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Interruptions Disrupt Reading Comprehension

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Previous research suggests that being interrupted while reading a text does not disrupt the later recognition or recall of information from that text. This research is used as support for Ericsson and Kintsch's (1995) long-term working memory (LT-WM) theory, which posits that disruptions while reading (e.g., interruptions) do not impair subsequent text comprehension. However, to fully comprehend a text, individuals may need to do more than recognize or recall information that has been presented in the text at a later time. Reading comprehension often requires individuals to connect and synthesize information across a text (e.g., successfully identifying complex topics such as themes and tones) and not just make a familiarity-based decision (i.e., recognition). The goal for this study was to determine whether interruptions while reading disrupt reading comprehension when the questions assessing comprehension require participants to connect and synthesize information across the passage. In Experiment 1, interruptions disrupted reading comprehension. In Experiment 2, interruptions disrupted reading comprehension but not recognition of information from the text. In Experiment 3, the addition of a 15-s time-out prior to the interruption successfully removed these negative effects. These data suggest that the time it takes to process the information needed to successfully comprehend text when reading is greater than that required for recognition. Any interference (e.g., an interruption) that occurs during the comprehension process may disrupt reading comprehension. This evidence supports the need for transient activation of information in working memory for successful text comprehension and does not support LT-WM theory.

Keywords: interruptions, reading comprehension, recognition, memory, long-term working memory

The question of what underlies the ability to successfully comprehend written text has long been of interest to psychologists (e.g., Daneman & Carpenter, 1980; Just & Carpenter, 1980; Kintsch & Van Dijk, 1978). Some have argued that the transient portion of working memory is necessary for successful text comprehension, while others have argued that it is not (see Ericsson & Kintsch, 1995 for a review). One prominent theory, long-term working memory (LT-WM) theory, argues that the transient portion of working memory is not necessary for successful text comprehension, claiming that "reading can be completely disrupted for over 30 s with no observable impairment of subsequent text comprehension" (Ericsson & Kintsch, 1995, p. 232).

LT-WM theory suggests that with enough deliberate practice, individuals are able to become experts in certain domains and that this domain expertise allows working memory to extend beyond the traditional, limited capacity of short-term working memory (ST-WM; Ericsson & Kintsch, 1995). This memory store, called LT-WM, has a nearly unlimited capacity. Expertise consists of learning to encode task-relevant information quickly in order to move it into this store. Furthermore, once this information is encoded, it is no longer subject to forgetting and can be immediately retrieved later in a single, automatic operation. This theory also states that performance should not suffer in the face of interruptions due to memory limitations, decay, or forgetting, as long as (a) the information has been encoded into LT-WM and (b) a retrieval cue exists in short-term memory (STM) that allows information from LT-WM to be located following the interruption.

Ericsson and Kintsch (1995) leveraged findings from Glanzer and colleagues (Fischer & Glanzer, 1986; Glanzer, Dorfman, & Kaplan, 1981; Glanzer, Fischer, & Dorfman, 1984) as evidence to support LT-WM. In these studies, participants were interrupted with a secondary task (e.g., math problems, different text) or not interrupted (control) while reading passages of text. Afterward, participants answered free response or true–false questions measuring the participants' ability to recognize and recall facts from the passages they had read. Across all of these experiments, interruptions did not disrupt the participants' ability to recognize and recall information from the passages.

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Ericsson and Kintsch (1995) interpreted Glanzer and colleagues' findings as inconsistent with the prevailing view that working memory is necessary for successful text comprehension. Ericsson and Kintsch (1995) captured this view as follows: "A disruption of reading and engagement in an unrelated, attention demanding activity should lead to an irretrievable loss of the information in ST-WM necessary for continued text comprehension" (p. 224). Ericsson and Kintsch (1995) thus concluded that Glanzer and colleagues' evidence "shows that the transient portion of working memory is not necessary for continued comprehension" (pp. 224–225). That is, since no disruption was found in these studies (i.e., interruptions did not impair text comprehension), they argued that working memory is not critical for text comprehension.

