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Repetition Effects From Paraphrased Text: Evidence for an Integrated Representation Model of Text Representation

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The effect of text repetition on reading performance and memory was examined. Participants read a set of short passages, each twice in succession. The second reading was either the same text or a paraphrased version of the original text. Both same texts and paraphrased texts were read faster during the second reading, but the repetition effect was slightly smaller for paraphrased texts. This was reflected by changes in global measures of reading performance (e.g., reduced reading time) and by reduced fixation durations on individual words. The results are consistent with a model of text repetition effects in which wording is represented in an abstract, context-independent manner, whereas the situation described by the text is represented in an episodic, context-dependent manner.

When a word or text is read twice, reading time generally decreases during the second occurrence (Raney & Rayner, 1995). This is known as a *repetition effect* or *rereading benefit,* and it occurs because memory for the first occurrence (of a word or a whole text) facilitates reprocessing during the second occurrence (Carr, Brown, & Charalambous, 1989; Levy & Burns, 1990; Raney & Rayner, 1995). Because repetition effects provide a sensitive, implicit measure of the content and structure of memory, much research has been devoted to understanding the source of text repetition effects.

There are two major competing explanations: the abstract view and the episodic view. According to the abstract view, text repetition effects result from the priming of abstract word representations, such as the *logogens* proposed by Morton (1969). Reading a word once activates its logogen, which makes the word easier to activate a second time regardless of the word's context (over limited durations). More recently, abstract repetition effects have also been attributed to memory for individ-

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ual words independently of their contexts (e.g., Carr et al., 1994). Regardless of the source of repetition benefits, abstract representations should facilitate reprocessing independent of the context during each occurrence of a word or each reading of an entire text (Tenpenny, 1995). For example, if a text contains the phrase *paper bag,* and a subsequent sentence in the text contains the phrase *plastic bag,* the word *bag* should be easier to read during its second occurrence, even though it is read in a new context and refers to a different bag.

In contrast, the episodic view holds that repetition effects result from memory for specific information or events in a text. Episodes include the meaning of a passage (e.g., what the paper bag is used for), details about the words and their contexts (e.g., the words used to describe the bag), and even physical attributes of the text (e.g., font style). All the information in an episodic text representation is tightly bound together and forms a single memory. This is described as context-dependent memory (Levy et al., 1995). Because information in memory is context dependent, the more similar the contexts during each reading of a word or text, the larger the repetition effect (Levy & Burns, 1990; Levy et al., 1995). In the *paper bag* example, memory for the first occurrence of the word *bag* might include *paper* (part of the context). Reading *paper bag* might not facilitate processing of the word *bag* in the phrase *plastic bag* because the word *bag* appears in a different context and has a different referent. O'Brien, Raney, Albrecht, and Rayner (1997) found exactly these results.

There is ample support for both theories, but results vary dramatically as a function of the experimental task used and the reader's goals. For example, Carr et al. (1989) had participants read normal texts or texts with word order scrambled and then reread the same text (normal–normal or scrambled–scrambled) or the opposite version (normal–scrambled or scrambled–normal). Participants read out loud with the goal of pronouncing each word correctly. Reading time decreased during the second reading in both the matched (normal–normal or scrambled–scrambled) and mismatched (normal–scrambled or scrambled–normal) conditions even though the context was changed in the mismatched conditions. This supports the abstract view because repetition effects were not context dependent. Levy and Burns (1990) repeated this experiment, but their participants read silently and focused on comprehending the passages. They found repetition effects for matched texts but not for mismatched texts. This supports the episodic view because repetition effects were context dependent. Carlson, Alejano, and Carr (1991) explained these contradictory results by appealing to task differences. Carlson et al. suggested that reading out loud emphasized memory for individual words, so repetition effects resulted from memory for individual words and not the context in which the words occurred. In contrast, reading silently for comprehension emphasized the overall meaning, so the repetition effect resulted from memory for the general meaning or context of the passage.

One criticism of these studies is their use of scrambled texts. Reading scrambled texts might not adequately test the theories because the task is not natural, and it violates normal grammatical structure (cf. Brown & Carr, 1993; Whittlesea, 1990). Levy, Di Persio, and Hollingshead (1992, Experiment 3) performed a study using nonscrambled texts. Participants read normal passages five times in a row while proofreading the passages for spelling errors. During the fifth reading, half of the passages had a few words replaced by synonyms. Reading times for identically repeated sentences were faster than for sentences with synonyms, but both sentence types produced repetition effects. Levy et al. interpreted their data as supporting the episodic position because changing the wording reduced repetition effects.

Levy, Barnes, and Martin (1993) performed a similar experiment without the proofreading task. Participants reread paraphrases in which the syntactic structure of a passage was changed but the wording was not changed (i.e., word order was rearranged), or paraphrases in which wording was changed using synonyms but syntactic structure was not changed. Significant repetition effects occurred in both conditions, but repetition effects were slightly larger for syntactic paraphrases. This is consistent with prior research by Tardif and Craik (1989). They found rereading benefits for identical and paraphrased passages (that changed word order and used synonyms) but slightly larger repetition effects for identical passages.

Levy et al. (1995, Experiments 4 and 7) modified the paraphrasing method by measuring transfer across texts (i.e., whether one text facilitates reading another text). During the second reading, participants read related texts (successive sections of a novel with many overlapping words), paraphrases of the related texts (words from the related texts were replaced by synonyms), different texts (new stories with many overlapping words from the first story), or unrelated stories (new stories with few overlapping words from the first story). Only related and paraphrased texts produced significant repetition transfer effects. Levy and her colleagues (Levy et al., 1993; Levy et al., 1995) concluded that semantic overlap is necessary to produce repetition effects and that repetition effects result from activation of the original text's episode in memory.

