Accessing Situation Model Information: Memory-Based Processing Versus Here-and-Now Accounts

JOHN D. MURRAY
Department of Psychology
Georgia Southern University

RANDALL ENGLE
School of Psychology
Georgia Institute of Technology

ABSTRACT. The focus of the present research was to compare the memory-based processing and here-and-now accounts of situation model updating during reading. The authors conducted two experiments as a follow-up on work by R. A. Zwaan and C. J. Madden (2004), who disputed the conclusions of E. J. O'Brien, M. L. Rizzella, J. E. Albrecht, and J. G. Halleran (1998). The latter researchers found support for the memory-based processing view by showing that readers experienced reading difficulty on a sentence that was consistent with an updated model of the story's protagonist but was inconsistent with initially stated information about the protagonist. In contrast, Zwaan and Madden eliminated what they argued were confounds in the items used by O'Brien et al. and found support for the here-and-now view. In the present article, data from 2 experiments seem to eliminate weaknesses inherent in both previous authors' work. Although the present results are consistent with the here-and-now account, they do not completely discredit the memory-based processing view.

Key words: memory-based processing, mental model, narrative text, updating

RESEARCHERS HAVE SHOWN THAT, DURING READING, individuals construct a memory representation of the text's propositional structure that also includes necessary inferences to maintain local coherence (Fletcher & Bloom, 1988; Kintsch & van Dijk, 1978; McKoon & Ratcliff, 1992). Also important, however, is the creation of a higher-level memory representation that pertains to the overall context or situation for the story. This situation, or mental model, is

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Address correspondence to John D. Murray, Department of Psychology, P.O. Box 8041, Georgia Southern University, Statesboro, GA 30460-8041; JMurray@georgiasouthern. edu (e-mail).

multidimensional and contains information about the story's physical setting and the protagonist's internal or external characteristics, thoughts, or feelings (Albrecht & O'Brien, 1993; Black, Turner, & Bower, 1979; Bower & Morrow, 1990; Glenberg, Meyer, & Lindem, 1987; Johnson-Laird, 1983; Morrow, Bower, & Greenspan, 1989; Morrow, Greenspan, & Bower, 1987; Zwaan, Magliano, & Graesser, 1995). Authors typically provide situation model information early in a story, and this information serves as a backdrop on which the narrative events unfold. Researchers have argued, however, that the content of a situation model is dynamic and is periodically updated as elements of the story's context and protagonist change during the narrative (Albrecht & O'Brien, 1993; de Vega, 1995; Glenberg et al., 1987; Morrow et al., 1989).

The updating process relies on the reader's ability to activate and instantiate background text information (i.e., information stated early in the passage) and use that information to understand the current line. Researchers have shown that readers will routinely activate and instantiate background text information even when the current line is coherent with the preceding line (Albrecht & O'Brien, 1993; Huitema, Dopkins, Klin, & Myers, 1993; Myers, O'Brien, Albrecht, & Mason, 1994; O'Brien & Albrecht, 1992). Until recently, it was thought that situation model information was reinstated only if this information was needed to mend a break in local coherence (e.g., McKoon & Ratcliff, 1992). However, it has been shown that situation model information is routinely accessed in the absence of a coherence break, such as whenever the current text refers to that information, either directly or indirectly.

In a well-known investigation by O'Brien et al. (1998), the researchers reported results in favor of a memory-based processing account that explains why situation model information becomes available when there is a break in global coherence. This view accounts for the availability of situation model information via passive, automatic connections to background text information and relevant world knowledge (McKoon, Gerrig, & Greene, 1996; McKoon & Ratcliff, 1998; Myers & O'Brien, 1998). Information in long-term memory (which includes prior text and relevant world knowledge) is activated in response to the current contents of working memory (i.e., the line currently being read). The amount of activation (termed *resonance*) is determined by the degree to which the semantic features in memory overlap with features of the current line. Memory items that strongly resonate are reinstated into working memory, where they subsequently influence processing and potentially lead either to inhibition or facilitation. (See Myers and O'Brien for a full description of this process.)