In light of Glanzer and colleagues' findings, Ericsson and Kintsch (1995) proposed their long-term working memory (LT-WM) theory, claiming that "in skilled activities a significant part of the accessible information is stored in LTM [long-term memory] and is accessible through retrieval cues in STM" (p. 222). According to this theory, once information enters LTM, it becomes protected (i.e., should not be disrupted by interruptions) and can be accessed with a retrieval cue from STM. This key distinction differentiates LT-WM theory from other models based on transient activation of information in working memory. Thus, Ericsson and Kintsch (1995) stated that "induced interruption is an effective technique to differentiate between storage in ST-WM and storage in LT-WM" (p. 222). Specifically, if the information necessary to complete the task is stored in LTM, interruptions *should not* disrupt text comprehension. However, if the information necessary to complete the task is stored in working memory, interruptions *should* disrupt text comprehension (Ericsson & Kintsch, 1995).

Oulasvirta and Saariluoma (2006) conducted a series of experiments to test LT-WM theory on interrupted-task performance while reading text. In their first three experiments, participants were tasked with reading passages while being interrupted, making minor changes across each experiment to ensure that the interruptions were distracting the participants and not allowing them to rehearse any information. Participants answered true–false recognition questions about the passages. The findings were similar to the original findings of Glanzer and colleagues, suggesting that interruptions do not disrupt an individual's ability to recall and recognize information from a passage. However, in Experiment 4, they were able to disrupt recognition when participants were forced to read the passages at a rapid pace. They argued that the rapid pace of task processing did not allow the participants to encode information into LT-WM. That is, the rapid pace did not allow retrieval cues and intraitem associations to form. Therefore, following the interruptions, participants were not able to reinstate the representations that would have been stored in LT-WM (Oulasvirta & Saariluoma, 2006).

The studies by Glanzer and colleagues (Fischer & Glanzer, 1986; Glanzer et al., 1981, 1984) and Oulasvirta and Saariluoma (2006) suggest that interruptions when reading are not problematic unless one is forced to read at an extremely fast pace. Importantly, all of this research appears to support Ericsson and Kintsch's (1995) LT-WM theory and not transient activation of information in working memory. However, when used as support for LT-WM theory, the studies suffer from a serious problem: Participants were not required to connect and synthesize information presented in the text to successfully answer each question. That is, every question asked in these studies could be answered by reading one single line from a passage. For example, the answer to the question "What is one ingredient in the poisonous compounds found on Jupiter?" came from this line: "This is mostly hydrogen, some of which has combined to form poisonous compounds" (Glanzer et al., 1984). Therefore, successfully answering these questions could rely solely on recognition of the information. Recognition is often considered a single, automatic process that relies on a familiarity-based decision (Anderson & Bower, 1973; Kintsch, 1970). We would argue that comprehension is not always as simple as what was measured in these studies and may require a deeper level of processing. Comprehension often requires individuals to connect and synthesize information across a text (e.g., successfully identifying complex topics such as themes and tones) and not just make a familiarity-based decision. At best, recognition is a crude index of comprehension.

Therefore, the goal for this study was to determine whether interruptions while reading disrupt reading comprehension when the questions assessing comprehension require participants to connect and synthesize information across the passage. Examples include questions addressing theme, tone, morals, and the author's goals, as these questions require information to be connected and synthesized across the text to be successfully answered. Importantly, we made efforts to model our experiments after those of Glanzer and colleagues and Oulasvirta and Saariluoma (2006). Specifically, the primary tasks consisted of high school- and college-level reading material as was used in the original study by Glanzer et al. (1981). Although we could have chosen any interruption lasting up to 30 s based on claims made by Ericsson and Kintsch (1995), we chose to be consistent with the previous work. Thus, we used math problems as the interruption task, just as Glanzer et al. (1981) and Oulasvirta and Saariluoma (2006) did in many of their experiments.

The finding that interruptions do not disrupt text comprehension would support LT-WM theory by suggesting that the transient portion of working memory is not necessary for text comprehension. By contrast, the finding that interruptions do disrupt text comprehension would support the view that the transient portion of working memory is necessary for text comprehension and thus would fail to support LT-WM theory.