In a similar experiment by Raney and Rayner (1995), participants read texts while their eye movements were monitored. Recording eye movements allows examination of individual word reading times as well as overall reading times. Passages were read twice in succession, and the second readings were either identical or had one word changed to a synonym. Repeated words and synonyms were both read faster during the second reading. Importantly, reading times for synonyms and repeated words were similar. This experiment demonstrates that changing a word to a synonym does not automatically lead to smaller repetition effects, which is consistent with the abstract view. Because only one word was changed during the second reading, this does not, however, produce nearly as large of a change in context as does a complete paraphrase.

It is worth restating that the goal of studying repetition effects is to understand how texts are represented in memory. Changes in repetition benefits reflect changes in text comprehension and memory and, as such, provide a window into the structure of memory. Discourse researchers view text memory as containing myriad types of information represented in many formats. Perhaps the most widely known example is the multiple levels of text memory proposed by van Dijk and Kintsch (1983). Given that memory is viewed as a complex system, it seems odd that abstract and episodic representations are treated as mutually exclusive. Raney (1999) recently suggested that both forms of representation may be used. He proposed the integrated representation model of text repetition effects, a model that integrates abstract and episodic representations into a single text memory. To do this, Raney combined the notion of abstract and episodic representation with the levels of memory proposed by van Dijk and Kintsch (1983).

van Dijk and Kintsch (1983) presumed that texts are represented at three levels: a surface form, a propositional textbase, and a situation model. The surface form includes the wording used in the text and results from lexical and syntactic analysis (Fletcher & Chrysler, 1990; van Dijk & Kintsch, 1983). The propositional textbase contains the text's meaning as a set of propositions (Kintsch, 1974; Kintsch & van Dijk, 1978). Importantly, the formation of the textbase is determined by the semantic constraints of the content words (nouns, adjectives, main verbs), how these words are combined into propositions, and how explicit propositions are coherently related. The status of world knowledge in the formation of the textbase is somewhat controversial, but it is believed that the content words and the semantic relations play a dominant role, perhaps more dominant than world knowledge (Fletcher & Chrysler, 1990). The situation model can be thought of as a merging of the textbase with the reader's prior knowledge (Fletcher, 1994; Kintsch, 1988; Kintsch, Welsch, Schmalhofer, & Zimny, 1990). The situation model represents the events and actions (episodes) described by the text but goes beyond the contents of the text itself and includes general knowledge, inferences, and the output of processes used to comprehend the text (Graesser, Millis, & Zwaan, 1997; Zwaan & Radvansky, 1998).

The basic assumption of Raney's (1999) integrated representation model is that the surface form and textbase are represented in a context-independent manner (i.e., abstractly) and the situation model is represented in a context-specific manner (i.e., episodically). In essence, texts are represented as episodes containing abstract concepts. The situation model is used to define the conceptual boundary of an episode, and the surface features and textbase are context-free (abstract) elements of the episode. Creating a situation model leads to the creation of a conceptual boundary that surface features and the textbase cannot freely cross. As long as the situation model matches between the first and second reading of a text, repetition effects should be produced. If a situation model is not developed or is not task relevant, then there is no conceptual boundary around the surface features and textbase.

The model supports two general predictions about text repetition effects. First, when a situation model is well formed and task relevant, processing of situation-consistent information will be facilitated because the situation model will guide retrieval of information from the text. Consequently, repetition effects will appear to be based on context-specific episodes. Second, when a well-formed situation model is not in memory or not task relevant, elements of the surface form and textbase that are repeated will be facilitated because the surface features and the textbase will guide retrieval. In this case, repetition effects will appear to be based on abstract information that is not context specific.

Within this model, the terms *abstract* and *episodic* are used to describe the format of the text representation. Abstract is used as a label for context-independent representations and episodic is used as a label for context-dependent representations. Previous models describe abstract repetition effects as based on lexical activation or memory for individual words, and episodic repetition effects as based on the activation of a specific text memory or context (e.g., Carr et al., 1989; Levy et al., 1993). Abstract and episodic are used here to maintain consistency with prior research in terms of describing repetition effects. In the integrative representation model, different repetition effects result from changes in context dependence as a function of the type of information in a representation and the task being performed. The model does not depend on different sources of activation for abstract and episodic repetition effects (although it is not incompatible with lexical activation as a source of repetition benefits), but it also does not depend on the recall of a specific event within a text episode. As such, it could be classified as either a weakly abstract model or a weakly episodic model (Tenpenny, 1995). Also note that task differences are incorporated within the structure of the model. Tasks that emphasize wording (e.g., reading aloud) will enhance memory for surface form, whereas tasks that emphasize meaning (e.g., normal reading for comprehension) will enhance memory for the situation (also see Carlson et al., 1991; Carr et al., 1989; Carr et al., 1994; Levy & Burns, 1990).

The actual components of the integrated representation model are not new. As described earlier, there is ample evidence for the existence of abstract (context-independent) representations, episodic (context-dependent) representations, and the multiple levels of text memory proposed by van Dijk and Kintsch (1983). It is also known that attention influences the contents of memory. What is new are the assumptions that abstract and episodic representations are combined into a single representation; that surface, textbase, and situational levels of memory reflect different degrees of context dependence; and that the situation model creates a boundary around text memories. The combination of these properties creates a novel model that can explain many of the inconsistent results of past research. The model also explains how an existing representation facilitates reprocessing of a text (or transfers benefits between two different texts) as well as when repetition benefits will occur. Most important, the model provides a theoretical basis for predicting when surface features, the textbase, and the situation model will lead to repetition effects as a function of task demands.

