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The Role of Individual Differences in Memory Processing
on Recall of Text

Sheila Chapman

A Thesis submitted to the Faculty of Graduate Studies
and Research in partial fulfilment of the requirement
for the degree of Master of Arts

Department of Psychology

Carleton University

May, 1995

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THE ROLE OF INDIVIDUAL DIFFERENCES IN MEMORY PROCESSING
ON RECALL OF TEXT

submitted by
Sheila Chapman, B.A.

in partial fulfillment of the requirements
for the degree of Master of Arts

Acting Thesis Supervisor

Chair, Department of Psychology
Carleton University

May, 1995

Abstract

The role of individual differences in working memory capacity and associative memory ability on text recall was examined in the context of (a) incidental recall of coherent text, and (b) intentional recall of scrambled text. Working memory capacity was measured with a reading span task, and associative memory ability with a paired-associates task. In addition, overall effects of text structure and allocation of attention on text recall were evaluated. Forty undergraduates underlined important information while reading a coherent text, and then were unexpectedly asked to recall the text. Subsequently, the same participants read a scrambled text for later recall, and responded to two on-line probes of working memory. Trends in the results suggested that (a) the effect of associative memory ability may be more evident in the recall of information, particularly details, that is considered important and allocated more attention; and (b) the effect of working memory capacity on text recall may be more evident in the reading of difficult text. Also, the powerful effect of text structure and attention allocation on text recall was replicated.

Acknowledgements

Many grateful thanks to my family for making this project possible, to Jo-Anne LeFevre for enthusiastically getting this project rolling and keeping it on track, to John Logan for so generously guiding it through the final gates, to Karen Hiscock for those elegant graphs, and to everyone in the lab for being such great company along the way.

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The Role of Individual Differences in Memory Processing on Recall of Text

Our knowledge of the world is formed by our memories of what we have experienced. Hence, the more complete our memories for an experience, the richer the knowledge base that is constructed. The quality of this knowledge, in turn, appears to affect learning from new experiences (Kyllonen, Tirre, & Christal, 1991; Rumelhart, 1980; Spiro, 1980; Tirre & Pena, 1992). Thus, individual differences in the ability to construct elaborate memories should be an important source of variability in memory performance. In the present study, the role of individual differences in two memory abilities that are related to memory for text was investigated. Specifically, I examined the roles of individual differences in two variables, (a) working memory capacity and (b) associative memory, on recall of expository texts. Working memory capacity refers to a finite capacity system involving both (a) storage, and (b) concurrent processing of information (Baddeley, 1990; Baddeley & Hitch, 1974; Daneman & Carpenter, 1980, 1983; Dixon, LeFevre, & Twilley, 1988). Associative memory, the second memory ability investigated, is presumed to have two distinct components, (a) processing speed, and (b) declarative knowledge or stored facts (Kyllonen et al., 1991).

Although both working memory capacity (Lee-Sammons &

Whitney, 1991) and associative memory ability (Hutsch, Hertzog, & Dixon, 1984; Kelley, 1964) have been shown to affect text recall, their relative contribution to text recall has not been contrasted within the same experiment. In fact, there is some doubt that working memory capacity and associative memory ability are separate constructs (Tirre & Pena, 1991). Yet theoretical justification for contrasting the effects of these two memory abilities on text recall comes from current information processing models of human cognition in which (a) working memory capacity and (b) component processes of associative memory are viewed as sources of individual differences in a wide variety of cognitive tasks (Kyllonen, 1991).

Individual differences in memory abilities, however, are not the sole source of variability in text recall. Well-documented variables such as (a) text coherence, (b) text structure, and (c) allocation of attention should also be accounted for in a study of memory for text. More specifically, robust findings in the text recall literature indicate that coherent texts are better recalled than scrambled texts (Goetz & Armbruster, 1980; McKeown, Beck, Sinatra, & Loxterman, 1992; Thorndyke, 1977). In addition, high level information in a text, such as a main idea, is recalled better than low level information, such as a detail, a finding also known as the levels effect (Glanzer & Nolan, 1986; Meyer, 1975; Thorndyke, 1977; Van Dijk &

Kintsch, 1983, 1985). Finally, information in a text that is presumably allocated more attention during reading, such as information that is underlined, has a higher probability of being recalled than information that is presumably allocated less attention, such as information that is not underlined (Rickards & August, 1975). Similarly, orienting instructions prior to reading, that direct readers' attention toward task-relevant information, successfully predict better recall of task-relevant information than task-irrelevant information (Einstein, McDaniel, Owen, & Cote, 1990; Lee-Sammons & Whitney, 1991). Another example of the effect of attention allocation on text recall comes from comparisons of intentional and incidental recall conditions. In an intentional recall condition readers expect a recall task after reading a text, whereas in the incidental recall condition readers do not expect a subsequent recall task. The intentional recall condition, during which readers presumably allocate more attention to the text in the form of rehearsal strategies, generally results in better recall of text than the incidental recall condition (Simon, Dixon, Nowak, & Hultsch, 1982).

Given these robust findings in the memory literature, individual differences in working memory capacity and associative memory ability on text recall were examined under two within-subject reading conditions. These conditions were (a) incidental recall of a coherent text, in

which the text was read one paragraph at a time without rereading of paragraphs, followed by (b) intentional recall of scrambled text, in which the text was read one sentence at a time without rereading of sentences.

The incidental recall condition was intended to reduce the effect of conscious rehearsal strategies on recall of the coherent text (Lorch, Lorch, & Klusewitz, 1993). The scrambled text was read in an intentional recall condition for the following two reasons: (a) The scrambled text was read after the coherent text, thus making it difficult to deceive the same readers twice about the purpose of reading and (b) the expectation of a later recall task was intended to motivate readers to persevere with a difficult reading task. The memory demands were assumed to be high under both reading conditions because texts were not presented in their entirety, and previous information could not be reviewed. The dependent measure of recall involved recall of (a) main ideas (high level information), and (b) details (low level information).

Furthermore, in the incidental reading condition, participants were requested to underline information in each paragraph that they considered important for a reproduction of the text. In this way, recall of information that was presumably allocated more attention (i.e., underlined) could be compared with information that had been allocated less attention. A different measure of attention allocation was

used in the intentional recall condition because participants were expected to have difficulty, at least initially, in determining the importance of information in a scrambled text. Therefore, in the intentional reading condition, on-line probes of the participants' current interpretation of the text were an attempt to provide an index of attentional resources expended during the reading task.

In the remainder of this section of the thesis, I will review in more depth (a) the theoretical background for this study, including a four-sources model of individual differences that provides a convenient framework for contrasting the roles of associative memory and working memory capacity on text recall; (b) the constructs of working memory capacity and associative memory, and their measurement; (c) the measurement of attention allocation; (d) the texts used, and their analysis into high and low level information; and finally, (f) I will summarize the specific hypotheses considered in the present investigation.

Theoretical background

Memory ability was at one time considered to be a unitary cognitive faculty. However, empirical evidence of individual variability across memory tests convinced many researchers that memory was a non-unitary composite of specific abilities (Bronner, Healy, Lowe, & Shimburg, 1927; Knopf, Korkel, Schneider, & Weinert, 1988). Consistent with

this multi-component view of memory, Kyllonen (1991) reports that there is currently a broad consensus in the field of cognitive psychology regarding the four basic components of a comprehensive model of human cognition. These four components are (a) working memory capacity, (b) declarative knowledge, (c) procedural knowledge, and (d) processing speed. According to Kyllonen, these four components of information processing are four potential sources of individual differences, and are particularly useful in aptitude testing.

Relating Kyllonen's (1991) four-sources model to the memory abilities that are the focus of the current study, associative memory performance is highly dependent on two of the components in his model, namely, (a) processing speed, and (b) declarative knowledge (Kyllonen et al., 1991). Turning to working memory capacity, Kyllonen (1991) describes working memory capacity as possibly the general factor in cognition. Clearly, Kyllonen's model predicts that (a) working memory capacity, and (b) the subcomponents of associative memory (processing speed and declarative knowledge) will be distinct, and important, sources of individual differences in text recall.

Memory abilities: Constructs and measurement

Working memory capacity. An influential model of working memory proposed by Baddeley and Hitch (1974) characterizes working memory as a limited capacity system

with both storage and processing functions. A central controversy in the research based on this construct of working memory revolves around the question of whether the storage capacity of working memory is limited by processing efficiency, known as the processing efficiency explanation, or is independent of processing efficiency, known as the total capacity explanation (Just & Carpenter, 1992; Dixon et al., 1988; Hasher & Zacks, 1988; Turner & Engle, 1989). If processing efficiency does increase working memory capacity, then individuals with better associative memories (and faster processing speeds) might be expected to have high working memory capacities during reading. Thus, a strong correlation between working memory capacity and associative memory ability is predicted by the processing efficiency explanation of working memory capacity. By contrast, a non-significant relationship between working memory capacity and associative memory ability is predicted by the total capacity explanation of working memory capacity.

Turning now to the role of working memory capacity in reading and text recall, Van Dijk and Kintsch (1983, 1986) proposed an inferential model of reading that is consistent with the Baddeley and Hitch (1974) construct of working memory. In addition, this model of reading relates working memory capacity and text structure effects to text recall. According to the van Dijk and Kintsch model, the reader constructs a coherent mental representation of the text

while reading using a limited capacity system. In their model, the limited storage capacity of working memory requires that at each processing cycle the reader selects the main ideas, or macropropositions, of the text for retention and delete the less important details, or micropropositions, from the short-term buffer. These macropropositions in the short-term buffer form the reader's ongoing mental text representation and render coherent the information currently being processed. The twin tasks of the reader are to achieve both local (sentence-to-sentence) coherence and global (whole text) coherence. At times, the reader must also make bridging inferences in order to maintain the coherence of the text representation. Bridging inferences are usually referred to as text-based inferences (Long, Golding, Graesser, & Clark, 1990; McKoon & Ratcliff, 1992), either referential (e.g., referring an anaphor to its antecedent), or causal (i.e., establishing causal links between sentences).

Thus, the robust finding in the memory literature that main ideas are recalled better than details from a text (Goetz & Armbruster, 1980; Thorndyke, 1977) is attributed in the van Dijk and Kintsch model to the retention and recycling of main ideas in working memory, in contrast to the deletion from working memory of nonessential details. Put simply, the main ideas of a text are cognitively processed more than details and are therefore remembered

better than details.

In sum, according to van Dijk and Kintsch's model, two factors have a significant affect on text recall . First, the limited capacity system of working memory constrains the total amount of information recalled from a text. Secondly, the reader's use of text structure as an organizing principle leads to more processing and higher recall of main ideas than of details. Moreover, research based on van Dijk and Kintsch's model, suggests that individuals with high working memory capacities appear to have more attentional resources available to construct more complete memories for a text than individuals with low working memory capacities (Lee-Sammons & Whitney, 1991).

Individual difference in working memory capacity in reading are frequently measured with variants of the Reading Span Test developed by Daneman & Carpenter (1980, 1983). In this test the reader is required to retain the final words of sentences for later recall while simultaneously processing novel sentences. The Reading Span Test correlates more highly with reading comprehension than tests of simple storage capacity (Just & Carpenter, 1992), and has been widely accepted as an index of functional working memory capacity (Tirre & Pena, 1992).