Experiment 1

Method

Participants. Twenty-four students from George Mason University participated for course credit. The participants (16 females, eight males) had an average age of 21.3 years ($SD = 2.6$), were fluent in English, and reported English as being their first language. The sample size was set a priori at 24 based on previous work by Glanzer et al. (1984) and Oulasvirta and Saariluoma (2006).

Materials. The primary task required participants to read and answer questions from passages designed specifically to assess reading comprehension on the SAT, a test that has been administered to millions of students. The four passages and their respective questions came from the College Board. These passages were approximately equal in length (measured by overall word count) and grade level (measured by Flesch–Kincaid Grade Level) and had exactly four paragraphs each. Importantly, any questions that

strictly tested vocabulary were removed, as they could be answered with prior knowledge (see the Appendix).

The interruption task consisted of answering a series of math problems (see the Appendix).

Design and procedure. The experiment used a within-subjects design. Participants were tested twice in both the interruption and no-interruption conditions. A Latin square design was used to counterbalance the four passages and two conditions. During the interruption conditions, 15-s interruptions occurred between each paragraph, resulting in three total interruptions per passage. Both the primary and interruption tasks were completed on a computer.

The paragraphs were presented serially. After reading each paragraph, participants were instructed to press the space bar key. In the no-interruption condition, pressing the space bar displayed the next paragraph. In the interruption condition, pressing the space bar activated the interruption task, which occluded the primary reading task. After completing the interruption task, the next paragraph was immediately displayed on the screen. After reading each passage, participants answered eight questions about the passage. There were no time restrictions for reading the paragraphs or answering the questions. This was to ensure that participants had adequate time to complete the task.

After reading and answering questions for all four passages, participants completed a short demographics survey and were thanked for their participation.

Measures. The number of correct responses for the questions was recorded, and the interruption task was scored for accuracy.

Results

On average, participants answered 91% ($SD = 6.4$) of the math questions correctly, suggesting that they were actively completing the interruption task.

We wanted to ensure that fatigue and individual passage (1, 2, 3, or 4) did not influence the reading comprehension scores. A repeated-measures analysis of variance (ANOVA) revealed no significant differences in correct responses over time, $F(3, 69) = 1.15$, $p > .249$ and no significant differences as a function of the passage, $F(3, 69) = 1.33$, $p > .249$.

We were interested in determining whether interruptions affect reading comprehension. We summed the scores for the two interruption conditions and for the two no-interruption conditions, as participants completed each condition twice. A paired-samples t test revealed a significant difference between the number of correct responses in the interruption ($M = 9.04$, $SD = 2.03$, 95% confidence interval [CI] [8.23, 9.85]) and no-interruption ($M = 10.8$, $SD = 2.11$, 95% CI [9.96, 11.64]) conditions, $t(23) = 11.63$, $p < .001$, $d = 2.37$ (see Figure 1). Moreover, individual analyses of the data sets revealed that no participants scored higher on an interruption condition compared to a no-interruption condition. These data support the view that the transient portion of working memory is necessary for successful text comprehension and thus fail to support LT-WM theory.

Experiment 2

The results from Experiment 1 suggest that interruptions disrupt reading comprehension when the questions assessing comprehension require participants to connect and synthesize information across the passage. However, as noted earlier, many studies have shown that interruptions do not affect recognition of information from text (Fischer & Glanzer, 1986; Glanzer et al., 1981, 1984; Oulasvirta & Saariluoma, 2006).

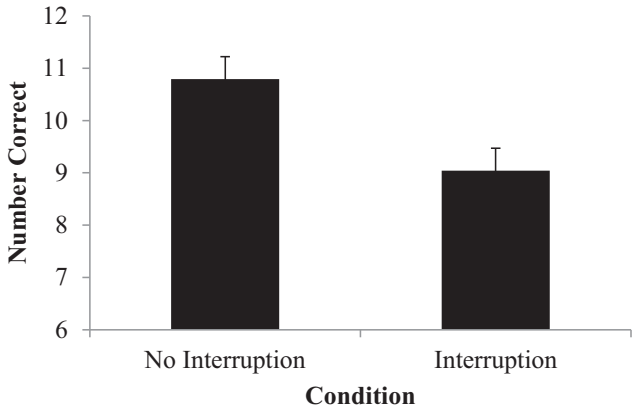

Figure 1. The average number of correct responses for reading comprehension questions (±*SE*) when interrupted and not interrupted.