O'Brien et al. (1998) contrasted the memory-based processing view with the here-and-now view, which states that the reader maintains the most recent version of the situation model; all previously stated information that is no longer relevant will not affect comprehension of the current line. Therefore, background information that was later qualified by additional information will not influence

reading times on lines presented later in the passage (Morrow et al., 1989; see also Zwaan & Madden, 2004).

To compare the memory-based processing and here-and-now accounts, O'Brien et al. (1998) conducted a series of experiments in which they measured participants' reading times on a line that was consistent or inconsistent with previously stated information about the subject of the story (the protagonist). For example, in their experiments, the target line "Mary ordered a cheeseburger and fries" was preceded by text describing Mary as a junk-food addict, one who enjoyed anything that was quick and easy to fix (consistent condition) or a health nut, one who had been a vegetarian for 10 years (inconsistent condition). In addition, a third condition was added that was similar to the inconsistent condition but which also included a sentence that qualified Mary's behavior in the target sentence ("Mary never stuck to her diet when she dined out with friends").

In this condition (the qualification condition), the target sentence is sensible only with an updated model of the protagonist, and it is this condition that was of primary interest. Both the memory-based processing and the here-and-now views would predict that target sentence reading time should be relatively fast in the consistent condition because the target sentence is consistent with the background text. In contrast, both views would predict slow target sentence reading times in the inconsistent condition because the background text in this case renders the target sentence anomalous. The views diverge in their predictions associated with the qualified condition: The memory-based processing view predicts relatively slow target reading times because of the presence of inconsistent information in the situation model, which places the reading times in the qualification condition between the consistent and inconsistent conditions (i.e., $C < Q < I$). In contrast, the here-and-now view would predict no interference from the inconsistent background text because of the presence of qualifying information. Hence, this view would predict target sentence reading times that are similar to those in the consistent condition.

Over five experiments, O'Brien et al. (1998) consistently found results that supported the memory-based processing view. These results emerged even as the nature of the qualification information was strengthened in such a way as to increase the plausibility of the target behavior. In Experiment 2, for example, the qualification was strengthened by providing an explanation (Mary occasionally departed from her diet because she occasionally ate meat). In Experiment 3, the inconsistent information was made to be relevant only at an earlier time (Mary had been a vegetarian). In Experiment 4, the time shift was accompanied by an explicit denial of the inconsistent information (Mary had been a vegetarian and was no longer one). In Experiment 5, the inconsistent information was described as having never been true (Mary remembered a story a friend once told about her being a strict vegetarian). In each of these experiments, the target sentence was read significantly more slowly in the qualification condition than in the consistent condition. These results by O'Brien et al. (1998) were interpreted as highly

consistent with the memory-based processing hypothesis and against the here-and-now view.

In a recent article, however, Zwaan and Madden (2004) argued that the findings of O'Brien et al. (1998) are difficult to interpret because there are confounds within the items. Specifically, Zwaan and Madden asserted that over all five experiments, the target sentence was more plausible in the consistent condition than in the qualification condition, which could account for the differences in reading times in the two conditions. In addition, they claimed that semantic overlap between the background text and the target sentence was greater with items in the consistent condition than with items in the qualification condition. Zwaan and Madden supported their first claim by demonstrating that participants from their own lab perceived the target sentence as much more plausible in the consistent condition than in the qualification condition with items used in the O'Brien et al. (1998) Experiments 1 and 5.

To address their second claim, Zwaan and Madden (2004) compared the qualification and consistent conditions from the same two experiments, in terms of semantic overlap, by using Latent Semantic Analysis (LSA; Kintsch, 1998; Landauer & Dumais, 1997). The results of this analysis showed greater semantic overlap in the consistent condition but only in the materials used in Experiment 5. Finally, Zwaan and Madden repeated the experiment with a new set of items they believed did not suffer from the problems of those used by O'Brien et al. (1998). In their experiment, Zwaan and Madden found no difference in target sentence reading times between the consistent and qualification conditions (both were slower than the inconsistent condition). They interpreted this result to be in support of the here-and-now hypothesis.