There is preliminary support for certain aspects of the model. For example, recall that Levy et al. (1995) had participants read and reread sets of stories that did or did not share meaning. Sharing meaning is analogous to overlap at the situation level. Reading one story facilitated reading a second story (reduced reading time) only if the stories shared meaning. In a study by Raney, Minkoff, and Therriault (1997), participants read pairs of texts that did or did not have overlapping situation models. Reading a word in one text facilitated processing of the same word when read in the second text only if the situation models overlapped. These results support episodic representation of the situation model because repetition effects were situation dependent.

There is also support for abstract representation of surface features and the textbase. In the study by Levy et al. (1993), participants reread paraphrases that changed the syntactic structure or the wording. Paraphrases alter the surface form and textbase, but not the situation model. They found repetition effects for both types of paraphrases. In a study by Raney, Atilano, and Gomez (1996), participants read texts twice in succession, and the texts were either identical during the second readings or different language translations (e.g., English–Spanish). Like paraphrases, translations change the surface form and textbase but not the situation model. For fluent bilinguals, similarly sized rereading benefits were found for identically repeated passages and for translations. These studies support abstract representation of surface form and the textbase because wording and language changes did not eliminate rereading benefits.

The purpose of the following experiment was to test a specific prediction of the integrated representation model. According to the model, when a text is read twice, repetition effects will occur as long as the situation models match between readings. However, repetition effects should decrease in magnitude as the degree of overlap in the surface form or textbase is reduced. That is, repetition effects are graded, not all or none. This occurs because the degree of overlap between surface features, textbases, and situation models varies between pairs of texts.

To test this prediction, a procedure is needed that allows for manipulation of the surface form and textbase independent of the situation model. In addition, to avoid the task-related confounds characteristic of some prior research, the procedure must allow participants to read natural text (e.g., not scrambled) without a secondary task (e.g., proofreading). Finally, the procedure must allow for measuring reading time for individual words so that the source of repetition effects can be localized. This experiment meets these goals by using a paraphrasing task similar to that used by Levy et al. (1993), but it uses eye movements to measure reading performance. Participants read a set of passages twice in succession. During the second readings, passages were either identical repetitions or paraphrases of the original passages. In addition, target words were embedded in the passages so that repetition effects for identically repeated words and synonyms could be compared. Repetition effects are expected for repeated passages and paraphrases because the situation models overlap in each case, but smaller repetition effects are expected for paraphrases because their surface features and textbases overlap less.

Sentence recognition has been one of the primary techniques for teasing apart the influence of surface features, the textbase, and the situation model on comprehension and memory (e.g., Bates, Masling, & Kintsch, 1978; Fletcher, 1994;

Fletcher & Chrysler, 1990; Kintsch & Bates, 1977; Kintsch et al., 1990; van Dijk & Kintsch, 1983). For example, comparing recognition of an original sentence to a paraphrase of the original is used to distinguish between the impact of the surface code and the textbase on memory. Comparing reading times for identically repeated and paraphrased texts extends the logic of this task without the need for explicit recognition judgments. Measuring changes in reading times between first and second readings is essentially an implicit savings measure, which is known to be a highly sensitive measure of memory (Rayner, Raney, & Pollatsek, 1995; Woodsworth & Schlosberg, 1954).

The eye movement technique also provides the ability to compare reading times for identically repeated words to words that are changed to synonyms. This comparison is essential for isolating the source of repetition benefits. Repetition benefits could result from several sources, including faster access of individual words as well as faster integration of a word into its context. Models that postulate abstract repetition effects indicate the source of facilitation is increased activation of a word's lexical entry or memory for individual words. Accordingly, individual words should be accessed faster. Episodic models postulate faster processing due to the reactivation of a specific text memory or context. This should facilitate semantic processes, such as integration of a word's meaning with its context, and lead to faster reading but not necessarily faster word access. These explanations can be distinguished by examining reading times for individual words in combination with global measures of processing, such as overall reading time. Comparing reading times for individual words in repeated and paraphrased texts is performed in this study for the first time.

METHOD

Participants

Thirty-six students from the University of Illinois at Chicago participated for course credit. All were native English speakers, had normal or corrected-to-normal vision (soft contacts were allowed), and were unaware of the purpose of the experiment.

Apparatus

A Dr. Bouis Monocular Oculometer was used to track eye movements. The eye-tracker works by emitting a low-intensity infrared light onto the participant's right eye and measuring the reflection across the surface of the eye. The reflection is minimal at pupil center, and this minimum reflection point is tracked to determine where the eye is focused. Eye position was sampled at a rate of 1000 Hz.

Texts were displayed using a VGA monitor positioned 72 cm from the participant. Two or three sentences (three or four lines of text) were displayed at one time. Lines were double spaced and maximum line length was 72 characters. Four horizontal characters equaled 1° of visual angle. Characters were cyan in color on a black screen.

Materials

The stimuli consisted of eight pairs of expository text passages that were, on average, 101 words in length. Passages were displayed in three segments, with two or three sentences per segment (because the eyetracker had limited vertical range). A version of each passage was read twice. During the second reading, participants either read the original text again or a paraphrased version of the original text. A sample passage is presented in the Appendix. Paraphrases were formed by replacing, on average, 37% of the original words with synonyms or word phrases of similar meaning. Of the words changed, 93% were content words and 7% were function words. Within the context of the passages, the meanings of the new words were judged to be highly similar to the original words, as illustrated in the Appendix and Table 1. Original and paraphrased passages were matched on number of words and average word frequency of the content words. Preliminary testing was performed to ensure that the original and paraphrased versions of a text were read at similar rates. One passage from each pair was then randomly chosen to be the original passage and the other the paraphrased passage.