Therefore, we wanted to confirm that a clear distinction exists between how interruptions affect comprehension as we have defined it (i.e., information that must be connected to successfully understand it) and the recognition of information read. To do this, we modified our original design to include questions that assessed recognition.

Method

Participants. Twenty-four students from George Mason University participated for course credit. The participants (18 females, six males) had an average age of 20.7 years ($SD = 2.3$), were fluent in English, and reported English as being their first language. The sample size was set a priori at 24 based on previous work by Glanzer et al. (1984) and Oulasvirta and Saariluoma (2006).

Materials. The primary task was identical to that used in Experiment 1 with one exception: The type of questions for each passage varied. For Passages 1 and 2, the questions were identical to those in Experiment 1. For Passages 3 and 4, the questions used were designed after the true–false questions used by Oulasvirta and Saariluoma (2006) and Glanzer et al. (1984) to test recognition (see the Appendix). For example, "Was it claimed in the text that: X?"

The interruption task was identical to that used in Experiment 1.

Design and procedure. The design and procedure were nearly identical to those in Experiment 1. Participants were interrupted once for Passages 1 and 2 and once for Passages 3 and 4. The trials were counterbalanced so that participants could receive any order of the passages (e.g., 2–4–3–1, 3–2–1–4, etc.) with two interrupted and two noninterrupted trials. Additionally, the distribution of passage locations and interruptions were balanced across all participants (i.e., each passage was in each of the four possible locations exactly six times).

Measures. The number of correct responses for the types of reading questions (reading comprehension and recognition) was recorded. The interruption task was scored for accuracy.

Results

On average, participants answered 85% ($SD = 7.1$) of the math questions correctly, suggesting that they were actively completing the interruption task.

We were interested in determining whether interruptions affect reading comprehension and recognition. A 2 × 2 (Question × Interruption) repeated-measures ANOVA revealed a main effect of interruption, $F(1, 23) = 40.92$, $p < .001$, $\eta^2_{partial} = .64$, a main effect of question type, $F(1, 23) = 237.23$, $p < .001$, $\eta^2_{partial} = .91$, and a significant interaction, $F(1, 23) = 46.00$, $p < .001$, $\eta^2_{partial} = .67$ (see Figure 2). Tests of simple main effects using a Bonferroni correction ($\alpha = .05$) within the comprehension questions revealed significantly poorer performance under the interruption condition ($M = 4.38$, $SD = .97$, 95% CI [3.97, 4.78]) than under the no-interruption condition ($M = 5.42$, $SD = 1.21$, 95% CI [4.91, 5.93]), $t(23) = 9.30$, $p < .001$, $d = 1.90$. Tests of simple main effects within recognition questions showed no significant difference between the interruption ($M = 6.46$, $SD = 1.28$, 95% CI [5.92, 7.00]) and no-interruption conditions ($M = 6.50$, $SD = 1.14$, 95% CI [6.01, 6.98]), $p > .249$.

These results are consistent with those of Experiment 1, supporting the view that the transient portion of working memory is necessary for successful text comprehension when actually measuring comprehension. The data again fail to support LT-WM theory.

Experiment 3

The data from Experiments 1 and 2 suggest that interruptions do not disrupt the basic recognition of information from a text but do disrupt the processing required to successfully connect and synthesize information presented in the text. These data support the view that the transient portion of working memory is necessary for successful text comprehension.

This suggests that an interruption should not disrupt text comprehension if an individual is given additional time for processing prior to the onset of an interruption. In Experiment 3, we tested this by adding a 15-s time-out period before any interruption occurred. We hypothesized that this additional time would allow for any processing needed to successfully comprehend the text to occur, thus negating any disruptive effects that may be caused by an interruption.

Method

Participants. Twenty-four students from George Mason University participated for course credit. The participants (15 females, nine males) had an average age of 21.1 years ($SD = 2.8$), were fluent in English, and reported English as being their first language. The sample size was set a priori at 24 based on previous work by Glanzer et al. (1984) and Oulasvirta and Saariluoma (2006).