Associative memory ability. The study of associative memory ability comes out of a tradition of verbal learning experiments, using paired-associates tasks and free recall

of word lists (Slamecka, 1967). These verbal learning tasks were supplanted for text recall research by the reading of natural prose (Meyer, 1975). The reason for this change in experimental design was that such things as the effect of text structure on recall could not be studied with the early verbal learning tasks. Nevertheless individual differences in performance on a paired-associates task, referred to as associative memory ability, does appear to be related to text recall (Hultsch et al., 1984). In addition, current interest in individual differences in memory performance has resuscitated the paired-associates task, in part because it provides a plausible measure of associative learning (Kyllonen et al., 1991).

Associative learning was traditionally characterized as the formation of stimulus-response associations between items (Jensen & Rohwer Jr., 1967). Controversies in associative learning research included (a) the extent to which associations are formed between adjacent items in a list, resulting in list position effects on item recall (Ebenholtz, 1967); and (b) whether associations are formed in an all-or-none fashion, such that an inaccurate response indicates an absence of an association between items, or in an incremental fashion across task trials, such that an inaccurate response indicates the possibility of either an absent or insufficiently strong association (Bower, 1967). With reference to list position effects on item recall, I

attempted to control for this possibility by randomizing the order of presentation of paired associates. Regarding the nature of the formation of associations, it is sufficient for the purposes of this study to interpret an accurate response on a paired-associates task as evidence of a sufficiently strong association between items.

Current associative learning models characterize associative learning as the construction of relations between items in memory and the retrieval of that information from long-term memory (Kyllonen et al., 1991). According to the "relation-construction" principle on which these associative learning models are based, the likelihood of recall of a pair of items in a paired-associates task is dependent on the quantity and quality of the relations constructed between the items during study. Kyllonen et al. (1991) measured associative learning with a paired-associates task. They reported that two memory components were highly predictive of associative learning. These components were (a) breadth of declarative knowledge and (b) processing speed, the former referring to a rich network of stored facts that presumably facilitates the construction of relations between items, and the latter referring to the speed with which facts can be retrieved and relations constructed. Breadth of declarative knowledge was found to predict performance on the paired-associates task across a range of study times. However, processing speed only

predicted learning success when study time was restricted (e.g., less than eight seconds of study time per paired item).

Allocation of Attentional Resources

In order to investigate the relations among (a) working memory capacity, (b) associative memory ability, and (c) limited attentional resources in terms of text recall, the reader's allocation of limited attentional resources was probed in the course of reading. In the coherent text condition, the reader's allocation of attentional resources was probed by asking the reader to underline important information in each succeeding paragraph while reading. The underlined information was presumed to have been allocated more of the reader's limited attentional resources (Rickards & August, 1975). For the scrambled text, the lack of obvious coherence of text would likely have made it difficult for the reader to discern the importance of information. Therefore, allocation of attentional resources during the reading of the scrambled text was inferred from on-line probes of the presumed contents of participants' working memories.

On-line probes of working memory have taken a range of forms, such as questions during reading, priming tasks, and reading latencies in the moving-window task (e.g., Keenan, Golding, Potts, Jennings, & Aman, 1990; Haberland & Graesser, 1990). Also, "thinking out loud" protocols are frequently

recorded throughout the reading process (e.g., Whitney, Ritchie, & Clark, 1991). All on-line probes of the reading process are criticized for being, to some extent, invasive, thereby contributing potential confounds to the assessment of the reading process (Keenan et al., 1990). With this design problem in mind, the working memory contents of participants were probed only twice during reading of the scrambled text. These probes required the readers to write down one-sentence descriptions stating what they thought the text was about at the time of the probe. The first probe occurred early in the reading of the scrambled text, while the second probe occurred when the reader had completed reading of the text. Admittedly, an additional confound in this probe of working memory is the writing ability of the participants. However, in lieu of a simple and less problematic alternative, the probe technique provides a reasonable measure of attention that is easy to implement in the context of paper-and-pencil tasks such as used in the present experiment.

A comparison of the written protocols from the first probe early in reading, to that from the second probe at the end of the reading, was considered to provide an index of the effort expended by the reader in constructing a coherent mental text representation while reading (Whitney et al., 1991). If a comparison of the two probes indicated that readers had not changed their minds about the basic theme of

the text over the course of the reading, it was concluded that these readers had maintained a fairly stable text representation in working memory. By contrast, if a comparison of the two on-line probes indicated that readers had changed their minds about the basic theme of the text while reading, it was concluded that these readers had disrupted their global text representation during the reading, and expended effort and attentional resources to modify their text representation.

In support of a relation between working memory capacity and the stability of text representations while reading, Whitney et al. (1991) reported evidence that readers with high working memory capacities appeared to have an open-ended hypothesis-testing approach to comprehension of a difficult text. In contrast, Whitney et al. concluded that readers with low working memory capacities had a range of comprehension strategies. For example, some low-capacity readers likely committed themselves to a single early interpretation of the text, whereas others interpreted each piece of information very specifically, with little global coherence.

Whitney et al.'s (1991) research suggests that readers with high working memory capacities and some readers with low working memory capacities will likely change their global text representation over the course of reading. However, because the on-line measure used in the present

investigation probes a vague thematic interpretation of the text, the open-ended interpretations of high-capacity readers were not expected to show a change across probes. In contrast, the more specific interpretations of low-capacity readers are likely to show a change across probes.

Texts and Structure Analysis

Two 400-word expository texts were used in this study (see Appendix A). The texts were written to be approximately equivalent in theme and structure, though different in content. One text, the Hoopah, text, concerned the invention of an imaginary vehicle. The second text, the Schools text, concerned the invention of an imaginary school. Both expository texts concern imaginary inventions, thus minimizing the effect of familiarity of text content on text recall (Yekovitch, Ogle, & Thompson, 1990). Participants read one text in coherent form, and the other in scrambled form.

These texts were analyzed into a simple hierarchy of two levels of propositions, level 1 main points and level 2 details, for each sentence. In accordance with current discourse analysis, each proposition contained a predicate and one or more arguments (Meyer, 1975; Thorndyke, 1977; van Dijk and Kintsch, 1985). Level one propositions (main points) typically comprised the main verb phrase of a sentence or clause, and level two propositions (details) typically comprised modifiers of the level one proposition.

For example, the first sentences in the Schools text was analysed in the following way: "The school ...is an architectural innovation" = main idea; "(the school is) incredible" = main idea (value judgement); "Baroland" = detail; "-A" = detail. A more extensive description of the text analysis scheme can be found in Appendix B.

A more ambitious analysis of the text into a tree-like hierarchy across paragraphs was not attempted. Hierarchical analyses of sentences and short paragraphs are reported to significantly predict text recall (Kintsch & Keenan, 1973).
Specific hypotheses

To summarize the current experimental design, the role of individual differences in working memory capacity and associative memories on text recall was investigated under two within-subject conditions. These conditions were (a) incidental recall of coherent text, and (b) intentional recall of scrambled text. These texts were approximately equivalent in structure and theme, though different in content. In addition, the reader's allocation of attentional resources was probed in two ways. In the first reading condition, participants underlined information they considered important while reading the coherent text. In the second reading condition, participants responded to on-line probes of their current interpretation of text while reading the scrambled text.

In terms of hypotheses, the processing speed component

of associative memory ability was expected to be more important in the recall of the scrambled text than in the recall of the coherent text, due to the rapid turnover of relatively arbitrary information in the scrambled text condition (Kyllonen et al., 1991). Thus, associative memory ability was expected to be more highly related to the recall of both main ideas and details from the scrambled text than from the coherent text.

By contrast, working memory capacity was expected to be more important in the recall of the coherent text than in the recall of scrambled text because the coherent text condition relies less on processing speed (as noted) and more on the text-integration processes that characterize the functioning of working memory in reading (van Dijk & Kintsch, 1983, 1985; Tirre, 1992). Therefore, working memory capacity was predicted to be more highly related to the recall of both main ideas and details from the coherent text than from the scrambled text.

A priori, it was unclear whether associative memory ability would be more important for the recall of details from a text than working memory capacity, given the arbitrariness of both factual details (such as names or exact amounts) and the items on a paired-associate task. However, the reading span measure of working memory capacity used in this study has been related to superficial processing of the text, as opposed to high-level processing

at the level of inferences (Dixon, LeFevre, & Twilley, 1988). Presumably, a superficial processing of the text would activate less information from long-term memory as required for inferential processing, thereby making fewer demands on working memory resources. Thus, more working memory resources might be available for the storage and processing of details. This potential confound between the construct of working memory and the operationalization of working memory abilities in the reading span task makes it difficult to predict the relation between working memory capacity (as measured by this test) and the recall of details.

In addition to the experimental manipulation of reading conditions, the impact of finite attentional resources on recall was investigated. Previous evidence suggests that high working memory capacity and fast associative memory ability put less demands on individuals' attentional resources (Kyllonen et al., 1991; Lee-Sammons & Whitney, 1991; Whitney, Ritchie & Clark, 1991). Thus, working memory capacity and associative memory ability are predicted to be related to better recall of information that received less attention during reading of the coherent text (non-underlined information). In addition, high working memory capacities are expected to lead to more attentional resources available for the construction of a coherent mental representation of information contained in the

scrambled text. Thus, individuals with high working memory capacity are expected to respond that they have not changed their basic thematic interpretation of the text while reading the scrambled text.

Method

Participants

Forty undergraduates (16 females, 24 males) taking Psychology 100 volunteered to participate in this study for course credit or ten dollars. All participants were contacted from a list of individuals who also participated in a study by LeFevre (1994).

Texts

Participants read two 400-word expository texts, titled "Hoopah" and "Schools" (see Appendix A). Each text was analyzed into level 1 propositions (main ideas) and level 2 propositions (details). According to this classification, the Hoopah text contained 49 main ideas and 43 details, and the Schools text contained 50 main ideas and 41 details. Using text analysis guidelines (see Appendix B), an independent rater classified 88.6% of the propositions in the Hoopah text and 82.3% of propositions in the Schools text in the same way as the experimenter.

Memory Abilities Tests

Paired-associates task. The paired-associates task contained one set of 20 unrelated word pairs (see Appendix C). The word pairs consisted of a random mix of abstract and

concrete words one to two syllables in length. These abstract and concrete words were high in frequency (category A or AA) according to the Thorndyke and Lorge (1944) inventory. High frequency words were chosen to minimize the effect of individual differences in vocabulary knowledge on performance (Dixon et al., 1988).

The paired-associates task involved ten presentations of the full set of twenty paired associates. Each presentation of the 20 word-pairs was referred to as a presentation trial. During a presentation trial, each pair of words was displayed for two seconds in the centre of a computer screen. The full set of 20 word pairs was presented in a different list order on each presentation trial to control for word-order effects. For example, the paired associates "arm kitchen" were presented first on presentation trial 1, seventh on presentation trial 2, and fourteenth on presentation trial 3. A response period followed each presentation trial. Thus, after the full set of 20 paired associates had been displayed in a particular list order, a response period began. In the response period, only the first word of each pair was displayed on the screen for two seconds. Participants were instructed to say aloud the second word of the pair to a research assistant who recorded the participants' responses. The list order of the full set of paired associates during each response period was identical to the list order of the

immediately preceding presentation trial. The number of correct responses by the participant was summed for each response period. Thus, every participant had a number-correct score for each of ten response periods. The maximum possible score for each response period was 20 (i.e., 20 words accurately recalled when prompted by their paired associates).