Embedded in each passage were two target words. Each target word was paired with a synonym (from the paraphrase) that was matched roughly for word length and word frequency. Thus, 32 different target words were used (16 pairs of synonyms). Target word pairs were chosen to maintain as similar a meaning as possible within a sentence. During the second reading, target words were either identical or were replaced with their synonyms. The two words preceding a target word were also matched roughly for word length and frequency. If the words preceding target words could not be replaced by matched synonyms, then they were not changed. This was done to control for potential spillover of processing (i.e., to ensure that words preceding target words did not influence processing time of the target words). Target words are listed in Table 1.

The combination of changing the passage and the target words during the second reading created four conditions: (a) same passage and same target words during each reading, (b) same passage during each reading but different target words during the second reading, (c) different passage (paraphrase) during the second reading but the same target words during each reading, and (d) different passage and different target words during the second reading. Reading target words in repeated (same) and paraphrased (different) passages allows evaluation of word repetition effects when target words are repeated in the same or different context. Eight versions of each passage pair were created so that every target word was read during both the first and second readings and as an identically repeated word or a synonym during the second reading. That is, for half of the participants, T1 targets were read during the first reading, and T2 targets were read during the first reading by

TABLE 1
Target Word Pairs Along With Their Frequencies and Lengths

	Target Words Pairs		*Frequency*		*Length*	
Passage Topic	*T1*	*T2*	*T1*	*T2*	*T1*	*T2*
1. Bison	Coming	Landing	16	15	6	7
	Articles	Objects	99	115	8	7
2. Punishment	System	Program	548	529	6	7
	Substitute	Replacement	17	23	10	11
3. Hibernation	Season	Months	125	627	6	6
	Stupor	Trance	4	6	6	6
4. Apples	Locations	Regions	81	119	9	7
	Varieties	Classes	93	292	9	7
5. Birds	Offspring	Descendants	7	7	9	11
	Sectors	Segments	23	20	7	8
6. Oyster	Pieces	Parts	219	160	6	5
	Areas	Places	562	584	5	6
7. Soap	Ceremony	Ritual	32	27	8	6
	Cover	Layer	52	22	5	5
8. Pollination	Material	Matter	269	342	8	6
	Practice	Pattern	132	159	8	7
M			142	190	7.3	7.0

the remaining participants. This ensured that every target word (i.e., all T1 and T2 target words) contributed to the mean in each condition, resulting in perfectly matched target words across conditions.

Procedure

All participants were tested individually. On arriving, participants were given a description of the apparatus and instructions about the experiment. The experimenter then prepared a bite bar that served to stabilize participants' heads while reading. Instructions indicated that each text would be read twice in succession, a true–false question would be presented after both the first and second readings, and the second reading would either be the same text or a paraphrase. Participants were instructed to read in a normal manner and at a comfortable reading rate. Participants were also told that each passage would be presented in three segments and that between reading each segment the accuracy of the eyetracker would be checked. The eyetracker was then calibrated (adjusted).

Before presenting the first segment of a passage (and between each segment), two rows of boxes (five in the top row and three centered in the bottom row) were displayed with the top left box corresponding to the position of the first letter in a text segment. Participants were told to look at each box, starting at the lower right, moving across the bottom row, proceeding to the top right, and then moving across the top row. If the calibration was satisfactory, then the experimenter presented the next segment. Otherwise, proper adjustments were made. Checking calibration normally took 3 to 5 s. After reading a segment, participants pressed a response key to clear the monitor screen, and calibration accuracy was again checked. After reading an entire passage (three segments), participants responded to a true–false question by pressing one of two response keys. The passage was then reread in one of the four conditions.

Before beginning the experiment, participants were given a practice session that included demonstrating the eyetracking procedure, reading a normal and paraphrased passage, and answering sample true–false questions. A break was given halfway through the experiment. The experiment never exceeded 1 hr.

RESULTS AND DISCUSSION

Two types of data are presented: global measures, which are based on reading an entire passage (i.e., all three segments of a passage), and target word measures, which are based on fixation time for the target words only.

Global Measures

Global measures include overall reading time, forward and regressive fixation durations, and the number of forward and regressive fixations. *Overall reading time* was defined as the sum of reading times for the three segments per passage. *Forward fixations* were defined as fixations following left-to-right moving saccades or following saccades from the current line to the subsequent line. *Regressive fixations* were defined as fixations following right-to-left moving saccades or following saccades from the current line to the previous line. Repetition effects are indicated by reduced fixation time and fewer fixations during the second reading.

For each measure except overall reading time, fixations less than 100 ms or greater than 800 ms were omitted. These cutoffs are consistent with prior research that has examined global changes in reading performance (Pollatsek, Raney, LaGasse, & Rayner, 1993; Raney & Rayner, 1995). Overall reading time is not based on the sum of individual fixations and saccades so, therefore, these cutoffs do not influence overall reading time. Because global measures reflect reading performance across an entire passage, global measures were collapsed across target word type (identical or synonym) prior to analysis. For each measure, separate one-way analyses of variance (ANOVAs) were performed to compare the first and second readings for repeated passages and paraphrases. Analyses were performed based on subject variability (F_1) and on item variability (F_2). Means as a function of reading presentation (first and second) and passage type (repeated and paraphrase) are presented in Table 2.