In a rebuttal, O'Brien, Cook, and Peracchi (2004) asserted that Zwaan and Madden's (2004) analysis of the items used in O'Brien et al. (1998), along with the re-test using new items, were flawed. Specifically, the differential plausibility between the consistent and qualification target sentences was shown to be as much of a problem in Zwaan and Madden's new items as it was in the items used by O'Brien et al. (1998). Furthermore, O'Brien et al. (2004) discounted Zwaan and Madden's use of LSA as an indicator of semantic overlap by showing how the analysis output changes with very slight, meaningless changes in item wording. Moreover, O'Brien et al. (2004) argued that Zwaan and Madden's overall conclusion is unwarranted because their new items did not even require readers to consult the situation model (rather, the target sentence used in Zwaan and Madden's item required an anaphoric reference). O'Brien et al. (2004) summed up their rebuttal by making the point that a passive resonance process is most likely an important part of every theory of comprehension, and that a nonsignificant difference in reading time between consistent and qualification conditions does not eliminate the possibility that background inconsistent information was reactivated (p. 290).

The focus of our present research was to compare the memory-based processing and here-and-now views by taking into account the comments from

Zwaan and Madden (2004) and O'Brien et al. (2004). We followed the paradigm initiated by O'Brien et al. (1998) and used modified versions of their original items. We used their original items because they were designed so that readers would have to consult the situation model depicted in the initial sentences of the passage, a fundamental weakness in the items used by Zwaan and Madden. We improved item plausibility by modifying the qualification version of the O'Brien et al. (1998) items. Like Zwaan and Madden, we hypothesized that participants in the O'Brien et al. (1998) experiments may have slowed down on the target line in the qualification condition because the target action may not have been sufficiently qualified.

Our goal, however, was to put the memory-based processing perspective to a fairer test by explicitly asserting, in the qualification condition, that the target behavior *could* be performed, rather than deny that the behavior was true. To illustrate with the sample item, our modification of the qualification condition states that Mary never stuck to her diet when she dined out with friends and would even eat greasy junk food. We predicted that the target sentence "Mary ordered a cheeseburger and fries" would be easier to read if participants know Mary occasionally eats greasy junk food than if they know that her status as a vegetarian is in question. This modification preserves the presence of the original, inconsistent information. Therefore, according to the memory-based hypothesis, the inconsistent information should still be activated at the point of reading the target action. However, the here-and-now view would predict that readers would have little trouble comprehending the target sentence because it is consistent with the most recent update of the situation model (i.e., that Mary occasionally eats greasy food).

EXPERIMENT 1

Method

Participants

Ninety-one undergraduates from Georgia Southern University and the Georgia Institute of Technology participated in exchange for extra credit in a psychology course.

Materials

The primary materials were 18 experimental passages and 6 filler passages, in the form of stories, taken from O'Brien et al. (1998). Experimental passages ranged in length from 13 to 17 sentences, and each followed a similar format. Two or three sentences of introduction were followed by three to four sentences of elaboration that pertained to a critical characteristic of the main protagonist.

There were three versions of this elaboration information. In the consistent version, the elaboration focused on characteristics of the protagonist that were consistent with the behavior described in the first target sentence. In the inconsistent version, the protagonist was described as possessing characteristics that were highly inconsistent with the behavior stated in the first target sentence. The qualification version was identical to the inconsistent version but contained one additional sentence that described a qualification under which the protagonist would execute the behavior stated in the first target sentence. The elaboration information was followed by six sentences that moved the focus away from the main character and served as background for the elaboration information. Each passage ended with a target sentence. The target action depicted the protagonist engaging in a behavior that was consistent or inconsistent with the preceding elaboration information.

The six filler stories shared the same format as the consistent versions of the experimental passages. As in O'Brien et al. (1998), the passages were arranged in three orders, and each order contained a different version of each experimental passage. Because each participant was exposed to only one order, only one version of each passage was read. Over the three orders, all the passages were represented in each version. The filler passages were randomly interspersed within the experimental passages.

In the present research, the consistent and inconsistent versions of each item were identical to those used by O'Brien et al. (1998) in their first experiment. We modified the qualification version in such a way as to increase the plausibility of the target action. To this end, we rewrote the original qualification information to directly state or imply that the protagonist would execute the target action. For example, in the item discussed in the introduction, the O'Brien et al. (1998) original qualification version stated "Nevertheless, Mary never stuck to her diet when she dined out with friends." In our modification, we replaced the original text with "Nevertheless, when Mary dined out with friends she never stuck to her diet and would even eat greasy junk food."