Reading span task. The reading span task required participants to perform two simultaneous tasks. The primary task involved word recall. After viewing all the sentences in a series, participants recalled the final words of each sentence to a research assistant. Recalled words were scored as correct only if they were recalled in the order of their appearance. The secondary task required participants to judge aloud whether each sentence in a series made sense. An example of a sentence is "When the sun comes, the cat plays art". Sentences were presented one at a time, for six seconds each, in a series containing two to five sentences. Participants received two series containing two sentences, and three series containing three through five sentences for a total of 11 series. Thus, the maximum word recall score on this task was 40.

Nelson-Denny Reading Test: Reading comprehension and reading rate subtests. The Nelson-Denny Reading Test (N-D test) is a standardized test of reading skills. A short (15-minute) version of the reading comprehension subtest was

given to each participant in this study, as part of the LeFevre (1994) study. Performance on the reading comprehension subtest was used as a general index of participants' reading skill in order to aid interpretation of the memory task results when necessary.

Procedure

Participants signed an informed consent form prior to beginning each of two testing sessions (see Appendix D). The first testing session lasted approximately one hour. The reading span task, the paired-associates task, and the reading comprehension and reading rate subtests of the Nelson-Denny Reading Test were given to the participants of this study as part of a battery of memory tasks in the LeFevre (1994) study. Participants in the LeFevre study were tested individually. The memory task battery, including the reading span and paired associates task, was presented on computer. Instructions were communicated both visually on the computer screen, and verbally by the research assistant.

The second testing session was arranged by phone with participants from the first session. The second testing session lasted approximately 50 minutes. Participants were tested in a quiet room either singly or in groups of up to four participants. The majority of participants were tested in groups of two or three. Participants were randomly assigned to one of two groups in order to counterbalance

text content. Half of the participants read the Schools text in coherent form and the Hoopah text in scrambled form. The remaining half of the participants read the Hoopah text in coherent form and the Schools text in scrambled form (see Appendix A).

Before testing, each participant was given a testing booklet that contained all the materials for the session. (For reading and recall task instructions, see Appendix E). Next, participants filled in a personal information questionnaire. For the first reading condition, incidental reading of a coherent text, participants were told the purpose of the task was to find out what information students thought was important in a text. Participants were briefly instructed to read the text at a normal rate, and to underline information they considered important for a reproduction of the text. Participants were also told that the text would be presented one paragraph at a time, and they should not reread paragraphs after turning a page.

When all participants had finished reading the first text, participants spent three minutes completing (a) questionnaire ratings of the text, (b) the first part of a questionnaire on subjective memory habits, (McMillan, 1984) and (c) several simple math problems. After this brief delay, participants were instructed to write down as much as they could recall of the text as if they were telling someone about it.

After completing the written recall of the first text, participants spent four minutes (a) marking down whether or not they had anticipated a recall component to the reading task, (b) completing the subjective memory questionnaire, and (c) doing additional math problems.

In the next reading condition, intentional recall of scrambled text, participants were instructed to read a scrambled text for later recall. Participants were told that they should attempt to recall the text in what they considered to be the original, non-scrambled, order of the text. Participants were also told that twice during reading of the scrambled text they would come to a page in the text that would contain a request for them to write a one-sentence description of what they currently thought the text was about. Participants were told the text would be presented one sentence per page, and they should not reread sentences after turning a page. The first request for a one-sentence description of the text occurred after seven sentences of the scrambled text. The second request occurred after the last sentence of the text.

After completing the recall of the second text, participants recorded whether they thought the two texts were similar or different, and provided additional personal information. Finally, participants were debriefed (see Appendix F).

Scoring of recall protocols. Recalled propositions

were scored as correct if they accurately reproduced (a) the gist of a level one proposition (main idea), or (b) the exact content of a level two proposition (detail).

Propositions were scored only once in a protocol. Thus, redundant propositions in a protocol did not count towards a proposition recall score. In addition to the accurate recall of propositions, errors and intrusions of novel information were also recorded. Propositions from the coherent text were also marked as (a) underlined during reading, or (b) not underlined during reading.

Interrater reliability on scoring of recall protocols.

To assess the reliability of the scoring of recall protocols, a total of eleven protocols were randomly selected for scoring by an independent rater. Interrater reliability using Cronbach's alpha was .72 for the designation of main ideas, and .96 for the designation of details. The lower reliability of main idea classification was due to the difficulty in evaluating the accuracy of a paraphrase of the original main idea propositions.

Results

In the present investigation I explored the role of working memory and associative memory in text recall using a variety of measures. Performance on these measures is described in two major sections. First, results from the tests of basic memory abilities are presented, followed by results from the text recall tasks. This second section is

divided into two parts, the first dealing with recall of the coherent text, and the second dealing with recall of the scrambled text. Descriptive statistics for the recall measures, reading comprehension and paired-associates task are summarized in Appendix G. Correlations among paired-associate performance, reading span, and coherent-text recall are presented in Appendix H, with the exception of intercorrelations among coherent-text recall measures which are presented in Table 4. Correlations among scrambled-text recall, paired-associate performance, reading span, and reading comprehension are presented in Appendix I.

However, before describing the major results, I will first describe results from several preliminary analyses that were done to ensure that efforts to control for the order of presentation and familiarity of the texts did not produce any confounds. Recall that participants were randomly assigned to one of two groups in which text content differed for coherent and scrambled reading conditions. Inspection of the mean performance for each group on the two memory ability measures and reading comprehension test, indicated no appreciable differences (see Appendix J and K). This observation was confirmed at $p > .05$ with separate MANOVAs, using (a) reading span and reading comprehension as dependent variables, and (b) mean paired-associates performance on ten response periods as dependent variables.

In addition to group ability differences, possible text

content effects on text recall in terms of differences in familiarity and difficulty were investigated. An examination of the mean ratings of familiarity and difficulty of text by text content suggested no appreciable difference across texts (see Appendix L). More specifically, as expected, mean ratings of familiarity and difficulty were extremely low for both texts. A MANOVA was performed on two dependent variables: ratings of difficulty and familiarity. The independent variable was text content (Schools vs. Hoopah). Results confirmed that no significant differences in familiarity or difficulty ratings were present across texts, at $p > .05$.

Memory Abilities Performance

Results for the reading span task and the paired-associates task are summarized below. Performance on the reading span task is considered an index of functional working memory capacity, based on its strong relation to reading comprehension ability. Therefore, the relation between the reading span task and reading comprehension in this sample was investigated. Performance on the paired-associates task is considered a measure of associative memory ability. In the present study performance on this task was examined for evidence of a processing speed effect.

Reading span task. The correlation between reading span and reading comprehension in the current sample and in three other studies in which reading span was used as an index of

functional working memory capacity during reading are presented in Table 1. Results indicate that reading span was not related to reading comprehension in the current sample, nor in the larger sample (LeFevre, 1994) from which this study's participants were drawn. However, in LeFevre (1993) and Dixon et al. (1988), reading span was significantly related to reading comprehension.

Insert Table 1 about here

The nonsignificant finding in the current study was unexpected, given that the validity of the reading span task as a measure of working memory capacity during reading was established by correlations with measures of reading comprehension (e.g., Dixon et al., 1988; Lee-Sammons & Whitney, 1991). Just and Carpenter (1985) reported correlations of .5 and .6 between their reading span task and reading comprehension measures such as the verbal SAT. The correlation between N-D Reading Test performance and verbal SAT performance are reported to be as high as .60 (Nelson-Denny Technical Manual, 1983).

The atypical relation between reading span and reading comprehension in the present study led to a closer examination of the reading skill data. Descriptive data from this study, LeFevre (1993, 1994), and Dixon et al. (1988) are presented in Table 2. Reading comprehension is scored

by the number of correct answers to questions about the text. Reading rate is scored by the approximate number of words read in one minute. Thus, higher scores on these two subtests indicate better comprehension of the text and faster reading rate.

Insert Table 2 about here

The summary data show that compared to the Lefevre (1993) sample, the mean N-D reading comprehension performance of the current sample was lower, the variability smaller, and range more limited. Participants in the current study were also substantially slower readers than those of the Dixon et al. (1988) sample in which a significant correlation was found between reading span and reading comprehension.

In sum, the participants in our sample may be characterized as relatively slow readers and poor comprehenders. In fact, five of the forty participants (12.5%) characterized themselves as reading-disabled. Compared with the mean performance of the sample as a whole, the mean performance of these five participants was lower on the N-D reading comprehension task (14 vs. 15.7), on the N-D reading rate score (202.6 vs. 233), and on the reading span task (22.0 vs. 26.9).

A likely explanation for the lack of relation between

reading span and reading comprehension in the current study is the reduced variability in the reading comprehension scores compared with that of the LeFevre (1993) sample. For both of these samples, the 15-minute Nelson-Denny Reading Test was used. This shortened version of the test is intended for efficient readers, not the relatively slow readers in this sample. This shortened version of the test may therefore have produced a floor-like effect in the reading comprehension and reading rate scores of the current sample, and thereby underestimated the correlation between the N-D performance measures and the reading span task.

Paired-associate task. Summary data by group for performance on the paired-associates task across the ten response periods is presented in Appendix J. In the first response period, mean accuracy is at approximately 19%. By response period 5, mean accuracy is 75%. From response periods 6 to 10, mean accuracy ranges from 80% to 90%.

Figure 1 illustrates the performance of participants on the paired associate task. The greatest change in mean performance for the whole sample occurs between response periods 1 and 5, suggesting that the main demand at this phase of the paired- associate task was to construct relations between the paired items in memory, and secondarily to store and retrieve these items from memory. The high accuracy and gradual improvement in performance in response periods 6- 10 suggests that the main processing

demand of these trials was to retain these constructed relations between items, and then use these relations to facilitate recall.

Insert Figure 1 about here

In sum, performance in the early response periods (periods 1 to 5) of the paired associate task was considered a better measure of the associative ability of these participants than was performance in the last 5 response periods because it is presumably on these early response periods that variability in the speed of relation-construction is demonstrated. Support for this interpretation comes from Kyllonen et al.'s (1991) report that individual differences in processing speed affected associative learning performance at study times of less than eight seconds per word pair. On the fourth presentation trial in the current study, participants had received a cumulative total of eight seconds of study time per pair (i.e., two seconds per pair over four presentation trials). It must be emphasized, however, that without independent measures of processing speed and declarative knowledge the interpretation of early paired-associate performance as representing a processing speed effect is purely speculative.

Coherent-Text Recall

Recall protocols from the coherent text were scored for (a) accurate recall of main ideas and details, (b) errors in the recall of main ideas and details, and (c) intrusions of novel information not found in the text (see Appendix M).

Accurate recall. The mean percentage of main ideas and details recalled accurately, according to whether they were underlined or not underlined, is presented in Table 3. This summary data indicates that the mean recall of underlined main ideas was higher than the recall of underlined details, or non-underlined information. In turn, the recall of underlined details was higher than the recall of non-underlined information. Finally, the recall of non-underlined main ideas was greater than the recall of non-underlined details. The large standard deviations in Table 3 testify to the extent of within-subject variability in the number and level of propositions recalled.

Insert Table 3 about here

To test the effects of text content, attention (underlining), and proposition level on accurate recall of the non-scrambled text, a 2 (Text: Schools, Hoopah) X 2 (Attention: Underlined, Not underlined) X 2 (Level: Main ideas, Details) ANOVA was performed, with repeated measures on the last two factors. Results revealed a significant

main effect of attention, $F(1,38) = 26.84$, $MSe = 72.26$, $p < .001$; and a significant main effect of level, $F(1,38) = 38.21$, $MSe = 14.29$, $p < .001$. There were no other significant findings.

