOC/S than readers with low-WM spans scores.

The results in this experiment support the notion that the EOC/S is a location for integration, encoding, rehearsal, or reinstatement of the propositions previously read into memory as was posited by Rayner and others (2000). Similarly, our data no longer deviates from the dwell-time hypothesis (Hirotani et al., 2006) in which wrap-up time could be occurring at the EOC/S in effort to provide sufficient time for any problems in the clause to be detected and prevent the need to return to that clause. In this case, the high- and low-WM groups are more distinct than the groups in experiment one due to a significant difference in the means for text recall of the self-paced MW reading task for both Level-I and Level-II texts.

Given that we found evidence of a pauses relating to an increase in text recall in the self-paced MW reading task, we expected to see an increase in text recall when inducing a pausing strategy in reading at the EOC/S, as in the Paused MW-RSVP. Our expectation was confirmed because all participants increased text recall in the Paused MW-RSVP in comparison to the Constant MW-RSVP. When we compared working memory groups and their performance on

both MW-RSVP conditions we found that the high-WM span group did not significantly differ from the low-WM span group. In the MW-RSVP conditions WM does not serve as a distinguishing factor in text recall as it did in self-paced MW reading task. The fact that induced pauses in the MW-RSVP condition did aid recall but reduced the recall advantage of high-WM readers illustrates the possibility that our Paused MW-RSVP condition was too limiting for the time allocation strategies of the high-WM group.

Provided that a relation between WM and EOC/S pauses exists, our expectation that high-WM span readers would have an advantage over low-WM span readers with what we called a "pausing" strategy in their reading was confirmed. In this manner, capacity alone is not responsible for individual difference in working memory but a strategic allocation of pauses also plays a role. Our evidence suggests that capacity alone cannot account for individual differences in text recall for the MW-RSVP conditions. Even though Engle, Cantor, and Carullo (1992) partially ruled some of the components of the *strategic allocation hypothesis* for individual differences in working memory, our data suggests that the notion of EOC/S pauses as an example of strategic allocation of resources is at least partially responsible for high-WM span readers producing better text recall of complex texts. In essence, strategic pausing is a form of executive control or attention and works in combination or coordination with an individual's WM capacity.

General Discussion

One of the purposes of this study was to shed light on the relation between text recall and the length of pauses at relevant locations in a paragraph. Unfortunately we have inconsistent

results between experiment 1 and experiment 2. In the first experiment, a proper allocation of

longer pauses at ends of clauses did not seem to correlate with better overall text recall or with

larger WM capacity, but a relation was found among those variables in experiment 2.   The

second purpose of this study was to assess the usefulness of MW-RSVP reading of texts as a

means of inducing a pausing strategy in reading that may improve text recall. Results from

experiment 1 where the Paused MW-RSVP condition did not increase text recall compared to a

constant rate, contradict results in experiment 2 where text recall was increased when forced to

read with strategic pauses as in the Paused MW-RSVP condition. Our results from experiment 2

showed that EOC/S pausing can be induced in the laboratory and potentially acts as a useful

strategy for reading as opposed to reading at a constant rate. However, in general, the MW-

RSVP conditions reduced the advantage in text recall for the high-WM span group, maybe

because they interfere with a more complex integration or rehearsal of the text that requires a

longer time allocation.

The conflicting nature of our data between the two experiments warrants conducting a

third experiment in order to elucidate effects. It is possible that the different times of data

collection may be responsible for the data conflictions. In experiment one, data collection began

in late spring and continued through the summer terms whereas data collection for experiment

two was conducted during the first half of the fall semester. Those students who participated

near the end of a semester may have had different levels of motivation compared to those who

participated at the beginning of a semester. Another possibility is that academic classification

played a role in the participants' motivation levels. Mostly seniors and juniors participated in experiment 1 whereas nearly half of the participants in experiment 2 were freshmen.

Not only is a third experiment needed to replicate findings and validate effects, but other future directions should include different pauses lengths at the EOC/S and a Random Paused MW-RSVP condition where pauses are introduced at random places in the texts instead of strategically placed at the EOC/Ss. Furthermore, based on the findings of experiment two, this pausing strategy in reading seems promising and should be implemented into a training program for reading a variety of texts using the Paused MW-RSVP format.

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Appendix A

Full List of Sentences Used Possible in the RST

1. Dinosaurs that a giant meteor killed had a height of over two hundred and fifty feet.

2. Small airplanes that private pilots fly can comfortably carry up to 500 adult passengers.

3. Eggs that chickens lay require a minimum of ten years of incubation.

4. The common cold that doctors cannot prevent or cure is most frequent at sea level.

5. The speed of sound that supersonic planes achieved with ease is lower than the speed of a train.

6. The Atlantic Ocean that Columbus crossed to discover America is made of milk chocolate.

7. The best way to travel to Europe that people in America can afford is by walking over the sea.

8. The sperm whales that Japanese whalers still kill in international waters are as small as anchovies.

9. Pure gold jewelry that people wear will leave a green ring on the person's finger.

10. All the motorcycles that people drive across country must have three wheels.

11. Wireless Internet that people use for laptops costs fifty thousand dollars per subscription.

12. Dairy products that people all over the world consume do not contain any calcium.

13. Guns that people own for personal protection cannot legally be longer than two inches.

14. The job of professional football player that many college players would like to achieve is free of physical injuries.