Pre-testing. Our modifications were pre-tested with a separate group of 52 undergraduates enrolled at the Georgia Institute of Technology. These students, participating in exchange for extra credit in a psychology class, rated the likelihood that the protagonist would execute the target action after reading one of three versions of the passages: (a) the inconsistent elaborations, (b) the qualification version used in the O'Brien et al. Experiment 1 (original qualification), and (c) the qualification version used in the present experiment (modified qualification).

We presented the passages in a booklet, one per page; they consisted of all the text from the beginning of the passage to the line immediately prior to the first target sentence. Each participant read six passages in each of the three conditions. Across all participants, each passage appeared in each condition an approximately equal number of times. Participants rated the likelihood that the

protagonist would execute the target action on a Likert-type scale ranging from 1 (*not likely*) to 7 (*very likely*). The mean likelihood ratings for the target action in the inconsistent, original qualification, and modified qualification versions were 1.71, 3.63, and 4.04, respectively. We hypothesized that the target behavior would be significantly less likely to occur following the inconsistent elaboration than following the original and modified qualification versions, Fs $(1, 51) = 224.95$ and 200.68, respectively. More important, we hypothesized that the target action would be more likely to occur following the modified qualification version than the original qualification version, $F(1, 51) = 5.9$, $p = .02$.

Procedure

Participants read each passage on a computer monitor. They were told that their primary goal was to read each passage carefully enough to accurately respond to a comprehension question that followed each passage. Each passage began with a "Ready" signal. Participants read each passage one line at a time, at their own pace, by pressing the space bar to advance each line. The time between key presses was stored as data. Each passage was followed by a comprehension question. Yes and no responses were made by pressing the "/" and "z" keys, respectively. There were an equal number of yes and no questions. Participants were not given feedback about their accuracy on the comprehension questions. Participants read through three practice passages before reading the 18 experimental and 6 filler passages.

Results and Discussion

The data from 1 participant were discarded because of a failure to follow instructions. Therefore, the analyses are based on the data from 90 individuals. The primary data of interest were the reading times on the target sentences. Outliers were defined as reading times greater than three standard deviations from a participant's mean in each condition. No data were eliminated on the basis of this criterion. The mean reading times for the target sentence in the consistent, modified qualification, and inconsistent conditions were 1,997, 2,051, and 2,275 ms, respectively (SDs = 563, 588, and 685 ms, respectively). The means were analyzed by a one-way analysis of variance (ANOVA). Analyses based on subject variability are denoted by F_1, and analyses based on item variability are denoted by F_2. All p values in both experiments were less than .05 unless otherwise noted, and p values for post hoc comparisons were based on Bonferroni probabilities, which allowed for a family-wise alpha of .05.

As we expected, reading times were slower in the inconsistent condition than in the consistent condition. However, the question of interest is with regard to the modified qualification condition. With respect to the target sentence, reading times were significantly faster in the modified qualification condition

than in the inconsistent condition. However, the difference in reading times between the modified qualification condition and the consistent conditions was not significant.

The findings with respect to the target sentence were confirmed by an ANOVA, which showed an overall effect of consistency, $F_1(2, 178) = 22.17$, $MSE = 88,097$, $\eta^2 = .199$; $F_2(2, 34) = 16.56$, $MSE = 23,505$, $\eta^2 = .493$. Post hoc comparisons indicated that reading times in the inconsistent condition were significantly slower than those in the consistent condition, $F_1(1, 89) = 39.00$, $MSE = 178,185$, $\eta^2 = .305$; $F_2(1, 17) = 35.62$, $MSE = 38,498$, $\eta^2 = .677$, and those in the modified qualification condition, $F_1(1, 89) = 22.06$, $MSE = 204,411$, $\eta^2 = .199$; $F_2(1,17) = 23.87$, $MSE = 38,519$, $\eta^2 = .584$. The difference between the consistent and modified qualification conditions was not significant, $F_1(1, 89) = 1.8$; $F_2 < 1$.