Thus, both the allocation of attention and text structure exerted powerful effects on text recall, despite the high within-sample variability. Information that was presumably allocated more attention during reading (i.e., underlined) was recalled better than information allocated less attention (i.e., not underlined). Also, a levels effect was obtained, whereby main ideas were recalled better than details.

To investigate whether high level information acts as an aid for the retention and recall of low level information, correlations among the recall measures were computed (see Table 4). The results of this analysis revealed significant positive relations between the recall of main ideas and details. More specifically, the recall of underlined main ideas was highly related to the recall of underlined details, as was the recall of non-underlined main ideas to the recall of non-underlined details. Given that, on average, more main ideas were recalled than details (the "levels effect"), it seems likely that at either the encoding or retrieval stages, or both, the processing of main ideas aids the processing of details.

Insert Table 4 about here

In addition, the recall of underlined main ideas was significantly negatively correlated with the recall of non-underlined main ideas. A speculative interpretation of this finding is that once a reader has selected certain main ideas for greater attention and discounted the remaining main ideas, the likelihood that discounted main ideas remain for either further encoding or retrieval is reduced. This competition between competing main ideas is the opposite of the subsumption of details to main ideas that characterizes the levels effect in recall.

In contrast to the relation between recall of underlined and non-underlined main ideas, recall of non-underlined details was not related to recall of underlined information at either proposition level.

Errors and intrusions in recall. Summary data for the frequency of errors and intrusions are presented in Table 5. The data show that a high percentage of participants made no errors in the recall of main ideas from the text, whether the main ideas were underlined or not while reading. By contrast, although a small majority of participants made no errors in the recall of details (underlined or not), about one third of the participants made one or two errors in the recall of details. Thus, it is somewhat easier to

accurately recall main ideas than details from a text. Almost two-thirds of the participants had no intrusions (novel elements) in their recall protocols. Very few participants added more than one novel element to the text in recall. Overall, these data indicate that participants were able to accurately recall information in the coherent texts.

Insert Table 5 about here

Correlational Analyses of Aptitude and Coherent-Text Recall

Accurate recall. The correlations of paired-associates task performance on response periods 1 - 10 with reading span and recall measures for the coherent text are presented in Table 6. The hypothesized relations between aptitude measures of reading span and associative ability on the one hand, and recall performance on the other, were marginally evident in these results. Paired-associate performance on response period 1 and the accurate recall of underlined details were weakly, but significantly related ($r = .31$, $p \leq .05$). There were no other significant correlations among measures.

Insert Table 6 about here

Although a relation between paired-associate ability

and the recall of non-underlined details was predicted, it is consistent with the nature of the paired-associate task, involving attending to arbitrarily paired words, that performance on that task would be related to the recall of attended-to arbitrary details. It is tempting to view this small, though significant, correlation between paired-associate ability and the recall of details from the text as support for the idea that recall of details involves an associative ability separate from working memory capacity, or a levels effect. However, when the lowest performer on the paired-associates task is removed from the sample, the subsequent correlation between paired-associate ability on response period 1 and the recall of underlined details is reduced and is no longer significant.

Cluster Analyses: Coherent-Text Recall, Paired-Associates Ability, and Reading Span

In order to investigate patterns of relationships among memory abilities and recall measures that might not emerge from a linear approach to statistical analysis, a hierarchical cluster analysis was performed on the recall and memory variables. Dependent variables were paired-associate performance (response period 1), reading span, and four recall measures (underlined main ideas, underlined details, non-underlined main ideas, non-underlined details). Performance on response period 1 of the paired associate task was used in this analysis because of (a) the

significant though weak correlation between performance on this trial and recall performance; and (b) previously cited evidence that individual differences in processing speed on associative learning are evident at short study times. Study time per word pair was two seconds on presentation trial 1, within the range reported by Kyllonen et al. (1991) for processing speed effects on associative learning.

Scores on each variable were standardized for comparability. because the Squared Euclidean distance criterion depends on the units of variable measurement. Therefore, when variables are measured on different scales, as in percentages for the recall and paired-associates data but number correct for the reading span data, variables that are measured with larger numbers will contribute more to the computed distance than variables that are recorded in smaller numbers. Using the criterion of average linkage between groups, the agglomeration schedule of squared Euclidean distance suggested a two-cluster solution. Further investigation revealed that the two-cluster solution consisted of one cluster with 39 participants, and the remaining single participant (#35) in the second cluster. A comparison of mean scores on the dependent variables for the two clusters is presented in Table 7.

Insert Table 7 about here

Participant #35 is characterized by very high associative ability (as measured by trial 1 performance on the paired associate task), and very high recall of underlined main ideas and details. Participant #35's reading span score was about average compared to that of the rest of the sample. A tentative interpretation of this finding is that high associative ability is related to the high recall of information allocated special attention during reading. This interpretation runs counter to predictions that associative ability would be related to the recall of information that did not receive special attention.

In order to investigate the possibility that other variables measured in this study might be related to the recall profile of case #35, scores on the following variables were compared: (a) reading comprehension scores, and text ratings of (b) familiarity and difficulty. The reading comprehension score of case #35 was higher than the mean score of the rest of the sample (19 vs. 15.64). However, the ratings of the coherent text by case #35 and the rest of the sample were approximately equivalent (familiarity: 0 vs. 1.1; difficulty: 1 vs. 1.2). Importantly, the low rating of familiarity of the text by case #35 indicated that this reader had no specific content knowledge that can account for the high percentage recall of the text.

Incidental versus Intentional Coherent-Text Recall

Thirteen participants indicated that they had expected a recall task to follow the reading of the first text. Therefore, although these thirteen participants were not able to use elaborate rehearsal strategies (e.g., note-taking), they were not strictly in an incidental recall condition. Comparison of the recall data from these thirteen participants with that from the rest of the sample is presented in Table 8.

Insert Table 8 about here

The data indicate that the intentional recall group recalled less of the underlined main ideas and details than the incidental group, but slightly more of the non-underlined information. The variability within groups is large for all recall measures. Because of the small and unequal group sizes, and the intercorrelation among recall measures, the data were not analyzed further. Overall, these results indicate little difference in the performance of the incidental and intentional recall groups.

Scrambled-text Recall

Accurate recall. Almost as many details (18.9%, SD = 7.8) were recalled as main ideas (19.5%, SD = 10.9) from the scrambled text. In order to determine if the small difference in recall of main ideas and details was

significant, a 2 (Text: Schools, Hoopah) X 2 (Level: Main ideas, details) ANOVA with repeated measures on the last factor revealed no significant main effects of text or proposition level, and no significant interaction between factors, at $p > .05$.

Thus, recall of propositions from the scrambled text did not show the "levels" effect evident in the recall of the non-scrambled text. On average, participants recalled as many details as main ideas. Despite the instructions to participants to try to recall the text in its presumed original coherent form, the readers' recall protocols mirrored the lack of hierarchical text structure in the scrambled text they had read.

Errors and intrusions in recall. The frequency of errors and intrusions in recall of the scrambled text are presented in Table 9. The data show that participants made more errors in recall of details than main ideas. This finding suggests that the lack of hierarchical structure in the text and in the readers' encoded representations of the text made it more difficult to maintain and retrieve accurate lower level information (details).

Insert Table 9 about here

In terms of intrusions of novel elements into the text recalls, the majority of readers had no intrusions in their

recall protocols, and most of the remaining readers had only one intrusion in their protocols. Overall, participants were less accurate at recalling information in the scrambled text than in the coherent text.

Correlational Analyses of Aptitude and Scrambled-Text Recall

The aptitude measures of reading comprehension, reading span, and paired-associate performance in response period 1 were correlated with accurate recall measures from the scrambled text. Reading span and percentage of main ideas recalled from the scrambled text were significantly, though weakly, correlated ($r = .32$, $p < .05$). The expected relation between associative memory ability and recall of the scrambled text was not observed.

This correlation between reading span and recall of main ideas, though weak, suggests that the task of recalling a scrambled text in coherent form put demands on the working memory capacity of the reader. To the extent that the greater the number of main ideas recalled from a text represents a more coherent mental representation of that text, it follows that readers with larger working memory capacities are able to construct a more coherent text representation.

On-Line Probes of Working Memory

Twice in the reading of the scrambled text participants were asked to write down a one-sentence description of what they currently thought the text was about. The first on-

line probe of the reader's text representation occurred after reading seven sentences of the scrambled text. The second on-line probe occurred after the last sentence had been read, and before the reader was asked to write down what they could recall of the text. From these two on-line probes, a measure of the amount of effort expended by the reader in forming a coherent representation of the scrambled was devised.

The on-line written responses of the participants were discriminated on a post-hoc basis into the following three categories: (a) No-change: no change in the first and second descriptions of text; (b) Expanded: no change, but an expanded description of the text from the first to the second probes; and (c) Changed: a change in the description of the text from first to second probes (see Appendix N). A problem with this measure of effort is that some participants may be more verbose than others, leading to an expanded description of the text on the second probe for the verbose readers, and identical responses for less verbose readers. It is possible, therefore, that the categories of (a) No-change, and (b) Expanded, may not reflect differences in text processing, but only differences in verbal style of the readers. An alternative possibility is that an expanded response on the second on-line probe may reflect the "dumping" of recent information that has been reported in recall of scrambled text (Goetz & Armbruster, 1980). In the

latter case, a "dumping" approach to recall suggests a lack of a coherent text representation. With these caveats in mind, the three groups of participants were compared on the recall measures and aptitude measures.

Recall measures by group. Summary data for the three groups of participants on recall measures are presented in Table 10. Because the mean number of intrusions was less than one for all groups, summary data for this variable were not included in Table 12. Due to the unequal and small n's in the groups, further analyses were not conducted on these data.

Insert Table 10 about here

The No-change group is distinguished by the high percentage of details recalled from the scrambled text. This group of four participants recalled on average more details than main ideas from the text. However, they also recalled more main ideas from the text than the other two groups. Thus, this group has generally high recall, with a particularly strong recall of details. This high recall of details resulted in more errors on details by this group than by the other groups, but the number of errors by all groups was small.

To relate this pattern of recall to the responses of this group on the two on-line probes, it appears that these

four readers used a successful strategy for reading text low in coherence. They decided early in the reading task what the story was about, and then were able to assimilate additional information to that stable text representation.

A puzzling finding is that the 26 participants in the Expanded category recalled the lowest number of main ideas and details compared to the recall of the other two groups. Clearly, the expanded response on the second probe by this group did not reflect a highly extensive text representation. In addition, the mean percentage of main ideas and details recalled by this group were very similar, echoing the general trend in the sample for no levels effect in recall.

The 10 participants in the Changed category did show a levels effect in recall, such that they recalled more main ideas than details. The recall of main ideas by this group was close to that of the no-change group. However, the participants in the Changed group recalled substantially fewer details from the scrambled text than did the No-change group.

Relating this pattern of recall to the responses of this group to the two on-line probes, it is possible that the strategy of changing the mental text representation while reading is related to a levels effect in subsequent recall. The recall of main ideas by the Changed group was close to that of the No-change group, but their recall of

details was substantially less than that of the No-change group. Speculating on the reading processes used by the Change group, it seems possible that by changing their idea of what the text was about, they disrupted their mental text representation by replacing the high level (thematic) information with new high level information. This rejection of the former high level information may have led to the loss of its related low level information (details), an interpretation consistent with evidence showing that the recall of higher level information facilitates the recall of lower level information.