15. Cat owners who dog owners tend to look down on are mostly lonely and frail old maids.

16. In expensive hotels that travel guides rate with five stars there is no free soap in the bathrooms.

17. Products of high quality that reputable companies produce are cheaper than lower quality products.

18. The distance between New York and Los Angeles that modern airplanes cover easily is less than 100 miles.

19. Urban pollution that cars and factories are mostly responsible for is good for the environment.

20. Bananas that the Caribbean islands produce in quantity are impossible to find in the grocery stores.

21. No planes that designers have produced lately can fly faster than the speed of sound.

22. McDonald's workers that some critics consider losers make more money than corporate lawyers.

23. In the northern hemisphere that geographers define as being north of the Equator January is the warmest period.

24. Churches that Baptists run will not let anyone from another religion set foot in the door.

25. The process of taking pictures that people use today was discovered by American natives.

26. All of the vehicles that people living in New York City operate are large, 6 wheel trucks.

27. The TV sets that most families own today only receive black and white broadcasts.

28. The diet that lions survive on is tightly restricted and only contains plants.

29. Nowadays nearly all the movies that Hollywood produces are in black and white.

30. The elephant that lives in India or Africa is the smallest animal alive.

31. Fancy bars that are located in rich parts of town only serve clients with college degrees.

32. Aspirin that doctors prescribe for headaches are also good as contraceptive.

33. All the wooden tables that can be purchased in furniture stores have three metal legs.

34. The United States during the Second World War that ended in 1945 did not drop the atomic bomb.

35. A potential student that is applying to a state college has to be at least 35 years old.

36. Modern spaceships that are designed by NASA can travel faster than the speed of light.

37. A microwave oven that is a common presence in home kitchens produces more smog than a car.

38. Children in the US that enter first grade for the first time must be at least 6 feet tall.

39. Albert Einstein who is the most famous physicist in the world was also the lead singer of a famous band.

40. The summer vacation for students that attend high school in the United States lasts more than one semester.

41. A driver's license that allows a person to drive a vehicle is obtained in a lottery.

42. Italian restaurants that can be found all over the world most of the time serve Chinese food.

43. Smoking tobacco that growths in the south east of the United States is good for your lungs.

44. Transatlantic ships that transported passengers and cargo never sunk in the ocean.

45. California wine makers that have an international reputation of quality brew a lot of beer.

46. Speaking fluent French that is a romance language with many irregular verbs requires only one week of training.

47. Playing polo that requires owning a horse, helmet, mallets, etc. is a very affordable sport.

48. Mathematicians' salaries that may differ in industry and academia are lower than the salaries of janitors.

49. All the new cars that are manufactured in Japan can only be sold to Japanese people.

50. The little kangaroo rat that lives in Australia is the largest animal in the Southern hemisphere.

51. Cell phones cameras that are sold by American companies are better than standard film cameras.

52. A healthy diet that is combined with exercise is much less effective than just a diet.

53. Bengal tigers that are born in the wild make very good pets for small children.

54. Some animals that are commonly used as pets for children include the anaconda and the jellyfish.

55. Hamsters that live in the wild kill animals up to three times their own size.

56. The majority of people that receive welfare in this country are missing a leg and an eye.

57. Movies that are rated R for extreme violence are suitable for children as young as nine.

58. People that are applying to college never have to take the ACT or the SAT tests.

59. Modern personal computers that students learn to use in school or college are mostly made of plastic and metal.

60. Narcotics that people in Afghanistan made cannot legally be exported anywhere.

61. Surgeons who the government certifies are the only ones qualified to perform major surgery.

62. Ice that cold weather produces can make for very hazardous driving conditions.

63. Cable TV that viewers subscribe to by paying a monthly fee includes only channels of movies.

64. In Spain, the bullfights that animal lovers consider inhumane are very popular.

65. Multiple choice tests that college professors like to administer are quick to score.

66. The old steam locomotives that one can find today in museums burned mainly wood or coal.

67. Love letters that couples in the past used as their only mean of communication are being replaced by e-mails.

68. Food that companies in America make must be safe to export across the seas.

69. Music that people illegally download off the internet violates the laws of copyright.

70. Cars that people drive on the highway must move out of the way of any emergency vehicles.

71. Annual flowers that people have in their gardens grow every year without replanting.

72. Plastic bags that people get at the grocery store pose a suffocation hazard.

73. Modern lighthouses that the coast guard maintains along the eastern board are automatically controlled.

74. Drinking beer during the weekend that parents and professors disapprove is very popular among college students.

75. Latin that a large number of people in the Roman Empire spoke is now a dead tongue.

76. The army of the Soviet Union that the modern Russian Federation inherited is one of the largest on the planet.

77. Raising sheep that historians consider an ancient trade is mainly profitable when selling the wool.

78. The most common female cancer that physicians agree is highly curable is cancer of the breast.

79. Siamese twins that people in the XIX century considered freaks are connected at some part of the body.

80. Colombia and Brazil that some students cannot locate on the world map are two important producers of coffee.

81. The ozone layer that scientists think is in danger protects us from ultraviolet rays.

82. The temperature on the surface of the Sun that astronomers have recently measured is higher than on Saturn's moons.

83. Helicopters that are operated by helicopter pilots have top and rear blades to control flight.