TABLE 2
Mean Reading Times, Forward and Regressive Fixation Durations, and Number of Forward and Regressive Fixations During the First and Second Readings

			Second Reading			
	First Reading		*Repeated Passages*		*Paraphrased Passages*	
Measure	*M*	*SE*	*M*	*SE*	*M*	*SE*
Total time (s)	33.5	1.3	26.0	0.8	28.4	1.0
Forward fixations						
Duration (ms)	255	5.5	242	4.9	245	5.1
Number	87.6	3.3	71.6	1.9	74.9	2.0
Regressive fixations						
Duration (ms)	240	5.0	233	5.4	237	6.9
Number	19.5	1.8	12.0	1.1	14.1	1.2

Note. Means represent averages across entire passages.

As predicted, participants read significantly faster during the second readings than during the first readings of identical passages, $F_1(1, 35) = 84.7$, $MSE = 11.83$, $p < .001$; $F_2(1, 7) = 386.07$, $MSE = .61$, $p < .001$, and paraphrased passages, $F_1(1, 35) = 87.5$, $MSE = 3.8$, $p < .001$; $F_2(1, 7) = 235.76$, $MSE = .45$, $p < .001$. Specifically, reading time decreased by 7.5 s for repeated passages and 5.1 s for paraphrased passages. Repeated passages were read significantly faster (by 2.4 s) than paraphrased passages, $F_1(1, 35) = 27.4$, $MSE = 5.26$, $p < .001$; $F_2(1, 7) = 56.02$, $MSE = .61$, $p < .001$.

Analyses of the fixation data showed that most global measures reflected repetition effects. For identically repeated passages, forward fixation duration decreased by 13 ms, $F_1(1, 35) = 52.4$, $MSE = 59.5$, $p < .001$; $F_2(1, 7) = 77.12$, $MSE = 10.35$, $p < .001$; the average number of forward fixations decreased by 16, $F_1(1, 35) = 55.2$, $MSE = 83.9$, $p < .001$; $F_2(1, 7) = 567.0$, $MSE = 1.29$, $p < .001$; regressive fixation duration decreased by 7 ms, $F_1(1, 35) = 3.2$, $MSE = 250.12$, $p = .08$; $F_2(1, 7) = 5.49$, $MSE = 48.06$, $p = .052$; and the average number of regressive fixations decreased by 7.5, $F_1(1, 35) = 63.3$, $MSE = 16.0$, $p < .001$; $F_2(1, 7) = 100.61$, $MSE = 1.67$, $p < .001$. For paraphrased passages, every global measure showed repetition effects except for regressive fixation duration: Forward fixation duration decreased by 10 ms, $F_1(1, 35) = 64.8$, $MSE = 24.6$, $p < .001$; $F_2(1, 7) = 36.62$, $MSE = .61$, $p = .001$, the average number of forward fixations decreased by 12.7, $F_1(1, 35) = 32.7$, $MSE = 89.0$, $p < .001$; $F_2(1, 7) = 323.61$, $MSE = 1.21$, $p < .001$; and the average number of regressive fixations decreased by 5.4, $F_1(1, 35) = 33.9$, $MSE = 15.5$, $p < .001$; $F_2(1, 7) = 224.86$, $MSE = .28$, $p < .001$. Regressive fixation duration decreased by 3 ms, but this change was not statistically significant, F_1 and $F_2 < 1.0$.

Fixations measures from the second readings were also contrasted. Except for regressive fixation duration, repetition effects were significantly larger for repeated passages than for paraphrased passages. Analyses revealed that forward fixation duration was 3 ms shorter in identically repeated passages, $F_1(1, 35) = 5.7$, $MSE = 44.5$, $p < .03$, the average number of forward fixations was 3.3 less in identically repeated passages, $F_1(1, 35) = 9.1$, $MSE = 2.4$, $p < .005$, and the average number of regressive fixations was 2.1 less in identically repeated passages, $F_1(1, 35) = 9.6$, $MSE = 0.9$, $p < .005$. Regressive fixation duration was 4 ms shorter in identically repeated passages, but this difference was not significant, $F_1 < 1.0$.

Summary of global measures. The analyses of global measures support the conclusion that rereading produces a general facilitation of processing. Every global measure except regressive fixation duration consistently reflected reliable repetition effects. Specifically, overall reading time, forward fixation duration, and the number of forward and regressive fixations were reduced during the second readings. Repetition effects were found for repeated passages and for paraphrased passages, but the effects were larger for repeated passages.

These results are consistent with several prior studies. For example, recall that Levy et al. (1993) had participants reread identical passages or paraphrases and measured total reading time. They found repetition effects in both conditions, but the repetition effects were larger for identical passages. Hyona and Niemi (1990, Experiment 1) had participants read a lengthy text twice in succession while their eye movements were monitored. Repetition again influenced most global measures, and repetition effects were similar in size to those found in this study. For example, average forward fixation duration reduced by 11 ms. In a similar study, Raney and Rayner (1995) had participants read short passages twice in succession while their eye movements were measured. Repetition effects were found for each global measure except regressive fixation duration. That study, along with the results reported here, supports the conclusion that regressions were primarily made to read skipped or misread words and not to review the semantic content of a text. If regressions were made to review content, regressive fixation duration should have been reduced during the second reading.

Target Word Measures

Target word measures include first fixation duration, gaze duration, and total time on the targets. *First fixation duration* represents the duration of the first fixation on a word, independent of the number of fixations made on the word. *Gaze duration* represents the sum of all fixations on a word prior to moving to another word (i.e., regressions are excluded). *Total time* represents the sum of all fixations made on a word, including regressions. Fixations less than 100 ms or greater than 800 ms were again excluded. Means for each target word measure are presented in Table 3.