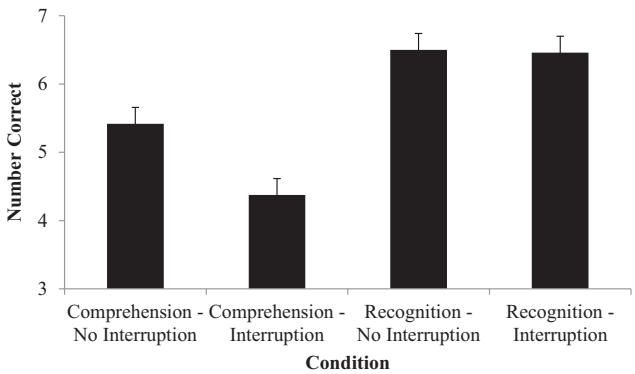

Figure 2. The average number of correct responses (±*SE*) when interrupted and not interrupted for reading comprehension and recognition questions.

Materials. The primary task was similar to that in Experiment 2 with one exception: Two additional conditions were added with a time-out period occurring prior to each interruption for both reading comprehension and recognition questions. The interruption task was identical to that used in Experiment 1.

Design and procedure. The design and procedure were similar to those in Experiment 2. However, this experiment was composed of six total conditions: interruption, no interruption (control), and a time-out period with interruption for reading comprehension questions; and interruption, no interruption (control), and a time-out period with interruption for recognition questions. The interruption and no-interruption (control) conditions were identical to those in Experiment 2. During the time-out conditions, the computer screen went blank when participants hit the space bar key for 15 s, followed by the interruption task. The experiment was counterbalanced following the procedure used in Experiment 2 by evenly distributing the passage locations and interruptions across all participants.

Measures. The number of correct responses for each condition was recorded. The interruption task was scored for accuracy.

Results

On average, participants answered 86% ($SD = 7.9$) of the math questions correctly, suggesting that they were actively completing the interruption task.

We were interested in determining whether a time-out period would remedy the disruptive effects of interruption shown in the previous experiments. The Greenhouse–Geisser correction was used, as the assumption of sphericity had been violated. A 2 × 3 (Question × Interruption) repeated-measures ANOVA revealed a significant main effect of interruption, $F(2, 46) = 21.57$, $p < .001$, $\eta^2_{partial} = .48$, a significant main effect of question type, $F(1, 23) = 60.06$, $p < .001$, $\eta^2_{partial} = .81$, and a significant interaction, $F(2, 46) = 18.47$, $p < .001$, $\eta^2_{partial} = .45$ (see Figure 3). Tests of simple main effects using a Bonferroni correction ($\alpha = .05$) within the comprehension questions revealed significantly poorer performance in the interruption condition ($M = 4.54$, $SD = 1.47$, 95% CI [3.92, 5.16]) compared to the no-interruption condition (($M = 5.63$, $SD = 1.61$, 95% CI [4.95, 6.30]), $t(23) = 7.42$, $p < .001$, $d = 1.51$) and the interruption with a time-out condition (($M = 5.58$, $SD = 1.38$, 95% CI [5.00, 6.17]), $t(23) = 6.81$, $p < .001$, $d = 1.39$). No other differences existed within the reading comprehension questions ($p > .249$), and no differences existed at all within the recognition questions ($p > .249$).

These results are consistent with the results of Experiments 1 and 2, supporting the view that the transient portion of working memory is necessary for successful text comprehension when actually measuring comprehension. These data fail to support LT-WM theory.

General Discussion

The goal for this research was to determine whether interruptions while reading disrupt reading comprehension when the questions assessing comprehension require participants to connect and