Group comparisons on memory and reading test performance. Performance by the three groups on the reading span task, the reading comprehension task, and the paired-associates task (response period 1) was compared. Summary data on these measures are presented in Table 11.

Insert Table 11 about here

When the data in Table 10 and Table 11 are compared, patterns of ability and recall become apparent. The No-change group had the highest mean percentage recall across proposition level. This group also had the highest mean reading span and highest mean performance on the paired-associates task (response period 1). Of particular note, the No-change group had both a superior recall of details

from the scrambled text and good paired-associate ability. Unfortunately, it is not possible to tease apart the effect of this group's reading strategy (i.e., of maintaining a stable mental text representation) on their pattern of text recall from the possible effect of high paired-associate ability on their pattern of recall.

Turning to the performance of the Expanded group on the aptitude measures, this group had the lowest mean score on the reading span task and the reading comprehension task. Their performance on the paired-associates task (response period 1) was substantially lower than that of the No-change group, but somewhat better than that of the Changed group. In sum, the generally low recall of the Expanded group (which comprises over half the sample) may be partially attributed to the relatively low reading comprehension and reading spans of this group.

Turning to the performance of the Changed group on the ability measures, the most salient findings are that (a) this group has somewhat higher reading comprehension scores than the other two groups, and (b) their recall protocols show a levels effect, unlike the recall protocols of the other two groups. Thus, these data suggest a link between better comprehension of text and the construction of a hierarchically organized text representation.

Cluster Analysis: Scrambled-Text Recall, Paired-Associate Ability, Reading Span

A hierarchical cluster analysis was performed on the recall and memory variables in order to investigate trends in the data not detected by a linear approach to statistical analyses. Dependent variables were paired associate performance (response period 1), reading span, and two recall measures (recall of main ideas, and recall of details). Performance in response period 1 of the paired-associates task was used in this analysis for the same reasons noted previously for the cluster analysis described in the section on coherent-text recall.

Scores on each variable were standardized for comparability because, as previously noted, the Squared Euclidean distance criterion is sensitive to units of variable measurement. Using the criterion of average linkage between groups, the agglomeration schedule of squared Euclidean distance suggested a three-cluster solution. Further investigation revealed that cluster 1 contained 34 participants, cluster 2 contained two participants, and cluster 3 contained four participants. Comparisons of the clusters on the dependent variables are presented in Table 12. Small sample sizes made a confirmatory multivariate analysis of variance inadvisable.

Insert Table 12 about here

Interpretation of clusters 2 and 3 are fairly straightforward. Cluster 2 ($n = 2$) appears to be a generally low memory, low recall group. Cluster 3 ($n = 4$) appears to be a high recall group, accompanied by large reading span. The paired associate performance of this group was slightly below average compared to the sample mean on paired associate performance. Cluster 1, with the largest number of cases, shows the recall profile of the overall sample, that is, recall of main ideas and details in the middle range between that of the other two clusters, and almost no levels effect.

A possible relation between the patterns of performance apparent in these clusters and the three groups discriminated by the on-line probe of working memory was investigated. Cluster 2 participants ($n = 2$), the low recall group, were in the Expanded group on the on-line probes. Thus, the "expanded" response of these two participants across on-line probes does appear to have been a "dump" of not well-integrated information, rather than an indication of the construction of an elaborate text representation. The group membership from the on-line probes of the participants in cluster 3 ($n = 4$), the high recall group, was not so straight-forward. Two participants

in cluster 3 were in the No-Change group, one was in the Expanded group, and the remaining participant was in the Change group. Thus, the range of group-membership of the participants in cluster 3 and of cluster 1, render interpretation impossible for these two clusters.

Discussion

Current models of human information processing assert that individual differences in working memory capacity and in the components of associative memory (processing speed and declarative knowledge) cause variability in the performance of a variety of cognitive tasks (Kyllonen, 1991). In the current study, the role of individual differences in working memory capacity and associative memory were examined in the context of memory for text. The construct of working memory capacity used in this research is consistent with the model first proposed by Baddeley and Hitch (1974) and widely used in subsequent research (e.g., Just & Carpenter, 1992; van Dijk & Kinstch, 1985).

Levels and Attention Effects

Turning now to the results of this study, the anticipated overall effect of text structure and attention were evident in the recall data from the coherent text. That is, main ideas were recalled better than details (the levels effect). Also, information considered important (i.e., underlined) and thus presumably allocated more attention was recalled better than information considered

unimportant (i.e., not underlined). Furthermore, as anticipated, the recall of main ideas was related to the recall of details, confirming that main ideas act as a retrieval cue for details in memory (Rickards & August, 1975). In terms of the role of individual difference in specific memory abilities on text recall, the current study provides weak support for the role of working memory capacity and associative memory in text recall.

General Issues

Are working memory capacity and associative memory ability distinguishable constructs? In addition to specific hypotheses about the effects of working memory capacity and associative memory on text recall, two general issues concerning these memory abilities were examined in this study. The first issue concerned whether working memory capacity and associative memory were distinguishable constructs. This issue is relevant to a controversy in the working memory literature concerning whether working memory capacity is increased by processing efficiency (the processing efficiency explanation), or is unaffected by processing efficiency (the total capacity explanation), (Just & Carpenter, 1992). If the processing efficiency explanation is correct, then presumably better associative memory ability (and thus faster processing speed) will be accompanied by higher working memory capacity. However, if the total capacity explanation is correct, no relationship

between associative memory ability and working memory capacity is predicted.

Are working memory capacity and associative memory ability equally important in recall of details? The second issue was related to the first. That is, if these memory abilities are distinguishable, are they both equally important for the recall of details, given that details are less likely to be recalled than main ideas from a text (van Dijk & Kintsch, 1983, 1985)? On the one hand better associative memory ability, as measured by a paired-associates recall task, is predicted to lead to a rich network of relations for items in memory (Kyllone et al., 1991), thus presumably leading to high recall of main ideas and their related details (Glanzer & Nolan, 1986). On the other hand working memory capacity, as measured by a reading span task, has been related to superficial processing of text (Dixon et al., 1988). It is possible that superficial text processing involves less information being activated from long-term memory, and therefore makes fewer demands on the resources in working memory. In turn, this potentially makes available more resources for processing information about details in the text. Therefore, working memory capacity, as measured by a reading span task, may be related to recall of details. Thus, performance on both the paired-associates task and the reading span task may reflect the ability of the reader to assimilate details found in the

text.

Tentative conclusions. Results of the current study make a small contribution toward resolving these two general issues. First, working memory ability and associative memory ability appear to be distinguishable constructs. Correlational analyses of working memory capacity and associative memory ability revealed no relation between the two memory abilities. Thus, this finding provides some support for the total capacity explanation of working memory capacity, whereby the total capacity of working memory is not influenced by the efficiency of specific processes (Turner & Engle, 1989).

Secondly, it is not clear whether both memory abilities are important for the recall of details. Correlational analysis revealed that associative memory ability was weakly related to recall of important (underlined) details from the coherent text, but not to recall of unimportant details from that text, or to details from the scrambled text. However, working memory capacity was not related to recall of details from either the coherent or scrambled text. This finding of no relation between working memory capacity and recall of details was qualified to a small extent by the results of a cluster analysis using as dependent variables the recall data from the scrambled text, associative memory ability, and working memory capacity tasks. This cluster analysis grouped four participants into a cluster (cluster #3)

characterized by high working memory capacity, modest associative memory ability, and relatively high recall of main ideas and details. Nevertheless, the performance of these four participants in the sample was not apparent in the general correlational finding of no relation between working memory capacity and recall of details. Further research, with a larger sample, may reveal whether or not the recall and ability profile of this cluster is representative of a subgroup of readers with high working memory capacities and good memories for details from a difficult text. In short, the current study does not provide a straightforward answer to the question of the role of specific memory abilities in recall of details, although there was a trend in the data for associative memory ability to be related to the recall of important details.

Specific Hypotheses and Results

Turning now to specific hypotheses concerning the role of working memory capacity and associative memory on text recall, four basic hypotheses were tested in the current study. The first hypothesis was that associative memory ability would be related to recall of both coherent and scrambled texts, though more highly related to recall of the scrambled text than of the coherent text. The second hypothesis was that working memory capacity would be related to recall of both coherent and scrambled texts, though more highly related to recall of coherent text than the scrambled

text. The third hypothesis was that both associative memory ability and working memory ability would be related to recall of information from the coherent text that was considered unimportant and presumably allocated less attention (i.e., not underlined). The fourth and final hypothesis was that high working memory capacity would lead to a more stable text representation, and therefore no change in the thematic interpretation of the scrambled text across on-line probes of working memory.

The results did not support the first hypothesis. Contrary to expectation, associative memory ability was not related to recall of the scrambled text. However, associative memory ability was weakly related to recall of underlined details from the coherent text. The fast processing speed of better associative memory was expected to provide an advantage for recall of the scrambled text because of the fast information flow in the scrambled text condition. This was not the case. Rather, associative memory ability was related to recall of information from a coherent text, read in a fairly normal paragraph by paragraph manner. Interestingly, only important details, not unimportant ones, were related to associative memory ability. One explanation for this finding may be that the task of recalling underlined details is similar to the task of recalling paired associates-- that is, both details and paired associates are fairly arbitrary types of information

that nonetheless are mentally tagged as important.

The results did not support the second hypothesis. Contrary to expectation, working memory capacity was not related to recall of the coherent text. However, working memory capacity was weakly related to recall of main ideas from the scrambled text. The orienting instructions (incidental vs. intentional) for each reading condition, and the amount of text on each page (paragraph vs. sentence) may provide an explanation for these results.

On the one hand, most participants were not expecting to have to recall the coherent text, and were told to concentrate on underlining important information in each succeeding paragraph. Thus, the lack of apparent need to concurrently store and process information beyond a small portion of the text may have reduced the load on working memory for participants and thereby also reduced the effect of individual differences in working memory capacity on text recall.

On the other hand, participants did encounter a demanding task of storage and concurrent processing while reading the scrambled text. Participants knew they would need to recall the text later in what they thought was the correct order, and would be asked what they thought the text was about during the reading period. Thus, the orienting instructions biased participants toward the processing of higher-level information, such as main ideas, that

participants would consider clues necessary to reconstruct the original order of the text. This significant, though weak, relation between working memory capacity and recall of main ideas supports the van Dijk and Kintsch (1983, 1985) model of working memory in which high level information, such as main ideas, is processed more and thus recalled better than low level information, such as details.

The results also did not support the third hypothesis. Working memory capacity and associative memory ability were not related to recall of information that was presumably allocated less attention while reading (i.e., not underlined). As noted previously, information allocated attention was better recalled than information allocated less attention. Thus, as anticipated, the allocation of attention is a powerful determinant of text recall, as is text structure.

Finally, results from the current study supported the fourth hypothesis. A comparison of on-line probes of working memory suggested that high working memory capacity may enable a more stable text representation at the thematic level. A grouping of participants according to their responses to the on-line probes revealed two participants who did not change their thematic interpretation of the scrambled text while reading, and who also had high working memory capacity and high text recall. Interestingly, this small pair of participants did not also have high reading

comprehension ability relative to the other groups of participants, corroborating the overall finding of no relation between reading span and reading comprehension. Given the small number of participants, these results are merely suggestive of a trend toward high working memory capacity and a stable text representation while reading a difficult text.