84. The type of alcohol that beer and liquor contain is called Ethyl alcohol.

85. Osteoporosis that many women suffer from is characterized by weak and brittle bones.

86. A long neck that the giraffe has helps them reach leaves high off the ground.

87. Classrooms and cafeterias that college students frequent are usually in separate buildings.

88. In a basketball game that follows standard rules there cannot be more than five players per team.

89. A computer that outsmarts humans in arithmetical computations does not have feelings.

90. The northern part of Canada that is extremely cold reaches up to the North Pole.

91. Most people that have to write extensively use personal computers.

92. George W. Bush who was raised in Texas was elected president in the last election.

93. Home refrigerators that can be bought at Home Depot cannot reach temperatures of 1,000 degrees below zero.

94. A working week that the majority of office employees follow consists of 40 hours of work.

95. The air around us that works as a conductive element allows us to hear sound waves.

96. The oil that is a heavy compound falls to the bottom when mixed with gasoline.

97. The Sahara desert that has very few annual rains is impossible to cross without water.

98. Cell phones that are becoming less expensive each year allow people all over the world to keep in touch.

99. Water that boils at 100 degrees Celsius freezes in Fahrenheit at 32 degrees.

100. The rising cost of living that economists watch continuously affects more people with lower incomes.

101. The ancient sailors who always traveled close to the coastline believed that the Earth was flat.

102. In all modern houses that are built in the US there are electricity, running water and sewage.

103. The large dinosaurs that lived all over the world millions of years ago are now all extinct.

104. Combing their friends' hair that is one gesture of friendship among girls is never seen among boys.

105. The Olympic Games that are celebrated every four years are the biggest international sporting event.

106. Studying under emotional pressure that is a common occurrence in college can be a frustrating experience.

107. The tango that originated in the slums of Buenos Aires at the beginning of the XX century is a dance.

108. Music that is sold in the form of compact discs outsells music sold in the form of records.

109. Most people who attend college are between the ages of eighteen and thirty years.

110. The amount of bottled water that has been sold in this country has skyrocketed in the last decade.

111. People that smoke cigarettes for many years are more likely to develop lung cancer.

112. People that drive over the speed limit are putting themselves and others at risk of an accident.

113. The thunder that occurs during a storm happens because lightning disturbs the atmosphere.

114. Men who play in the NBA for the most part are taller than the average human being.

115. Chicken that has not been thoroughly cooked can be very hazardous to a person's health.

116. Children who spend a lot of time on the Internet are very likely to encounter offensive material.

Appendix B

Reference Screen for Text Display Area

Appendix C

General Background Questionnaire

1.   ☐ Male   ☐ Female

2.   Age:_____

3.   Major: _____

4.   Year: ☐ Freshman   ☐ Sophomore   ☐ Junior   ☐ Senior

5.   GPA: _____

6.   Average grade in English Composition courses (ENGL1100, 1120, 1107, 2000, 2010):_____

7.   Have you ever read, or know the plot of the following novels…
        a.   "Gulliver's Travels"   ☐ Yes   ☐ No
        b.   "Robinson Crusoe"   ☐ Yes   ☐ No
        c.   "Ivanhoe"   ☐ Yes   ☐ No
        d.   "Oliver Twist"   ☐ Yes   ☐ No

8.   Have you ever received any formal foreign languages training in high school or college?
        ☐ Yes
                a) Which language?: _____

                b) How many years of this foreign language study have you completed at the present?
                        ☐ less than 1 year   ☐ 1 to 2 years   ☐ 2 to 3 years   ☐ More than 3 years

                c) Rate your ability in this foreign language?

	Beginner	Intermediate	Advanced	Near-native
Listening	☐	☐	☐	☐
Reading	☐	☐	☐	☐
Speaking	☐	☐	☐	☐
Writing	☐	☐	☐	☐

        ☐ No

9. Have you had any "immersion" experience(s) in a non-English-speaking country (i.e. living there for a moderate or extensive period of time, where you mainly spoke the local language)?
☐ Yes

   a) Which country? _____
   b) For how long in total did you have this immersion experience(s) ?
       ☐ 6 months or less   ☐ 6 to 12 months ☐ 1 to 2 years   ☐ More than 2 years

   c) Did you attend school during your immersion experience?
       ☐ Yes
            At what level? (mark as many as apply)
            ☐ Elementary School   ☐ High School   ☐ College
       ☐ No
☐ No

THANK YOU.

Tables

Table 1 (Experiment 1)

Means and Standard Deviations for the RST, Text Recall for Level-I and Level-II Texts in the

Self-Paced MW Reading Task, and Text Recall for the Constant and Paused MW-RSVP

Conditions (n=59).

Response	M	SD
Reading Span Task	.756	.146
Self-Paced MW Level-I Text Recall	48.5	16.0
Self-Paced MW Level-II Text Recall	27.4	12.0
Constant MW-RSVP Text Recall	21.8	12.0
Paused MW-RSVP Text Recall	23.9	10.4

Table 2 (Experiment 1)

Correlations among the RST, Self-Paced MW (Level-II) Text Recall, Constant MW-RSVP Text Recall, and Paused MW-RSVP Text Recall.

n = 59

	Span Scores	Self-Paced MW Text Recall	Constant MW-RSVP Text Recall
Span Scores			
Self-Paced MW Text Recall	.227		
Constant MW-RSVP Text Recall	.303*	.539**	
Paused MW-RSVP Text Recall	.261*	.487**	.728**

Note: *p <.05   **p <.01   ***p<.001

Table 3 (Experiment 1)

Means and Standard Deviations for the Self-Paced MW Text Recall (Level-II), Constant MW-

RSVP Text Recall, and Paused MW-RSVP Text Recall based on membership in either the high-

and low-WM span groups.

WM Span Group	Self-Paced MW Text Recall		Constant MW-RSVP Text Recall		Paused MW-RSVP Text Recall	
	M	SD	M	SD	M	SD
Low-WM Span Group (*n* = 19)	25.0	12.4	18.1	8.0	20.7	10.6
High-WM Span Group (*n* = 20)	31.0	12.6	27.1	14.8	27.8	9.5

Table 4 (Experiment 1)

Means and Standard Deviations for text recall for Level-I texts and Level-II texts in the self-paced MW condition based on membership in either the high- and low-WM span groups.

WM Span Group	Level-I Text Recall		Level-II Text Recall	
	M	SD	M	SD
Low-WM Span Group ($n = 19$)	38.0	12.1	25.0	12.4
High-WM Span Group ($n = 20$)	59.0	16.2	31.0	12.6

Table 5 (Experiment 1)

ANOVA table for the comparison of WM group and text recall for Level-I and Level-II texts.