TABLE 3
Mean First Fixation Duration, Gaze Duration, and Total Time (in ms) for Target Words During the First and Second Readings

	First Fixation Duration		*Gaze Duration*		*Total Time*	
	M	*SE*	*M*	*SE*	*M*	*SE*
First reading						
M	268	7.9	320	11.4	385	16.1
Second reading						
M	252	7.5	292	11.3	320	12.3
Repeated passages						
Identical target	244	8.8	269	11.2	293	13.2
Synonym target	250	9.7	304	19.5	339	20.1
Paraphrased passages						
Identical target	255	10.7	298	17.5	319	18.1
Synonym target	259	10.2	299	14.8	326	20.6

For all three target word measures, ANOVAs based on fixation times during the first reading revealed no differences between conditions, by subject, all $Fs(1, 35) < 1.2$; by items, all $Fs(1, 31) < 1$. Therefore, for analyses comparing fixation times during the first and second readings, reading time for the first reading was based on the average duration from the first reading regardless of the subsequent condition during the second reading. From the readers' perspective, different conditions did not exist during the first reading because they did not know what type of passage they would read during the second reading.

Separate one-way ANOVAs were performed to compare the first and second readings for repeated passages, paraphrased passages, identical targets, and synonym targets. Separate analyses were performed because passage type (repeated or paraphrased) and word type (identical or synonym) were dummy variables during the first reading. The second reading data were also analyzed separately to check for differences in fixation durations across conditions. These analyses included passage type and word type as variables.[1]

[1]In text repetition studies, the second reading data are commonly analyzed in one of two ways. One way is to directly compare reading times between conditions for the second reading only. This approach was adopted in the analyses reported here. The second approach is to analyze the difference between first and second reading times as a function of condition during the second reading. If reading times during the first reading vary as a function of condition during the second reading, then it is possible for analyses based on difference scores to support different conclusions than analyses based on reading times during the second reading alone. To examine this possibility, analyses were also performed based on differences between first and second reading times. These analyses produced the same pattern of results as analyses based on fixation times during the second reading. Therefore, analyses based on difference scores are not reported here. Finding similar outcomes across analyses lends confidence to our results.

First fixation duration. As predicted, first fixation duration on the target words reduced during the second reading for repeated passages (21 ms) and paraphrased passages (11 ms). The repetition effect was statistically significant for repeated passages, $F_1(1, 35) = 5.54$, $MSE = 1{,}370$, $p < .03$; $F_2(1, 31) = 9.2$, $MSE = 679$, $p < .005$, but only marginally significant in the items analysis for paraphrased passages, $F_1(1, 35) = 1.56$, $MSE = 1{,}252$, $p = .22$; $F_2(1, 31) = 2.95$, $MSE = 846$, $p = .10$. When the data were grouped by target word type, repetition effects were found for identical targets (18 ms on average) and for synonyms (13 ms on average). However, the repetition effect was significant for identical targets, $F_1(1, 35) = 4.90$, $MSE = 942$, $p < .04$; $F_2(1, 31) = 4.95$, $MSE = 610$, $p < .04$, but only approached statistical significance for synonyms, $F_1(1, 35) = 2.63$, $MSE = 1{,}154$, $p = .12$; $F_2(1, 31) = 3.44$, $MSE = 822$, $p = .08$.

Evaluation of mean first fixation durations from the second readings shows that fixation duration increased by approximately 5 ms with each incremental change to the passage. That is, first fixation duration was 244 ms for repeated target words in the same passage (i.e., same passage and same targets), 250 ms for synonyms read in the same passage (i.e., same passage and different targets), 255 ms for repeated targets in a different passage (i.e., different passage and same targets), and 259 ms for synonyms read in a different passage (i.e., different passage and different targets). According to the integrated representation model, repetition effects should decrease in magnitude as the passage is increasingly modified relative to the initial reading. Although first fixation durations follow this pattern, when fixation times from the second reading were analyzed, no reliable differences were found as a function of passage type, $F_1(1, 35) = 1.35$, $MSE = 2{,}690$, $p = .25$; $F_2 < 1$, or target word type, $F_1 < 1$; $F_2 < 1$, nor was there a significant interaction, $F_1 < 1$; $F_2 < 1$.

These analyses demonstrate the existence of reliable repetition effects for target words that were repeated in the same passages during the second reading and for target words that were identically repeated, regardless of passage type. The 11-ms repetition effect for paraphrased passages and the 13-ms repetition effect for synonyms did not reach the traditional level of significance. Although the size of repetition effects varied, the difference in fixation times between target words was not significant during the second reading. Given the small repetition effect for paraphrased passages, the first fixation duration data support the conclusion that reading a paraphrase reduces individual word-level repetition effects to a non-significant amount.

Gaze duration. As expected, gaze duration on the target words reduced during the second reading for repeated passages (34 ms) and for paraphrases (21 ms). This difference was significant for repeated passages, $F_1(1, 35) = 6.07$, $MSE = 3{,}467$, $p < .02$; $F_2(1, 31) = 13.17$, $MSE = 1{,}456$, $p < .001$, and for paraphrased passages, $F_1(1, 35) = 6.62$, $MSE = 1{,}250$, $p < .02$; $F_2(1, 31) = 3.11$, $MSE = 1{,}918$, $p = .09$. When the data were examined by target word type, repetition effects were found for identical targets (36 ms), $F_1(1, 35) = 16.27$, $MSE = 1{,}450$, $p < .001$; $F_2(1, 31) = 10.7$, $MSE = 1{,}219$, $p < .005$, and for synonyms (18 ms), $F_1(1, 35) = 3.01$, $MSE = 2{,}113$, $p = .09$; $F_2(1, 31) = 4.35$, $MSE = 1{,}483$, $p < .05$, although size of the effect was larger for identical targets.