Suggestions for Future Research

It should be noted that this study was exploratory in many ways. Small sample sizes and the relatively low reading skill of the participants, make generalizability of results tentative. Possible future research directions include replicating the basic experimental design of the current study with a larger sample size to test the reliability of the trends in the current results. This larger sample should contain individuals with a wider range of reading skill. In this way, by correlating reading span and reading comprehension performance a more informative test of the validity of the reading span task as an index of the functional capacity of working memory while reading (Hasher & Zacks, 1988) would be possible. Also, future research should include independent measures of (a) the hypothesized components of associative memory ability (i.e., processing speed and declarative knowledge), and (b) working memory capacity (i.e., measures that do not include a reading component). In addition, the potential confound of

writing skill on recall measures and on-line probes of working memory, should be controlled by using oral responses in these measures. Finally, interrater reliability of text analysis and protocol scoring would be increased if the text were less complex than the ones used in this study. Unfortunately ease of text analysis and scoring frequently involves diminishing the naturalness of the text.

Conclusion

In conclusion, this study provides weak support for the role of individual differences in working memory capacity and associative memory ability on text recall. Trends in the current study suggested that (a) the effect of associative memory ability may be more evident in the recall of information, particularly details, considered important and thereby allocated more attention; and (b) the effect of working memory capacity may be more evident in difficult reading situations. Finally, the findings of the current study confirm that any investigation of memory for text must consider the powerful effects of text structure and allocation of attention on text recall.

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Figure Caption

Figure 1. Paired-associates performance across 10 response periods.

Paired-Associates Performance across 10 Response Periods

Table 1

**Correlations between Nelson-Denny (N-D) Reading
Comprehension and Reading Span: Comparative Data**

Sample		Reading span
Current study (n=40)	Read.comp1	.04
LeFevre, 1994 (n=80)	Read.comp1	.20
LeFevre, 1993, Experiment 2 (n=80)	Read.comp1	.42*
Dixon, LeFevre, & Twilley, 1988 (n=95)	Read.comp2	.39*

Note. Read.comp1 = 15-minute Nelson-Denny reading comprehension measure. Read.comp2 = 20-minute Nelson-Denny reading comprehension measure. * $p < .05$.

Table 2

Comparative Data on the Nelson-Denny (N-D) Reading Test

Sample	N-D Read.Comp.			N-D Read. Rate		
	Mean	SD	Rge	Mean	SD	Rge
Current study (n=40)	15.7	4.0	6- 24	233	69	112 - 501
LeFevre, 1994 (n=83)	15.2	4.6	4- 26	228	76	75 - 501
LeFevre, 1993 Exp.2 (n=80)	17.6	6.1	5- 35			
Dixon et al, 1988 (n= 95)				284	85	134 - 575

Note. Read.Comp. = reading comprehension. Read.Rate = reading rate. SD = standard deviation. Rge = range. Empty cells indicate data either not reported (LeFevre, 1933), or not comparable (Dixon et al., 1988).

Table 3

Coherent-Text Recall of Main Ideas and Details: Underlined
or Not Underlined

Underlined				Not Underlined			
Main idea		Detail		Main idea		Detail	
Mean %	SD	Mean %	SD	Mean %	SD	Mean %	SD
14.8	8.0	11.6	7.6	8.3	4.5	4.1	4.3

Note. Underlined, Mean % = mean percentage of total main ideas or details in text both underlined and recalled. Not underlined, Mean % = mean percentage of total mean ideas or details in text both non-underlined and recalled. SD = standard deviation. N = 40.

Table 4

Correlations among Coherent-Text Recall Measures

Accurate recall	2.	3.	4.
1. Underlined main ideas	.59**	-.37*	-.02
2. Underlined details		-.12	.08
3. Non-underlined main ideas			.53**
4. Non-underlined details			

Note. N= 40. * $p < .05$. ** $p < .001$.

Table 5

Percentage of Participants Making Errors and Intrusions in
Coherent-Text Recall

	Errors				Intrusions
	Underlined		Not underlined		
Number	Main idea	Detail	Main idea	Detail	
0	92.5%	55 %	87.5%	57.5%	67.5%
1	7.5%	27.5%	7.5%	27.5%	27.5%
2		10%		15%	2.5%
3		5%	5%		2.5%
4					
5		2.5%			

Note. Number= number of errors or intrusions in individual recall protocols. % = percentage of sample (N = 40).

Table 6

Correlations among Paired-Associates Task (response periods 1 - 10), Reading Span, and Coherent-Text Recall

	R Span	Und.Main	Und.Det.	N-U Main	N-U Det.
Trial 1	.20	.27	.31*	-.03	-.01
Trial 2	.15	.23	.12	-.02	-.02
Trial 3	.15	.28	.17	.01	.03
Trial 4	.21	.25	.06	.07	.19
Trial 5	.09	.30	.07	.03	.22
Trial 6	.06	.23	.05	.07	.22
Trial 7	.03	.24	.04	.08	.25
Trial 8	-.01	.20	.01	.04	.20
Trial 9	-.07	.20	.03	.15	.27
Trial 10	-.10	.19	.02	.14	.19
R Span	1.0	.04	.17	.07	-.06

Note Trial = paired-associates task response trial. R Span = reading span task. Und. Main = percentage recall of underlined main ideas. Und. Det. = percentage recall of underlined details. NU Main = percentage recall of non-underlined main ideas. NU Det. = percentage recall of non-underlined details. N = 40 for all analyses. * $p < .05$.

Table 7

Comparison of Clusters on Coherent-Text Recall, and Memory Measures

Variable	Cluster 1 (#35)	Cluster 2	
	Mean	Mean	SD
Reading span	26.0	27.0	6.3
%Paired associate	35.0	18.3	12.8
%Underlined main ideas	46.0	14.0	6.2
%Underlined details	26.8	11.2	7.3
%Non-underlined main ideas	.0	8.5	4.4
%Non-underlined details	2.4	4.2	4.4

Note. Cluster 1, n = 1; Cluster 2, n = 39. SD= standard deviation.

Table 8

Comparison of Coherent-Text Recall under Incidental vs.
Intentional recall conditions

Reading Condition	Underlined Main ideas		Underlined Details		Not under. Main ideas		Not under. Details	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Incidental	15.4	9.3	13.1	7.9	8.0	4.5	4.0	4.4
Intention.	13.5	4.2	8.3	6.1	8.8	4.7	4.5	4.4

Note. Incidental condition, n = 27; intentional condition, n = 13. Intention.= intentional; SD= standard deviation.

Table 9

Percentage of Participants with Errors and Intrusions in
Scrambled-Text Recall

	Errors		Intrusions
Number	Main idea	Detail	
0	45%	40%	62.5%
1	35%	22.5%	30%
2	15%	15%	7.5%
3		15%	
4		2.5%	
5		2.5%	
6	5%	2.5%	

Note. n% = percentage of sample (N = 40); Number = number of errors or intrusions in recall.

Table 10

Comparison of Scrambled-Text Recall by Probe Group

	Accurate Recall				Errors in recall			
Group	Main ideas		Details		Main ideas		Details	
	Mn %	SD	Mn %	SD	Mn %	SD	Mn %	SD
No-change	24.9	11.1	37.7	8.7	0.0	--	2.8	1.7
Expanded	17.1	6.2	16.0	9.6	.2	.4	1.4	1.4
Changed	23.5	7.6	18.9	6.1	.2	.4	1.2	1.2

Note. No-change category, n = 4; Expanded category, n = 26; Changed category, n = 10. SD= standard deviation. Accurate Recall = accurately recalled information. Errors in Recall = inaccurately recalled information.

Table 11

Mean Reading Span, Reading Comprehension, and Paired-Associate Ability (response period 1) by Probe Group

Group	Reading span		Reading comprehension		Paired associate (period 1)	
	Mean	SD	Mean	SD	Mean %	SD
No-change	29.0	1.4	15.5	5.1	26.3	17.1
Expand.	26.4	7.1	14.9	3.9	18.7	12.7
Changed	27.4	4.9	17.9	3.2	16.0	12.0

Note. n= 4 for No-change group; n= 26 for Expand(ed) group; n= 10 for Change group. Mean % = mean percentage accurate recall on paired associate task, response period 1. SD = standard deviation.

Table 12

Comparison of Clusters formed on Memory measures and
Scrambled- Text Recall

Dependent Measure	Cluster 1		Cluster 2		Cluster 3		Sample	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Read.span	27.5	5.5	13.0	1.4	29.0	5.8	26.9	6.2
PA 1 (%)	20.0	13.0	5.0	7.1	15.0	10.8	18.8	12.9
Main (%)	18.3	5.5	8.1	3.0	34.5	4.8	19.5	7.7
Details(%)	16.6	9.3	25.0	2.5	35.8	8.8	18.9	10.7

Note.: n= 34 for cluster 1. n= 2 for cluster 2. n= 4 for cluster 3. N= 40 for the sample. Read.span= reading span. PA 1 (%) = mean percentage accurate on paired-associate task, response period 1. Main (%) = mean percentage of main ideas accurately recalled. Details (%) = mean percentage of details accurately recalled. SD= standard deviation.

Appendix A

Hoopah Text: Coherent Form

1. The GM Hoopah 1 is an amazing technological innovation. It's a commuter vehicle that seats 2 people. It has an interior the size of a small living room. It has storage compartments under the seats containing ear plugs and pre-folded parachutes. This hoopah is fast, both vertically and horizontally, going 0 to 95 mph. in 7.9 seconds, with a maximum speed of 132 mph. To top it all off, this hoopah is electric. This amazing vehicle was built by a 65-year-old inventor called Bob McAllister. Three years ago McAllister signed a contract with the vice-president of GM to build a new hoopah. Then McAllister's company, Holenviroment, spent 1.8 million dollars and worked 7-day weeks to show everyone they could do it.

2. The biggest obstacle McAllister's team of engineers faced was the sad state of battery technology. Ordinary batteries accelerate a standard hoopah about as fast as a car with a flat tire accelerates up a hill. McAllister arranged a meeting with the vice-president of GM to explain their solution to the problem. McAllister's people were going to look at the battery problem in a different way. They were not going to build better batteries for a standard hoopah. They were going to put standard batteries in a better hoopah. GM Vice-president Smeeton looked out his office window and considered McAllister's plan.

3. The vice-president discussed the hoopah design with McAllister for a long time, about 5 1/2 hours. McAllister's three main goals for the hoopah were explained. They would reduce the weight of the hoopah to only 2,010 pounds, using ordinary materials. McAllister's team would make the hoopah more aerodynamic by giving it a dolphin shape and a smooth underbelly instead of the rope, hose and flashlight usually found under hoopahs. They could make the hoopah more aerodynamic than current hoopahs (about 55% more aerodynamic), and much more aerodynamic than hoopahs of 10 years ago (about 73% more aerodynamic). The third goal was to give the hoopah the acceleration of a sports car. The vice-president started to laugh. He pointed out that for the last twelve years, big hoopahmakers had wasted close to 1.7 billion dollars on battery research. GM had even tried to make a fast hoopah with standard batteries, and they had failed.

4. Three years after that first meeting, the new hoopah stunned the crowds at the hoopah show in Los Angeles on June 13. GM Hoopah 1, a year behind schedule, hurtled over the heads of 1600 people. And sitting in the driver's seat,

waving like a wildman, was McAllister.