		SS	*df*	*MSE*	*F*	*p*	η_p^2	Power
Between								
	High vs. Low WM Group	3524.575	1	3527.575	12.230	.001	.248	.926
	Error	10663.126	37	288.193				
Within								
	Condition	8209.329	1	8209.329	112.256	.000	.752	1.000
	WM*Condition	1104.295	1	1104.295	15.100	.000	.290	.966
	Error	2705.831	37	73.131				

Table 6 (Experiment 1)

Correlations among the WM span scores, Self-Paced MW Text Recall (Level-II Texts Only), and

RTs for words at the EOC/S.

n = 59

	Span Scores	Self-Paced MW Text Recall	RT for EOC/S Words
Span Scores			
Self-Paced MW Text Recall	.227		
RT for EOC/S Words	.191	.193	

Note: *p <.05   **p <.01   ***p<.001

Table 7 (Experiment 1)

Means and Standard Deviations for EOC/S words, non-EOC/S words, and overall word reading times based on membership in either the high- or low-WM span groups.

Reading Span Group	EOC/S Words		Non-EOC/S Words		Overall RT	
	M	SD	M	SD	M	SD
Low-WM Span Group (*n* = 19)	843	448	585	167	627	202
High-WM Span Group (*n* = 20)	1093	1063	614	228	691	306

Table 8 (Experiment 1)

ANOVA table for the comparison of WM group and RTs for EOC/S and non-EOC/S words

	SS	*df*	*MSE*	*F*	*p*	η_p^2	Power
Between							
High vs. Low WM Group	378214.443	1	378214.443	.858	.360	.023	.147
Error	16308408.01	37	440767.784				
Within							
RTs	2643273.114	1	2643273.114	9.530	.004	.205	.852
WM*RTs	235370.279	1	235370.279	.849	.363	.022	.146
Error	1510.299	37	40.819				

Table 9 (Experiment 1)

ANOVA table for the comparison of WM group and RTs for EOC/S, non-EOC/S words, and

overall RTs.

	SS	*df*	*MSE*	*F*	*p*	η_p^2	Power
Between							
High vs. Low WM Group	382166.795	1	382166.795	.821	.371	.022	
Error	17220432.78	37	465417.102				
Within							
RTs	3047425.869	2	1523712.934	9.507	.001	.204	.976
WM*RTs	271826.316	2	135913.158	.848	.432	.022	.190
Error	11859970.73	74	160269.875				

Table 10 (Experiment 1)

ANOVA table for the comparison of WM group and text recall for the Constant and Paused MW-RSVP reading conditions.

	SS	*df*	MSE	*F*	*p*	η_p^2
Between						
High vs. Low WM Group	1280.023	1	1280.023	6.307	.017	.146
Error	7509.271	37	202.953			
Within						
Condition	54.081	1	54.081	1.325	.257	.035
WM*Condition	17.221	1	17.221	.422	.520	.011
Error	1510.299	37	40.819			

Table 11 (Experiment 1)

ANOVA table for the comparison of WM group and text recall for the Self-Paced MW, Constant

MW-RSVP, and Paused MW-RSVP reading conditions.

	SS	*df*	*MSE*	F	p	η_p^2
Between						
High vs. Low WM Group	1590.622	1	1590.622	6.030	.019	.140
Error	9759.941	37	263.782			
Within						
Condition	596.489	2	298.244	4.376	.016	.106
WM*Condition	48.199	2	24.100	.354	.703	.009
Error	5043.537	74	68.156			

Table 12 (Experiment 2)

Means and Standard Deviations for the RST scores, RSPAN scores, Text Recall for Level-I and Level-II Texts in the Self-Paced MW Reading Task, and Text Recall for the Constant and Paused MW-RSVP Conditions. (n = 39)

Response	M	SD
Reading Span Task	.737	.203
RSPAN	56.7	9.5
Self-Paced MW Level-I Text Recall	52.3	19.0
Self-Paced MW Level-II Text Recall	31.8	16.8
Constant MW-RSVP Text Recall	20.4	11.0
Paused MW-RSVP Text Recall	24.6	11.9

Table 13 (Experiment 2)

Correlations among the RSPAN, modified RST, Self-Paced Recall, Constant MW-RSVP Recall, and Paused MW-RSVP Recall. (n=39)

Task	RSPAN Scores	Span Scores	Self-Paced MW Text Recall	Constant MW-RSVP Text Recall
RSPAN Scores				
Span Scores	.535**			
Self-Paced MW Text Recall	.167	.262		
Constant MW-RSVP Text Recall	.011	.115	.715**	
Paused MW-RSVP Text Recall	.009	.088	.752**	.852**

Note: *p <.05   **p <.01   ***p<.001

Table 14 (Experiment 2)

Means and Standard Deviations for the RST, Self-Paced Recall, Constant MW-RSVP Recall, and

Paused MW-RSVP Recall for high- and low-WM span groups.

Task	Self-Paced MW Text Recall		Constant MW-RSVP Text Recall		Paused MW-RSVP Text Recall	
	M	SD	M	SD	M	SD
Low-WM Span Group (*n* = 12)	23.6	13.5	20.2	13.0	23.4	15.9
High-WM Span Group (*n* = 13)	38.0	20.4	23.3	12.4	25.4	9.8

Table 15 (Experiment 2)

Means and Standard Deviations for text recall for Level-I texts and text recall for Level-II texts based on membership in either the high- and low-WM span groups.

WM Span Group	Level-I Text Recall		Level-II Text Recall	
	M	SD	M	SD
Low-WM Span Group ($n = 12$)	48.0	20.4	23.6	13.5
High-WM Span Group ($n = 13$)	55.4	21.2	38.0	20.4

Table 16 (Experiment 2)

ANOVA table for the comparison of WM group and text recall for Level-I and Level-II texts.