Inspection of mean gaze durations from the second reading shows that fixation duration was 30 ms to 35 ms shorter for identical target words in repeated passages (i.e., same passage and same targets) than for the remaining three conditions, which were highly similar to each other. Analysis of gaze durations during the second reading indicated a significant main effect of target word type in the subjects ANOVA but only a marginally significant effect in the items ANOVA, $F_1(1, 35) = 3.82$, $MSE = 3{,}732$, $p = .06$; $F_2(1, 31) = 1.61$, $MSE = 4{,}640$, $p = .21$, reflecting the fact that gaze duration for identical targets (284 ms) was 18 ms faster than gaze duration for synonym targets (302 ms). Although the mean gaze duration for targets in repeated passages was 13 ms shorter than for targets in paraphrased passages, this difference was not significant, $F_1 < 1$; $F_2 < 1$. There was only a hint of an interaction between passage type and target word type, $F_1(1, 35) = 1.66$, $MSE = 6{,}075$, $p = .21$; $F_2 < 1$, which is surprising given that the target type effect seems almost wholly due to differences between targets in repeated passages.

The analyses indicate repetition effects existed in each condition, although the size of the effects varied. There were reliable differences between reading times for identical target words and synonyms during the second reading, which suggests that changing a word to a synonym does reduce the repetition effect for that word. This stands in contrast to the first fixation data, in which reliable repetition effects were not found for paraphrased passages or for synonym targets. Taken together, these results show that when multiple fixations are made on words, repetition effects are enhanced. This issue is discussed further after the total time data are presented.

Total time. Total time on the target words was reduced during the second reading for repeated passages (69 ms) and for paraphrases (62 ms). This difference was significant in both conditions: for repeated passages, $F_1(1, 35) = 19.32$, $MSE = 4{,}406$, $p < .001$; $F_2(1, 31) = 34.68$, $MSE = 2{,}214$, $p < .001$, and for paraphrased passages, $F_1(1, 35) = 31.27$, $MSE = 2{,}227$, $p < .001$; $F_2(1, 31) = 25.2$, $MSE = 2{,}232$, $p < .001$. Grouping the data by target word type showed large repetition effects for identical targets (79 ms), $F_1(1, 35) = 33.91$, $MSE = 3{,}014$, $p < .001$; $F_2(1, 31) = 51.28$, $MSE = 1{,}350$, $p < .001$, and for synonyms (52 ms), $F_1(1, 35) = 18.77$, $MSE = 2{,}624$, $p < .001$; $F_2(1, 31) = 22.39$, $MSE = 2{,}141$, $p < .001$.

During the second reading, fixation duration was again shortest for identical target words in repeated passages than for the remaining three conditions, but repetition effects were apparent in all four conditions. Analyses indicated a significant main effect of target word type for the subject analysis, but not for the items analysis, $F_1(1, 35) = 4.66$, $MSE = 6{,}375$, $p < .04$; $F_2(1, 31) = 1.06$, $MSE = 11{,}045$, $p = .31$. This reflects the fact that total time for identical targets (306 ms) was 27 ms faster than for synonyms (333 ms). There was no significant main effect of passage type, $F_1 < 1$; $F_2 < 1$, nor an interaction, $F_1(1, 35) = 1.45$, $MSE = 9{,}121$, $p = .24$; $F_2 < 1$.

The total time data are consistent with the gaze duration data: Significant repetition effects were found for repeated and paraphrased passages and for identical and synonym targets. These results further support the conclusion that changing a word to a synonym reduces the repetition effect for that word.

Summary of target word measures. Target word repetition effects were found using each measure, but average repetition effects were smallest for first fixation duration (16 ms), slightly larger for gaze duration (28 ms), and largest for total time (65 ms). Recall that the average repetition effect was 12 ms for forward fixation duration (a global measure). It is apparent that global measures, which are averaged across all fixations, underestimate the size of repetition effects for individual content words.

Significant repetition effects occurred for target words in repeated passages and in paraphrased passages. However, when reading a paraphrased passage, repetition effects were primarily limited to words that received multiple fixations (i.e., gaze duration and total time). The same pattern was found when identically repeated target words were compared to synonyms (i.e., collapsing across passage type). Repetition effects were robust for identical target words, but when the measure of processing time included multiple fixations, repetition effects increased to a significant magnitude for words replaced by synonyms.

In summary, the target word analyses demonstrate that changing words to synonyms does not eliminate repetition effects, but the effects are enhanced when multiple fixations are made on a word. Multiple fixations are most likely made when a word is long, occurs with low frequency, or requires extra time to be integrated into its context (Rayner & Pollatsek, 1989). Given that every target word was used within each condition, word length and word frequency cannot be used to explain our findings. This leads to the conclusion that reduced integration difficulty during the second reading contributed to the reduction in fixation times. Once a word is accessed, the context in which it must be integrated is already familiar, so integration and comprehension will be facilitated and processing time will be reduced (Rayner et al., 1995).

CONCLUSIONS

This experiment tested the integrated representation model of text repetition effects (Raney, 1999). It was predicted that repetition effects would decrease in size as the overlap in the surface form and textbase was reduced. Precisely this pattern of results was obtained. Repetition effects were found for most global measures, demonstrating that repetition effects occur for multiple aspects of reading performance. Importantly, analyses of target words extended these findings by providing information about when and why word-level repetition effects occur. The fact that first fixation duration, gaze duration, and total time were all shorter during the second reading for repeated words supports the conclusion that early stages of word processing, such as lexical access, and later stages, such as integration, are both facilitated for repeated words. Only gaze duration and total time were facilitated for synonyms, which suggests that only later processing stages are substantially facilitated for synonyms. These findings demonstrate that text repetition effects cannot be limited to a single source or mechanism. Overall, the pattern of results is highly consistent with the integrated representation model of text repetition effects. Implications of the primary results are discussed next.