Hoopah Text: Scrambled Form

1. And sitting in the driver's seat, waving like a wildman, was McAllister.
2. Three years after that first meeting, the new hoopah stunned the crowds at the hoopah show in Los Angeles on June 13.
3. He pointed out that for the last twelve years, big hoopahmakers had wasted close to 1.7 billion dollars on battery research.
4. The third goal was to give the hoopah the acceleration of a sports car.
5. McAllister's team would make the hoopah more aerodynamic by giving it a dolphin shape and a smooth underbelly instead of the rope, hose, and flashlight usually found under hoopahs.
6. McAllister's three main goals for the hoopah were explained.
7. GM vice-president Smeeton looked out his office window and considered McAllister's plan.

(On-line probe #1)

8. They were not going to build better batteries for a standard hoopah.
9. McAllister arranged a meeting with the vice-president of GM to explain their solution to the problem.
10. The biggest obstacle McAllister's team of engineers faced was the sad state of battery technology.
11. Three years ago McAllister signed a contract with the vice-president of GM to build a new hoopah.
12. To top it all off, this hoopah is electric.
13. It has storage compartments under the seats containing ear plugs and pre-folded parachutes.
14. It's a commuter vehicle that seats 2 people.
15. GM Hoopah 1, a year behind schedule, hurtled over the heads of 1600 people.
16. GM had even tried to make a fast hoopah with standard batteries, and they had failed.
17. The vice-president started to laugh.
18. They would make the hoopah more aerodynamic than current hoopahs (about 55% more aerodynamic), and much more aerodynamic than hoopahs of 10 years ago (about 73% more aerodynamic).
19. They would reduce the weight of the hoopah to only 2,010 pounds.
20. The vice-president discussed the hoopah design with McAllister for a long time, about 5 1/2 hours.
21. They were going to put standard batteries in a better

- hoopah.
22. McAllister's people were going to look at the battery problem in a different way.
 23. Ordinary batteries accelerate a standard hoopah about as fast as a car with a flat tire accelerates up a hill.
 24. Then McAllister's company, Holenvironment, spent 1.8 million dollars and worked 7-day weeks to show everyone they could do it.
 25. This amazing vehicle was built by a 65-year-old inventor called Bob McAllister.
 26. This hoopah is fast, both vertically and horizontally, going 0 to 95 miles per hour in 7.9 seconds, with a maximum speed of 132 miles per hour.
 27. It has an interior the size of a small living room.
 28. The GM Hoopah 1 is an amazing technological innovation.

(On-line probe #2)

Schools Text: Coherent Form

1. The Baroland School-A is an incredible architectural innovation. It is an elementary school which seats 230 children. It has an interior the size of a small football field. It has a plumbing system dug in the ground, protected by sandbags and crushed stone. This school is easy to build, having no ceilings or solid walls, and takes between 2 1/2 to 5 hours to put up, and 1 3/4 hours to take down. And believe it or not, this school is portable. This incredible school was designed by a 26-year-old architect called Joe Bennett. Nine months ago Bennett made a deal with the mayor of Baroland to build a new school. Then Bennett's company, Scholaction, spent 1.4 million dollars and worked around the clock to make the school a reality.

2. The biggest problem Bennett's team of architects faced was the terrible effects of the storms. Standard schools withstand these storms about as well as a house of cards holds up in a strong wind. Bennett met with the mayor of Baroland to explain their answer to the problem. Bennett's team was going to look at the storm problem in a different way. They were not going to build a reinforced school to withstand the storms. They were going to build a portable school that could be taken down before the storms hit. Baroland mayor Watkinson looked at the papers on his desk and considered Bennett's plan.

3. The mayor listened to Bennett's plans for a long time, about 4 3/4 hours. Bennett's three main goals for the

school were outlined. They would decrease the weight of the school structure to only 340 pounds, using available materials. Bennett's team would give the school an open atmosphere, by using detachable blankets for walls, and by building it on a level hilltop instead of in the valleys, lowlands and forests where schools are usually located. The third goal was to give the portable school better facilities than a standard school. They could make the school better-equipped than neighboring schools (about 17% better-equipped), and much better-equipped than schools of 10 years ago (about 26% better-equipped). The Baroland mayor smiled broadly. He remarked that for the last 8 years, big architecture companies had wasted close to 2.3 million dollars trying to design better schools. Another Baroland company had tried to design a school with standard materials that could be dismantled before a storm hit, and they had failed.

4. Nine months after that first meeting, the new school impressed the crowds at the school opening in Kingstown on September 2. Baroland School-A, 3 months behind schedule, was displayed on a hilltop overlooking a crowd of 420 people. And standing on the auditorium stage, thrusting his fist triumphantly in the air, was Bennett.

Schools Text: Scrambled Form

1. And standing on the auditorium stage, thrusting his fist triumphantly in the air, was Bennett.
2. Nine months after that first meeting, the new school impressed the crowds at the school opening in Kingstown on September 2.
3. He remarked that for the last eight years, big architecture companies had wasted close to 2.3 million dollars trying to design better schools.
4. The third goal was to give the portable school better facilities than a standard school.
5. Bennett's team would give the school an open atmosphere, by using detachable blankets for walls, and by building it on a level hilltop instead of in the valleys, lowlands and forests where schools are usually located.
6. Bennett's three main goals for the school were outlined.
7. Baroland mayor Watkinson looked at the papers on his desk and considered Bennett's plan.

(On-line probe #1)

8. They were not going to build a reinforced school to withstand the storms.
9. Bennett met with the mayor of Baroland to explain their

- answer to the problem.
10. The biggest problem Bennett's team of architects faced was the terrible effects of the storms.
 11. Nine months ago Bennett made a deal with the mayor of Baroland to build a new school.
 12. And believe it or not, this school is portable.
 13. It has a plumbing system dug in the ground, protected by sandbags and crushed stone.
 14. It is an elementary school which seats 230 children.
 15. Baroland School-A, 3 months behind schedule, was displayed on a hilltop overlooking a crowd of 420 people.
 16. Another Baroland company had tried to design a school with standard materials that could be dismantled before a storm hit, and they had failed.
 17. The Baroland mayor smiled broadly.
 18. They could make the school better-equipped than neighboring schools (about 17% better-equipped), and much better equipped than schools of 10 years ago (about 26% better-equipped).
 19. They would decrease the weight of the school structure to only 340 pounds, using available materials.
 20. The mayor listened to Bennett's plans for a long time, about 4 3/4 hours.
 21. They were going to build a portable school that could be taken down before the storms hit.
 22. Bennett's team was going to look at the storm problem in a different way.
 23. Standard school withstand these storms about as well as a house of cards holds up in a strong wind.
 24. Then Bennett's company, Scholaction, spent 1.4 million dollars and worked around the clock to make the school a reality.
 25. This incredible school was designed by a 26-year-old architect called Joe Bennett.
 26. This school is easy to build, having no ceilings or solid walls, and takes between 2 1/2 to 5 hours to put up, and 1 3/4 hours to take down.
 27. It has an interior the size of a small football field.
 28. The Baroland School-A is an incredible architectural innovation.

(On-line probe #2)

Appendix B

Guidelines for Text Analysis

Purpose: To designate each proposition as either a level 1 proposition (main idea) or a level 2 proposition (detail).

Definition of a proposition:

- one complete idea unit
- contains a verb, either (a) explicitly, as in "The engine is new", or (b) The new engine...
- may contain more than one verb or grammatical phrase, if the idea unit is more complex, e.g., "What goes around, comes around"
- may take various forms, i.e., subject-main verb-object; adjective (with subject and verb implied); adverb (with subject and verb implied)

The problem:

-2 factors influence whether a proposition is designated level 1 or level 2. These are:

- 1) syntactic importance--
 - i.e., main verb phrase = level 1
 - adjective, adverb phrase = level 2
- 2) psychological importance at the paragraph/text level
 - i.e., essential/defining information = level 1
 - non-essential/supplementary information = level 2

-the text was carefully written in order to make the syntactic and psychological criteria equivalent for the majority of propositions. In some cases there is a conflict. The resolution of this conflict is as follows.

- Case A: A proposition of apparent low, psychological important is in the main verb phrase.
Designation: level 1
- Case B: A proposition of apparent high psychological importance is not in the main verb phrase.
Designation: level 1

(Note: The term "psychological importance at the paragraph or text level" refers to a quasi-objective reader-text interaction, according to which information can be designated as logically essential or not.

Description of Levels

Level 1 (Main Ideas)

- general information
- essential information
- a paraphrase of more specific information attached to a main verb phrase, if the paraphrase is the essential idea unit, e.g.,
 - "The car's exhaust smells like a rotten egg"
 - (The exhaust smells bad = level 1
 - The smell is like a rotten egg = level 2)
- defining characteristics of the vehicle/structure, i.e., characteristics that identify the object as one type of object rather than another. E.g., a vehicle with wings not tires.
- general obstacles/solutions/goals
- general means by which something is to be achieved
- events of the story (i.e., actions, occurrences), e.g.,
 - "He said the car is a lemon"
 - (He said/noted/remarked..= level 1 (action)
 - the car is a lemon = level 1 (characteristic of car)
- **grammatical syntax:
 - main verbs of either simple or compound sentences are always level 1 propositions
- **exception to the syntax rule above:
 - adjectives and adverbs that express an emotion or value judgement are level 1, even if they are not part of a main verb phrase, e.g., "This great car is mine"
 - (This car is great = level 1
 - this car is mine = level 1)

Level 2: Details

- specific information, supplementary to more general information
- non-essential arbitrary information: facts that could have been otherwise
- supplementary descriptions of people and objects
 - E.g., names, amounts, time periods, ages, sizes, location, dates
- the specific phrase paraphrased in a level 1 proposition, e.g.,
 - "it's like a rotten egg" = level 2, paraphrased by level 1 proposition "it smells bad"
- grammatical syntax: mainly adjective and adverb phrases

2 of/de 2

PM-1 3 1/2 x 4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT

PRECISIONSM RESOLUTION TARGETS

Scoring of Propositions:

- one mark for each proposition
- a proposition can only be scored as present once
- exact wording is not necessary, but the word should be phonetically accurate, i.e., the word should sound right even if it is spelled incorrectly

Appendix C

Paired Associates

moon	nail
report	path
bee	money
office	wagon
iron	heaven
effort	quarter
face	noise
steel	dinner
rose	army
chair	village
king	heat
oak	leader
land	order
force	edge
region	uncle
corner	job
friend	centre
arm	kitchen
common	ocean
time	side

Appendix D INFORMED CONSENT FORM

The purpose of the informed consent form is to ensure that you understand the purpose of the study and the nature of your involvement. The informed consent must provide sufficient information such that you have the opportunity to determine whether you wish to participate in the study.

Title: Individual Differences in Reading Strategies

Research Personnel: The following people are involved in this research project and may be contacted for further information. Sheila Chapman (Principal Investigator, 788-2600 ext. 2696), and Dr. Jo-Anne LeFevre (788-2600 ext. 2693). If you have any ethical concerns about this study, please contact Dr. Lise Paquet (Chair, Psychology Department, 788-2600 ext. 2648).

Purpose: The purpose of this study is to explore the nature of individual differences in reading strategies, and to identify mental abilities which may be related to these individual differences.

Requirements: You will read two texts in different formats, with different instructions each time about how to read the text. You will be asked to fill in questionnaires on personal information relating to education, reading experience, age and handedness, and on general memory for tasks in everyday life. You may also be asked to do some basic arithmetic problems.