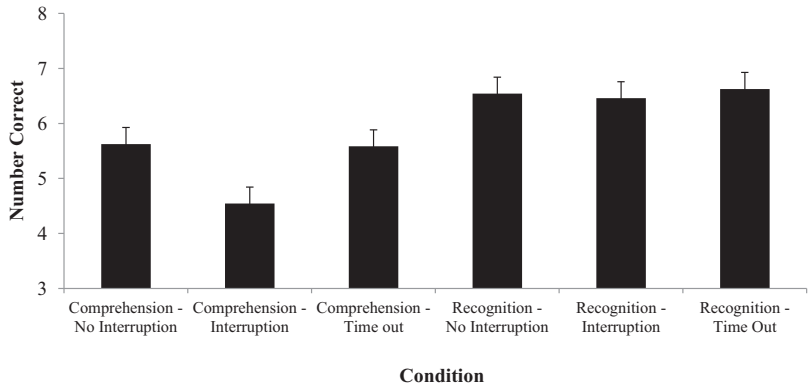

Figure 3. The average number of correct responses (±*SE*) when interrupted, not interrupted, and interrupted with a 15-s time-out period for reading comprehension and recognition questions.

synthesize information across the passage. In Experiment 1, we found that interruptions disrupted reading comprehension. In Experiment 2, we made the distinction between reading comprehension and recognition. Consistent with Experiment 1, we found that interruptions disrupted reading *comprehension*. Consistent with work from Glanzer and colleagues (Fischer & Glanzer, 1986; Glanzer et al., 1981, 1984) and Oulasvirta and Saariluoma (2006), interruptions did not affect *recognition* of text. In Experiment 3, we replicated the findings from Experiments 1 and 2 and also found that adding a 15-s time-out period prior to each interruption prevented the disruption caused by interruptions when answering questions assessing comprehension. The time-out period had no effect on the recognition condition.

Our data showing that interruptions disrupt reading comprehension are at odds with Ericsson and Kintsch's (1995) LT-WM theory. Ericsson and Kintsch (1995) claim that adults are expert readers and possess the domain expertise to quickly encode task-relevant information into LT-WM. They further state that interruptions shorter than 30 s will not impair subsequent text comprehension (Ericsson & Kintsch, 1995; Kintsch, Patel, & Ericsson, 1999). The data from the current study show that interruptions do in fact disrupt reading comprehension, contradicting the predictions of LT-WM theory. It may be possible that the original evidence used to support LT-WM theory (i.e., the studies by Glanzer and colleagues) relied on the automatic, familiarity-based decisions that are needed to successfully answer recognition questions. That is, not needing to connect information across the text may have been driving the null effect (i.e., no effect of interruption) from these earlier studies.

Our data support the view that the transient portion of working memory is necessary for text comprehension, a contention that Ericsson and Kintsch (1995) argued against. Specifically, when the questions used to assess text comprehension required a level of processing beyond recognition, transient activation of information in working memory appeared to be necessary. This was further supported by the addition of a time-out period in Experiment 3. This time-out period likely allowed any processing in working memory to finish; thus, when the interruption occurred, there was no information to disrupt.

Alternatively, it is possible that the time-out period allowed participants to encode cues that could act as a "mental bookmark" facilitating resumption and activation of the reading task following the interruption. This explanation would be in line with findings from Trafton, Altmann, Brock, and Mintz (2003), who showed that adding a warning period before interruptions in a computer-based procedural task reduced the amount of time it takes to resume a task following an interruption. They argued that participants were able to encode cues that allowed for the successful reactivation of the task during the time period following the warning but before the interruption.

Future work should be directed at determining whether experts exist within certain knowledge-specific domains of reading and whether these experts are immune to the disruptive effects caused by interruptions. Additionally, work should be directed at understanding whether the timing or location of the interruption matters. For example, if interrupted midparagraph, would it be better to return to the start of that paragraph or to start from the beginning of the chapter? It may also be useful to examine whether other strategies (e.g., alerts) can be used to mitigate the disruptive effects of interruptions.

These findings have important implications for work performance. When reading an important document, it may be best to limit external sources of interruptions (e.g., silence your cell phone, shut your door, etc.). If not, the interruptions will not only delay your reading, they may also affect your ability to comprehend the text.