As predicted, global measures showed significant repetition effects for repeated and paraphrased passages, and the size of the repetition effect was larger for repeated passages. Target word measures evidenced a similar pattern for repeated and paraphrased passages, as well as for identical and synonym target words. The size of target word repetition effects did, however, vary across measures. These analyses support the conclusion that repetition effects were found across conditions, but the effects were most robust for repeated passages and for identical targets. These findings match the prediction that repetition effects will systematically decrease when the surface form and textbase are altered between the first and second readings.

It is important to remember that words are changed in paraphrased texts, which could lead to changes in meaning. How well the meanings match determines how well the situation model is repeated. If a paraphrase led to the development of a slightly different situation model, then the impact of repeating the situation model will be underestimated. This is consistent with the integrated representation model's prediction that changes in the situation model will reduce repetition benefits. The same restriction applies to synonyms. If synonyms are not well matched, then word-level repetition effects will be reduced, and, consequently, the impact of repeating surface features will be underestimated. Mismatched synonyms might also focus more of the reader's attention on wording (Raney, 1999).

The results also support the model's assumption that a passage's surface form and textbase are represented in memory in a context-independent (abstract) manner. The evidence for this is that when the situation model is maintained across readings, repetition effects are not dependent on repeating the surface form and textbase. However, exact repetition of the surface form and the textbase (a repeated passage) enhanced repetition effects relative to passages that had portions of the surface form and the textbase altered (a paraphrased passage). This implies that the surface form and the textbase are represented independently from the situation model (which is consistent with prior research) and that the concepts referenced by words, not necessarily the words themselves, are bound together to form a text memory (i.e., an episode).

Because episodes are based on semantic concepts, not specific words, the wording is free to vary across readings. This implies that the critical element for obtaining text repetition effects must be repetition of concepts, not repetition of individual words. The importance of conceptual repetition has been shown in other studies that measured eye movements (O'Brien et al., 1997; Raney & Rayner, 1995; Rayner et al., 1995) and overall reading time (Levy et al., 1993; Levy et al., 1995). Taken together, there is convincing evidence that conceptual repetition is a primary source of repetition effects during normal reading.

The global and target word data also support the conclusion that rereading facilitated performance in a general manner. This implies that increased reading speed during a second reading does not result from a single source but from multiple sources. This conclusion is supported by the finding that every global measure except regressive fixation duration reflected robust repetition effects. When the situation described by a text is maintained between the first and second readings, passage-level repetition effects can be thought of as an accumulation of repetition effects from several sources, including word-level and situation-level repetition effects.

Because word-level repetition effects for synonyms were primarily limited to measures based on multiple fixations, a likely source for these effects is reduced integration difficulty. Integration difficulty is related to familiarity with the concepts and situation described by the text. Concepts are familiar during the second reading, and, therefore, it is easier to integrate repeated words or synonyms into the text's representation. For identical words, both word access and integration appear to be facilitated. This makes sense because a word's lexical entry and concept are repeated. Thus, the target word data provide important new evidence that repetition at the word level (i.e., surface level) and situation level both contribute to the overall repetition effect.

Changes in integration difficulty may also provide a clue as to why repetition effects are not found when a repeated word within a single text has a different referent in each occurrence (O'Brien et al., 1997) and why repetition effects do not occur for passages that share wording but are semantically unrelated (Levy et al., 1995). In both cases, the situation referred to during the first and second encounter is different, and, therefore, repeated words are not being integrated into a repeated situation. In essence, the repeated words are bound to their original contexts or episodes. This is consistent with the integrated representation model, which predicts that when a situation model is developed and task relevant, repetition effects will occur as long as the situation is repeated. Additional research is needed to evaluate repetition effects when the situation model is changed between readings.

In conclusion, the integrated representation model of text repetition effects finds considerable support in this research. The model clarifies our understanding of text repetition effects and provides a guide for future research. These findings also provide new information that enhances our understanding of text comprehension and memory in general by specifying how a text is stored in memory and the relation between text structure and memory.

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APPENDIX
Sample Passages

Target words are presented in CAPITAL letters for illustration purposes only. The slash (/) indicates segment breaks. A true–false question was asked after the first and second readings.

Original

The invention of soap was probably accidental. One Roman legend suggests that fat from candles that were burned in a sacred RITUAL was mixed with wood ashes./ This substance flowed down a hill into a stream. The mixture of fat and wood ashes created a good cleanser. The Romans noticed it was easier to wash clothes at this point./ Water by itself cannot remove dirt and can form a protective LAYER over the dirty surface. Soap breaks through this cover and traps dirt in the liquid. Before soap was invented, olive oil and plant ashes were used as a cleaning agent.
True–False: People did not have a cleaning agent before soap was invented.

Paraphrase

The discovery of soap was most likely unplanned. One Roman story proposes that lard from candles that were lighted in a holy CEREMONY was blended with wood ashes./ This mixture ran down a slope into a creek. The combination of lard and wood ashes made a great cleanser. The Romans found it was simpler to clean clothing at this spot./ Water alone cannot extract dirt and may create an insulating COVER on the grimy surface. Soap cuts into this layer and captures soil in the water. Before soap was created, olive oil and plant ashes were used as a cleanser.
True–False: History suggests that soap was first made from wax and wood ashes.