		SS	*df*	*MSE*	*F*	*p*	η_p^2	Power
Between								
	High vs. Low WM Group	1475.371	1	1475.371	2.274	.145	.090	.304
	Error	14923.279	23	648.838				
Within								
	Condition	5447.276	1	5447.276	62.210	.001	.730	.999
	WM*Condition	147.757	1	147.757	1.687	.207	.068	.238
	Error	2013.931	23	87.562				

Table 17 (Experiment 2)

Correlations among the WM span scores, Self-P aced MW Text Recall, and RTs for words at the

EOC/S.

n = 39

	Span Scores	Self-Paced MW Text Recall	RT for EOC/S Words
Span Scores			
Self-Paced MW Text Recall	.262		
RT for EOC/S Words	.290	.614**	

: *Note*: *p <.05   **p <.01   ***p<.001

Table 18 (Experiment 2)

Means and Standard Deviations for EOC/S words, non-EOC/S words, and overall word reading times based on membership in either the high- or low-WM span groups.

Reading Span Group	EOC/S Words		Non-EOC/S Words		Overall RT	
	M	SD	M	SD	M	SD
Low-WM Span Group (*n* = 12)	974.1	420.8	542.5	115.7	733.8	263.0
High-WM Span Group (*n* = 13)	2202.5	1916.5	747.6	313.2	1464.8	1025.5

Table 19 (Experiment 2)

ANOVA table for the comparison of WM group and RTs for EOC/S and non-EOC/S words

		SS	*df*	*MSE*	*F*	*p*	η_p^2	Power
Between								
	High vs. Low WM Group	6411531.579	1	6411531.579	4.816	.039	.173	.557
	Error	30619231.14	23	1331270.919				
Within								
	RTs	11104935.99	1	11104935.99	15.266	.001	.399	.962
	WM*RTs	3266899.173	1	3266899.173	4.491	.045	.163	.528
	Error	16730642.19	23	727419.226				

Table 20 (Experiment 2)

ANOVA table for the comparison of WM group and RTs for EOC/S, non-EOC/S words, and

overall RTs.

		SS	*df*	*MSE*	*F*	*p*	η_p^2	Power
Between								
	High vs. Low WM Group	9744933.677	1	9744933.677	5.174	.033	.184	.587
	Error	43317080.05	23	1883351.307				
Within								
	RTs	11109954.74	2	5554977.370	14.674	.001	.389	.998
	WM*RTs	3267740.564	2	1633870.282	4.316	.019	.158	.722
	Error	17414011.69	46	378565.472				

Table 21 (Experiment 2)

ANOVA table for the comparison of WM group and text recall for the Constant and Paused MW-RSVP reading conditions.

		SS	*df*	*MSE*	F	p	$\eta^2_{par.}$	Power
Between								
	High vs. Low WM Group	81.205	1	21.205	.260	.615	.011	.078
	Error	7195.387	23	312.843				
Within								
	Condition	89.325	1	89.325	4.922	.037	.176	.566
	WM*Condition	3.936	1	3.936	.217	.646	.009	.073
	Error	417.389	23	18.147				

Table 22 (Experiment 2)

ANOVA table for the comparison of WM group and text recall for the Self-Paced MW, Constant

MW-RSVP, and Paused MW-RSVP reading conditions.

		SS	*df*	*MSE*	F	p	$\eta^2_{par.}$	Power
Between								
	High vs. Low WM Group	784.073	1	784.073	1.429	.244	.059	.209
	Error	12615.610	23	548.505				
Within								
	Condition	1086.928	2	543.464	12.588	.001	.354	.995
	WM*Condition	579.534	2	289.767	6.712	.003	.226	.898
	Error	1985.962	46	43.173				

Figures

Figure 1
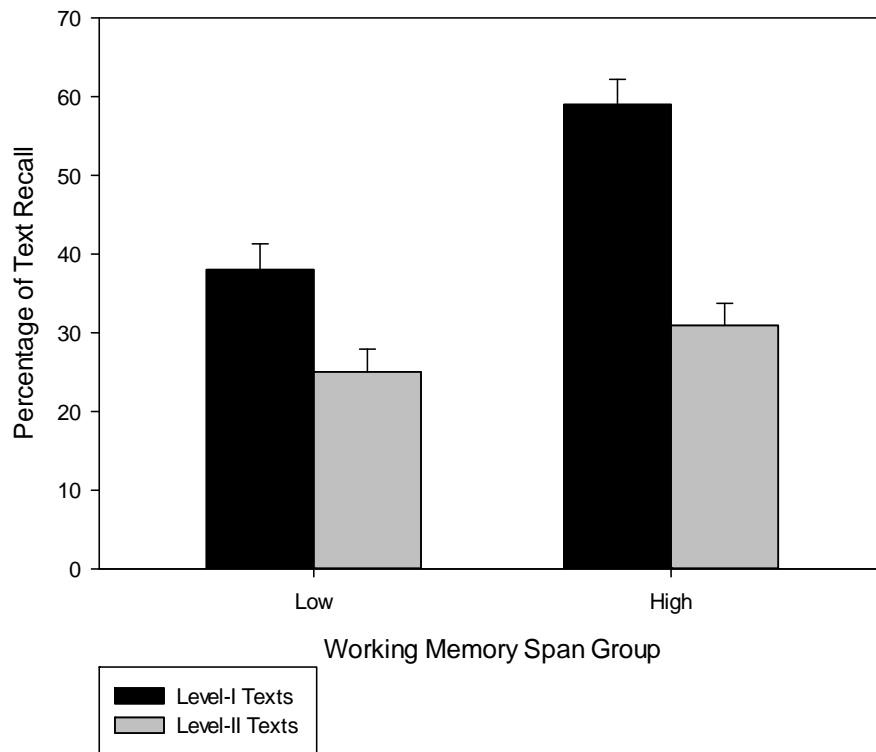
Figure 1. Percentage of text recall for Level-I and Level-II texts for the low- and high-WM span

groups.