Duration and Locale: The experimental session will last about 1 hour. Testing will probably take place in Room A500A of the Loeb Building, Carleton University.

Potential Risk/Discomfort: There are no known physical or psychological risks in this experiment.

Anonymity/Confidentiality: The data collected in this experiment is confidential. All data are coded such that your name is not associated with the data. The coded data is made available only to the researchers associated with the project.

Right to Withdraw: You have the right to withdraw from the experiment at any time without academic penalty.

Signatures:

I have read the description of the Individual Differences in Reading Strategies study and understand the conditions of my participation. My signature indicates that I agree to participate in this experiment. Date:

Signatures: Participant _____
 Researcher _____

Appendix E

Instructions for reading text 1

You will be shown a text one paragraph at a time.

Read each paragraph and underline what you think are the most important parts of the paragraph, i.e. the parts of the paragraph most essential for a reproduction of the text.

Only underline the parts of sentences that seem important to you.

When you have finished reading and underlining, turn the page and read the next paragraph. Please do not reread any paragraphs. It is very important that you only look at each paragraph once.

When you have finished reading the whole text, please sit quietly. You will be given something else to do.

INSTRUCTIONS for recall of text 1

You were not asked to try to remember the text, but we would like to find out what you can remember from a text even when you are not trying to memorize it.

So please write down everything you can remember about the text you read, as if you were telling someone about it.

Use the lined paper provided. You can write in full sentences or point form.

INSTRUCTIONS for the reading of text 2 (scrambled)

You are going to read a scrambled text, 1 sentence per page.

When you finish reading a sentence, turn the page and read the next sentence. Do not reread sentences.

At the end of the text you will be asked to write down everything you can remember about the whole text, in what you think is the correct order.

While you are reading the text, you will occasionally be asked to write 1 (brief) sentence about what you think the text is generally about.

Instructions while reading text 2: A

Write down in 1 sentence what you think this text is generally about.

Be very brief.

If you don't know, just write "I don't know".

What you think this text is generally about:

INSTRUCTIONS while reading text 2: B

Write down in 1 sentence what you think this text is generally about.

Be very brief.

If you haven't changed your mind, just write the same thing you wrote the first time you were asked to do this task.

If you don't know, just write "I don't know".

What you think this text is generally about:

INSTRUCTIONS for recall text 2 (scrambled)

Now write down everything you can remember about the whole text, in what you think is the correct order.

Use the lined paper provided.

You can write in sentences or point form.

Appendix F

DEBRIEFING

INDIVIDUAL DIFFERENCES IN READING STRATEGIES AND MEMORY FOR TEXT

We are interested in how people read a text and in what they remember from a text. Usually studies of memory for text investigate such things as the influence of instructions or text structure on what people remember from a text. In this study we are more interested in how people differ from each other in what they remember from a text, given the same instructions and texts.

It is very common for people to say they have a "good" memory for certain kinds of information, and "bad" memories for other kinds. You may characterize yourself as a "big picture" person (someone who has a good memory for ideas but not details), or you may see yourself as a "detail" person (someone who has a good memory for details). A number of studies with brain-damaged subjects have found individual differences in memory for general ideas compared to that of specific details. Also, there is evidence that as people get older their ability to remember general ideas and details may change.

In this experiment we want to find out whether there are individual differences in what people think are the most important parts of the text, and how this affects recall performance. In addition, we are investigating the role that working memory limitations and rote learning ability may have on how well certain types of information are retained and retrieved by individuals.

Individual differences in memory for what is read have an impact on our success in school and in the workforce. We hope that our results will be interesting in terms of both cognitive theory and everyday living.

Thank you very much for your participation.

For further information about this experiment, please contact either the experimenter, Sheila Chapman at 788-2600 ext 2696, or Dr. LeFevre at 788-2600 ext. 2693. If you have any questions or concerns about the conduct of this study, please contact Dr. Lise Paquet, chair of the Psychology Department at 788-2600 ext. 2648.

Appendix G

Table G

Descriptive Statistics for Recall under Coherent Text (C-T) and Scrambled Text (S-T) Conditions, Reading Span, Reading Comprehension and Paired-Associates Performance (response periods 1-10)

Variables	Mean	SD
C-T Main Ideas (%)	23.1	7.6
C-T Details (%)	15.6	9.0
C-T Total Recall(%)	38.7	14.8
S-T Main Ideas (%)	19.5	7.7
S-T Details (%)	18.9	10.7
S-T Total Recall(%)	38.4	15.2
Reading Span	26.9	6.2
Reading Comp.	15.7	3.8
PA 1 (%)	18.8	12.9
PA 2 (%)	38.4	22.3
PA 3 (%)	52.9	26.9
PA 4 (%)	66.4	24.5
PA 5 (%)	75.1	23.8
PA 6 (%)	80.4	23.0
PA 7 (%)	83.4	22.6
PA 8 (%)	86.1	20.5
PA 9 (%)	88.6	17.6
PA 10 (%)	89.9	20.5

Note. SD = standard deviation. Total Recall % = mean percentage of main ideas and details recalled accurately. PA n (%) = mean percentage accurate on paired-associate response period # 1-10.

Appendix H

Table H

Correlations among Paired-Associates (PA) Performance
(response periods 1 - 10), Reading Span, and Coherent-Text
Recall

	Read. Span	Read. Comp.	Und. Main Ideas	Und. Det.	N-U. Main Ideas	N-U. Det.	Tot. Main Ideas	Tot. Det.	Tot. Rec.
PA 1	.20	.21	.27	.31*	-.03	-.01	.27	.25	.29
PA 2	.15	.21	.23	.12	-.02	-.02	.23	.08	.17
PA 3	.15	.17	.28	.17	.01	.03	.31	.15	.25
PA 4	.21	.25	.25	.06	.07	.19	.30	.13	.23
PA 5	.09	.31*	.30	.07	.03	.22	.34*	.16	.27
PA 6	.06	.27	.23	.05	.07	.22	.28	.14	.23
PA 7	.03	.31	.24	.04	.08	.25	.30	.15	.25
PA 8	-.01	.30	.20	.01	.04	.20	.24	.10	.18
PA 9	-.07	.29	.20	.03	.15	.27	.30	.16	.25
PA 10	-.10	.28	.19	.02	.14	.19	.29	.11	.21
R Span	1.00	.04	.04	.17	.07	-.06	.09	.12	.11
R Comp	.04	1.00	.19	.03	-.21	.10	.08	.08	.08

Note Trial = paired-associates task response trial. R Span = reading span task. Und. Main Ideas = percentage of main ideas both underlined and recalled. Und. Det. = percentage of details both underlined and recalled. NU Main Ideas = percentage of main ideas both non-underlined and recalled. NU Det. = percentage of details both non-underlined and recalled. Tot. Main Ideas = percentage of main ideas recalled. Tot Det. = percentage of details recalled. Tot. Rec. = percentage of both main ideas and details recalled. N = 40 for all analyses. * $p \leq .05$.

Appendix I

Table I

Correlations among Scrambled-Text Recall, Paired-Associate (PA) Performance (response periods 1-10), Reading Span, and Reading Comprehension

	Main Ideas (%Recalled)	Details (%Recalled)	Total Recall (%)
PA period 1 (%)	.06	.20	.17
PA period 2 (%)	.13	.23	.22
PA period 3 (%)	.28	.22	.30
PA period 4 (%)	.26	.23	.30
PA period 5 (%)	.24	.27	.31*
PA period 6 (%)	.24	.28	.32*
PA period 7 (%)	.23	.31	.33*
PA period 8 (%)	.21	.18	.24
PA period 9 (%)	.18	.24	.26
PA period 10 (%)	.17	.19	.22
Reading Span	.32*	.0	.16
Reading Comp.	.16	.28	.28
Main Ideas (%)	1.0	.35*	.75**
Details (%)	.35	1.0	.88**

Note. * $p \leq .05$. ** $p \leq .001$.

Appendix J

Table J

Summary of Mean Reading Comprehension and Reading Span
Performance by group

	Reading span		N-D reading comprehension	
	Mean	SD	Mean	SD
Group 1	26.0	5.6	16.9	4.1
Group 2	27.9	6.8	14.5	3.5
Maximum score possible	40		36	

Note. n = 20 for each group. SD = standard deviation.

Appendix K

Table K

Paired-Associate Performance (percentages) by Group across Response Periods

	Group			
	1		2	
Period	Mean %	SD	Mean %	SD
1	17.75	10.82	19.75	14.9
2	38.5	20.6	38.3	23.9
3	54.0	24.7	51.8	29.0
4	67.5	24.7	65.3	24.3
5	78.8	21.8	71.3	25.7
6	82.5	22.6	78.3	23.4
7	87.3	21.1	79.5	24.1
8	90.3	17.9	81.8	23.1
9	91.8	15.8	85.3	19.4
10	93.3	19.4	86.5	21.5

Note. n= 20 per group. Mean% = mean percentage recalled. SD = standard deviation.

Appendix L

Table L

Mean Ratings of Difficulty and Familiarity for the Coherent
Texts

	Difficulty		Familiarity	
Text	Mean	SD	Mean	SD
Schools	1.4	1.3	1.2	1.4
Hoopah	1.1	1.1	1.0	1.4

Note. n= 20 for each text group. SD= standard deviation.

Appendix M

Sample Recall Protocols

1. Participant # 61

From Hoopah: Coherent form, incidental recall

- a Mr. McAllister was in charge of building a vehicle for GM
- the vehicle was called the hoopla or something close to that
- A problem the designer had was that the regular GM batteries were too slow and ineffective at powering the vehicle
- the vehicle was said to accelerate like a car with a flat tire going up a hill
- to change the vehicle's performance the batteries were not changed but the design of the vehicle was
- the weight of the vehicle was reduced by 2010 kg and was redesigned with a dolphin tail
- the vehicle was debuted at a show where it zoomed over spectators heads with Mr. McAllister in the driver's seat.

Score: Correct 9 main ideas (1 underlined; 8 not underlined)
 5 details (3 underlined; 2 not underlined)
 Errors 1 detail (underlined)

From Schools: Scrambled Form, intentional recall

- A new type of school was designed by a 26 year old architect named Mr. Bennet
- he designed this school to be able to be put up in 2 1/2- 5 hours and dismantled in 1 3/4 hours
- to get the school built Mr. Bennet had to convince the Mayor of the town that the school was feasible
- the mayor and Mr. Bennet met when the mayor suggested that alot of money had been spent on these schools and never really improved on any
- Mr. Bennet's school only weighed 460 lbs. but was able to hold 230 students
- the school had permanent plumbing held in place by sand bags and crushed stone
- when the school was shown off to the public 460 people showed up to see it and saw the mayor smiling and Mr. Bennet triumphantly raising his fist

Score: Correct 10 main ideas
 10 details
 Errors 3 details
 Intrusion 1 (i.e., "permanent (plumbing)")

Appendix N

Examples of On-Line Probe Responses1. No-Change response:

(Participant #9)

Probe #1:-about the construction of a new "portable" school

Probe #2: This is about the construction of a portable
school2. Expanded response:

(Participant #61)

Probe #1: The building of a new school in an area with bad
stormsProbe #2: The building of a school that is able to withstand
the storms of the area3. Changed response:

(Participant #8)

Probe #1: The relocation of a school at risk from severe
stormsProbe #2: It is about making a new school which can
withstand the pressure of severe storm.

END

0 3-0 6-9 6

FIN