References

Anderson, J. R., & Bower, G. H. (1973). *Human associative memory*. Oxford, England: VH Winston & Sons.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19,* 450–466. http://dx.doi.org/10.1016/S0022-5371(80)90312-6

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review, 102,* 211–245. http://dx.doi.org/10.1037/0033-295X.102.2.211

Fischer, B., & Glanzer, M. (1986). Short-term storage and the processing of cohesion during reading. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 38,* 431–460. http://dx.doi.org/10.1080/14640748608401607

Glanzer, M., Dorfman, D., & Kaplan, B. (1981). Short-term storage in the processing of text. *Journal of Verbal Learning and Verbal Behavior, 20,* 656–670. http://dx.doi.org/10.1016/S0022-5371(81)90229-2

Glanzer, M., Fischer, B., & Dorfman, D. (1984). Short-term storage in reading. *Journal of Verbal Learning and Verbal Behavior, 23,* 467–486. http://dx.doi.org/10.1016/S0022-5371(84)90300-1

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review, 87,* 329–354. http://dx.doi.org/10.1037/0033-295X.87.4.329

Kintsch, W. (1970). *Models for free recall and recognition: Models of human memory* (Vol. 124). New York, NY: Academic Press.

Kintsch, W., Patel, V. L., & Ericsson, K. A. (1999). The role of long-term working memory in text comprehension. *Psychologia, 42,* 186–198.

Kintsch, W., & Van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review, 85,* 363–394. http://dx.doi.org/10.1037/0033-295X.85.5.363

Oulasvirta, A., & Saariluoma, P. (2006). Surviving task interruptions: Investigating the implications of long-term working memory theory. *International Journal of Human-Computer Studies, 64,* 941–961. http://dx.doi.org/10.1016/j.ijhcs.2006.04.006

Trafton, J. G., Altmann, E. M., Brock, D. P., & Mintz, F. E. (2003). Preparing to resume an interrupted task: Effects of prospective goal encoding and retrospective rehearsal. *International Journal of Human-Computer Studies, 58,* 583–603. http://dx.doi.org/10.1016/S1071-5819(03)00023-5

Appendix

Sample Materials Used to Assess Reading Comprehension and Recognition

Sample Paragraph (from Prompt 1)

The chief claim for the use of science in education is that it teaches a child something about the actual universe in which he is living, in making him acquainted with the results of scientific discovery, and at the same time teaches him how to think logically and inductively by studying the scientific method. A certain limited success has been reached in the first of these aims, but practically none at all in the second. Those privileged members of the community who have been through a secondary or public school education may be expected to know something about the elementary physics and chemistry of a hundred years ago, but they probably know hardly more than any bright boy can pick up from an interest in wireless or scientific hobbies out of school hours.

Sample Reading Comprehension Questions

The author implies that the professional schoolmaster has:

A. no interest in teaching science
B. thwarted attempts to enliven education
C. aided true learning
D. supported the humanists
E. been a pioneer in both science and humanities.

The author's attitude to secondary and public school education in the sciences is:

A. ambivalent
B. neutral
C. supportive
D. satirical
E. contemptuous.

If the author were to study current education in science to see how things have changed since he wrote the piece, he would probably be most interested in the answer to which of the following questions?

A. Do students know more about the world about them?
B. Do students spend more time in laboratories?
C. Can students apply their knowledge logically?
D. Have textbooks improved?
E. Do students respect their teachers?

All of the following can be inferred from the text except:

A. At the time of writing, not all children received a secondary school education.
B. The author finds chemical reactions interesting.
C. Science teaching has imparted some knowledge of facts to some children.
D. The author believes that many teachers are authoritarian.
E. It is relatively easy to learn the scientific method.

Sample Recognition Questions

What were the pioneers of the teaching of science concerned about?

A. The schoolmasters would make the material dull and unappealing to students.
B. The students would not believe what they were being taught.
C. The students would not attend classes.
D. The parents of the students would not encourage learning about the universe.
E. The schoolmasters would mix the teaching of science with religion.

What is one country where 50 years of education in the methods of science had no impact on the actual learning of the scientific method?

A. United States of America
B. Britain
C. Austria
D. France
E. China.

Was it claimed in the text that:
one of the chief claims of science in education is that it acquaints students with scientific discovery?

True (Yes, it was claimed)
False (No, it was not claimed)

Was it claimed in the text that:
the pioneers of the teaching of science were concerned that students would not believe what they were being taught and would instead think for themselves?

True (Yes, it was claimed)
False (No, it was not claimed)

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