Figure 2
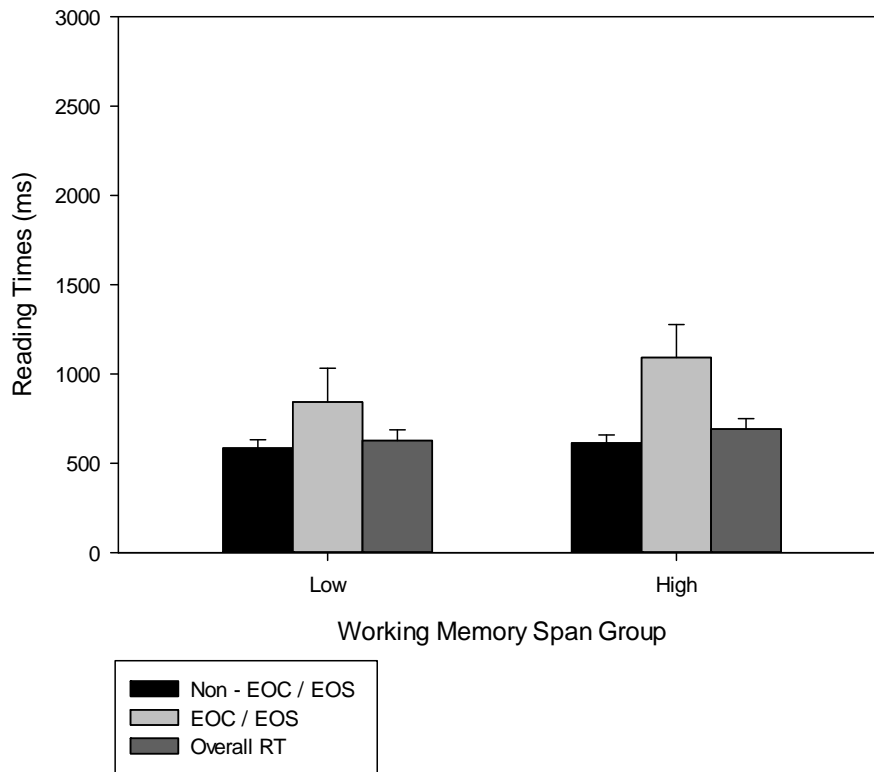
Figure 2. Reading times for the nonEOC/S words, EOC/S words, and overall for both the low- and high-WM span groups.
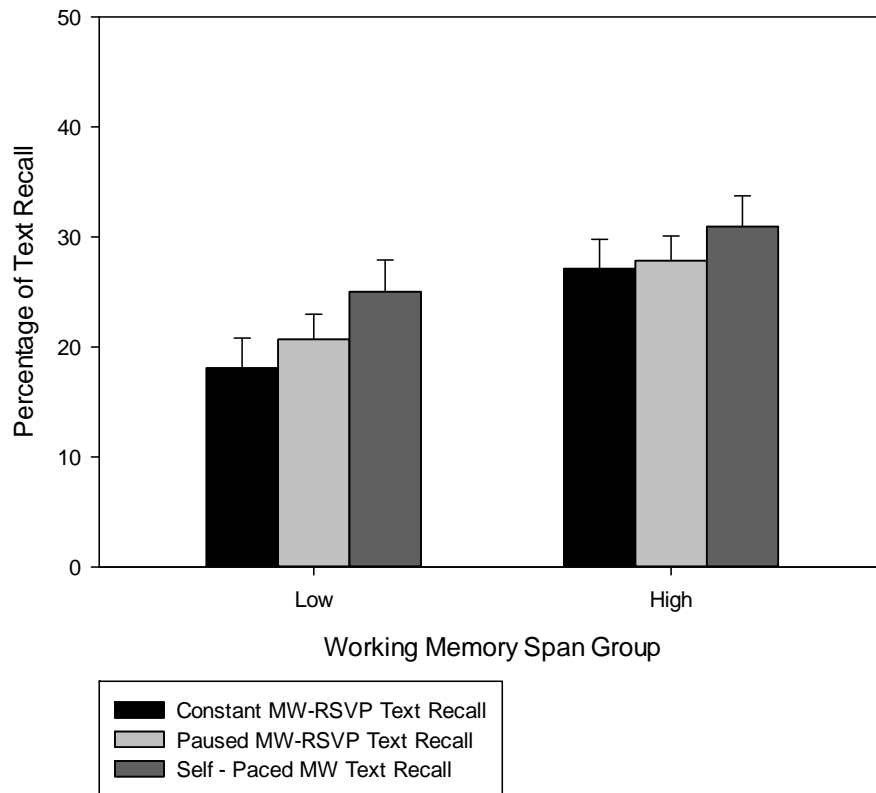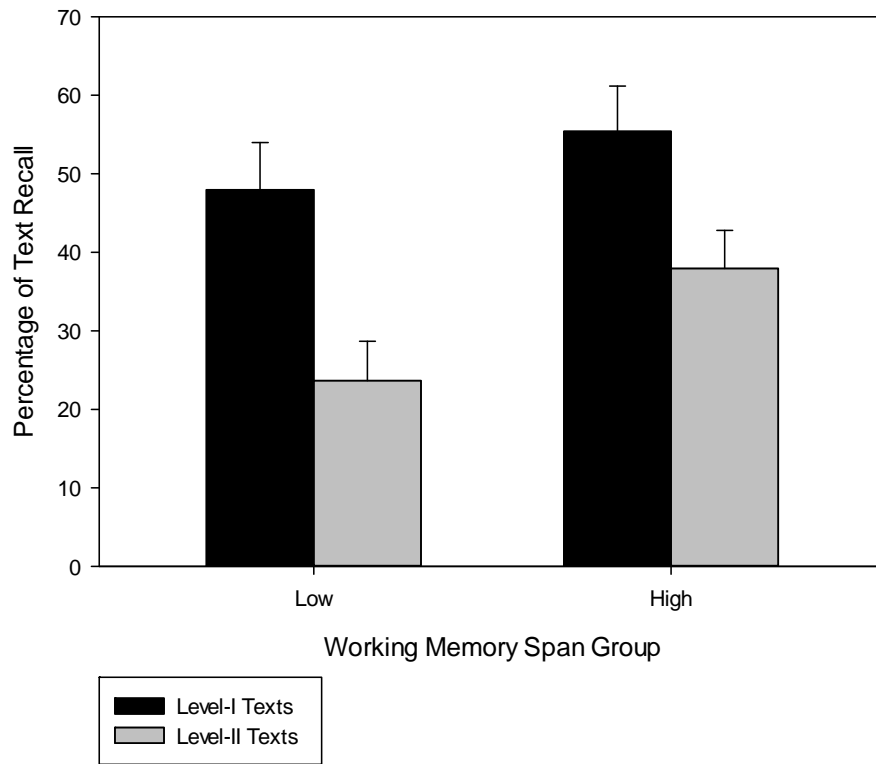
Figure 3
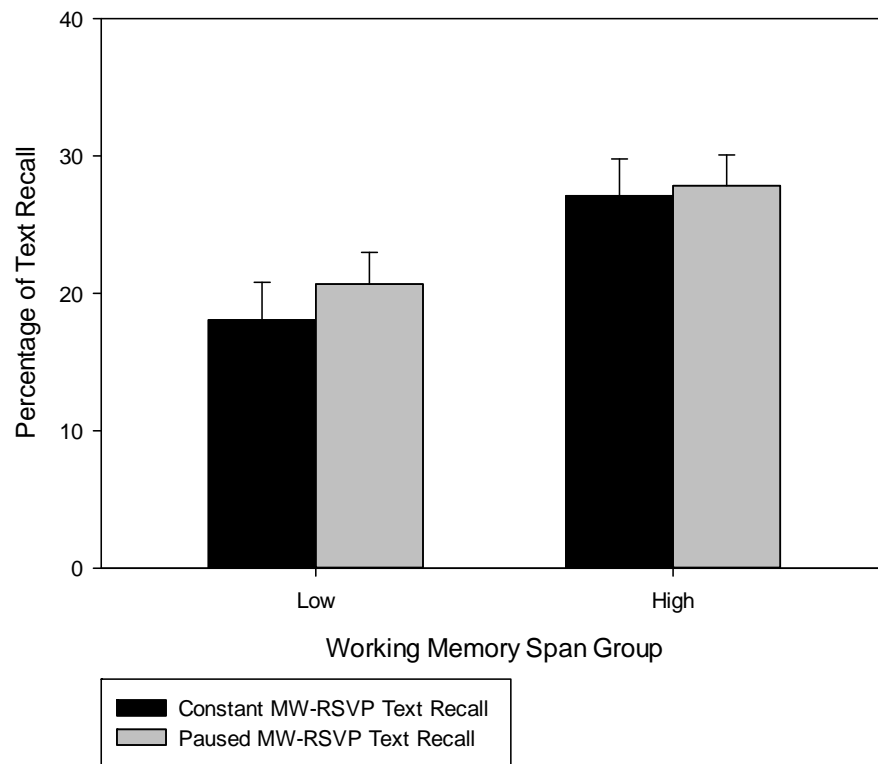
Figure 3. Percentage of text recall on the Constant MW-RSVP and Paused MW-RSVP

conditions for the low- and high-WM span groups.

Figure 4

Figure 4. Percentage of text recall for all reading conditions (Self-Paced, Constant MW-RSVP, Paused MW-RSVP) for the low- and high-WM span groups.
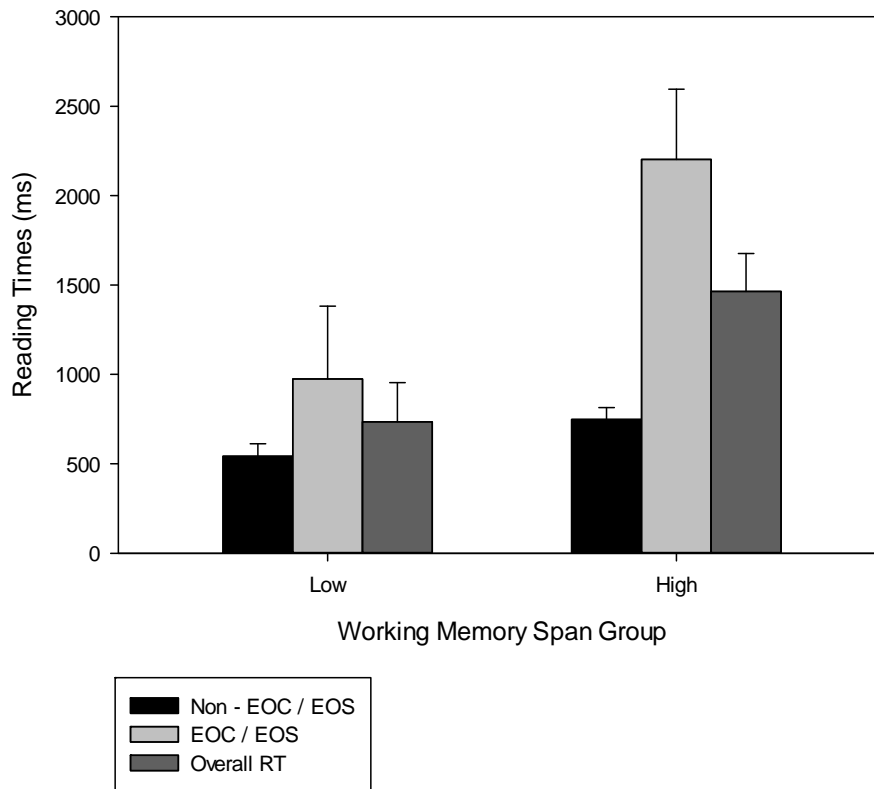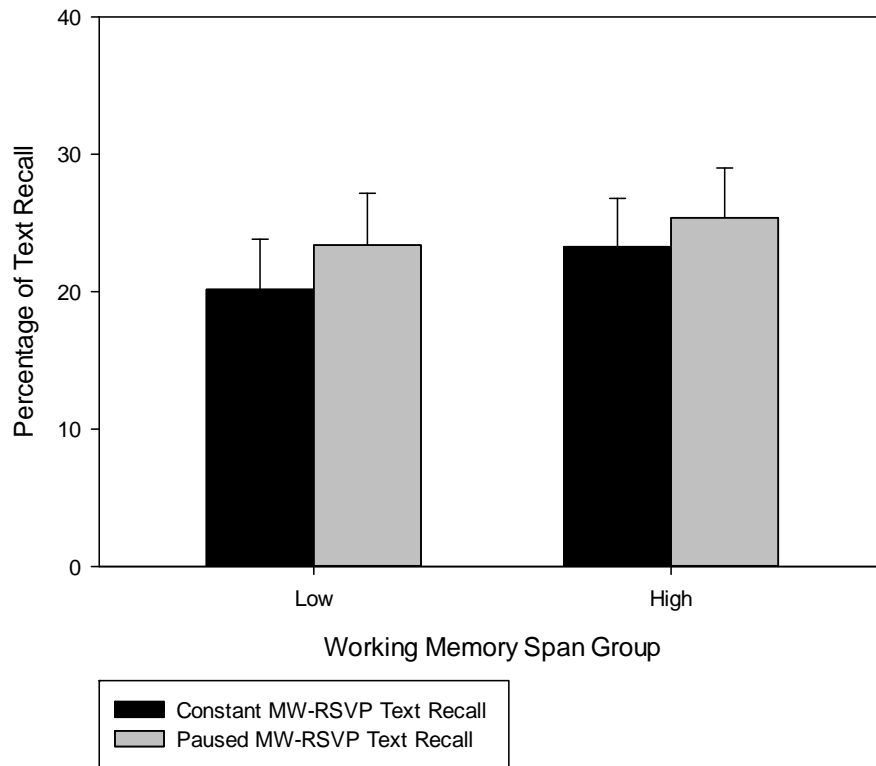
Figure 5

Figure 5. Percentage of text recall for Level-I and Level-II texts for the low- and high-WM span
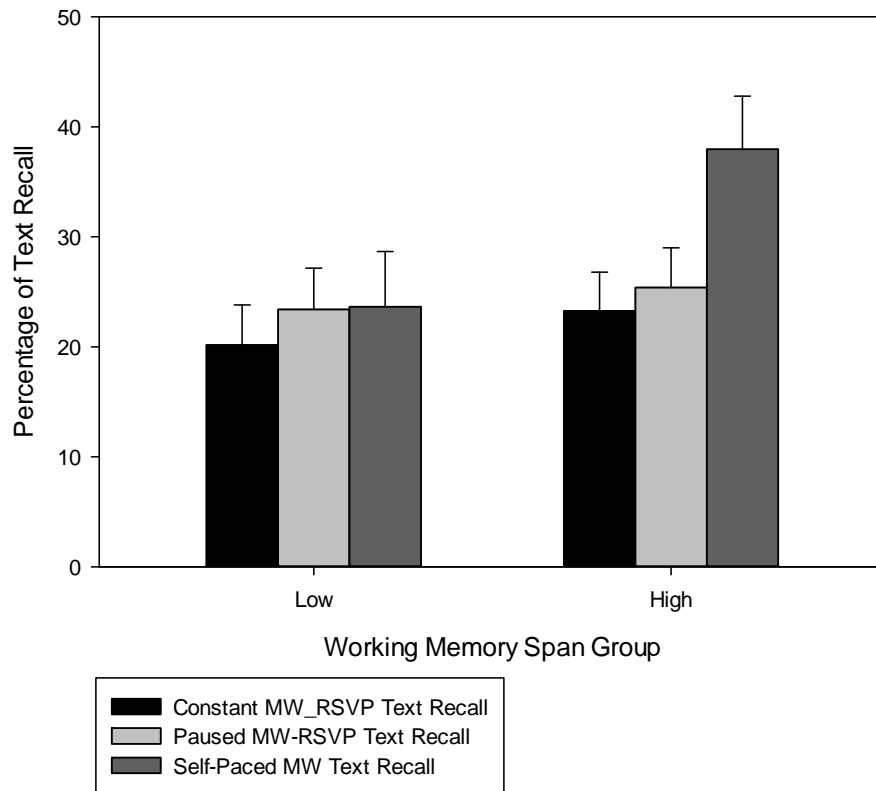
groups.

Figure 6

Figure 6. Reading time for the nonEOC/S words, EOC/S words, and overall for both the low- and high-WM span groups.

Figure 7

Figure 7. Percentage of text recall on the Constant MW-RSVP and Paused MW-RSVP

conditions for the low- and high-WM span groups.

Figure 8

Figure 8. Percentage of text recall for all reading conditions (Self-Paced, Constant MW-RSVP, Paused MW-RSVP) for the low- and high-WM span groups.