The results of Experiment 1 replicate the results of prior research in that, in the context of stories, participants showed sensitivity to a violation of global coherence. The difference in reading times between the inconsistent and consistent conditions indicates that the background information pertaining to the protagonist was activated when the target action was encoded (Albrecht & O'Brien, 1993; Hakala & O'Brien, 1995; O'Brien et al., 1998). When this reinstated information was interpreted, it caused reading disruption in the inconsistent version because it was incompatible with the protagonist's behavior depicted in the target sentence.

The results pertaining to the modified qualification condition are consistent with those found by Zwaan and Madden (2004). However, our findings are highly meaningful because our items required participants to consult the situation model to understand the target sentence. In contrast, in their materials, Zwaan and Madden manipulated the availability of a particular instrument (e.g., a hammer) that would be necessary to execute an action depicted in the target sentence. As pointed out by O'Brien et al. (2004), in the majority of Zwaan and Madden's passages (Experiment 3), the target sentence presented a direct anaphor to a previously established antecedent. Therefore, it is highly likely that a primary determinant of reading time in that experiment is anaphor resolution rather than reliance on the existing discourse model. Because the items in the current experiment actually required participants to consult the situation model, we were able to conduct a fairer comparison between the memory-based processing and here-and-now views.

The present findings are consistent with a here-and-now view of situation model updating in story comprehension. Because a significant slow-down in reading time was not observed in the modified qualification condition, in comparison to the consistent condition, we have shown that participants suffered little comprehension difficulty from the presence of inconsistent information in the background situation model. It is, therefore, plausible that the revised qualification information may have led participants to "fully update" their mental model of the protagonist, carrying forward the most recent model of the protagonist and then integrating each subsequent line with respect to the most current version of

the mental model. However, before elaborating on the overall meaningfulness of this finding, we wanted to attempt a replication in Experiment 2.

EXPERIMENT 2

Method

Participants

Eighty-four undergraduates from Georgia Southern University took part in this experiment in exchange for extra credit in an introductory psychology class.

Materials and Procedure

The passage versions were identical to those used in Experiment 1, with one slight modification. To equate the three passage versions to an even greater extent with respect to wording, we added a primary content word appearing in the modified qualification and inconsistent conditions to the text of the consistent condition. For example, the word *vegetarian*, included in the inconsistent and modified qualification conditions, was omitted from the consistent condition. Therefore, we included it in the consistent version: "Hardly a vegetarian, Mary enjoyed anything that was quick and easy to fix." We made this change in the consistent version of all 18 experimental items. The procedure was identical to that used in Experiment 1.

Results and Discussion

The data from 7 participants were omitted from the analyses. Two participants failed to follow instructions; 3 missed more than four comprehensions; and mechanical difficulty led to the elimination of the data from 2 additional participants. The reported analyses, therefore, are based on 77 participants.

We computed mean reading times on the target sentence for each participant, for each condition. As before, no outliers were found in these data. Mean reading times for the consistent, modified qualification, and inconsistent conditions were 2,186, 2,216, 2,390 ms, respectively (SDs = 616, 546, and 672 ms, respectively). Analyses on the target sentence reading times showed the same pattern found in Experiment 1: The inconsistent condition was read more slowly than both the consistent and modified qualification condition. The former comparison was significant by both subjects and items, and the latter was significant only by subjects. The very slight difference between the consistent and modified qualification condition was not statistically reliable.

We confirmed these findings with a one-way ANOVA in which an overall effect for consistency emerged, $F_1(2, 152) = 8.91$, $MSE = 104,881$, $\eta^2 = .105$; $F_2(2, 34) = 6.02$, $MSE = 36,117$, $\eta^2 = .261$. The comparison between the consis-

tent and inconsistent conditions was highly significant, $F_1(1, 76) = 13.12$, $MSE = 244,239$, $\eta^2 = .147$; $F_2(1, 17) = 9.91$, $MSE = 77,921$, $\eta^2 = .368$. The comparison between the modified qualification and inconsistent conditions was significant only in the subjects analysis, $F_1(1, 76) = 12.45$, $MSE = 187,284$, $\eta^2 = .141$; $F_2(1, 17) = 5.56$, $p = .03$, $MSE = 90,520$, $\eta^2 = .246$. The difference between the consistent and modified qualification conditions was not reliable, both $Fs < 1$.

The findings from this experiment are consistent with those of Experiment 1. Again, reliable differences emerged between the inconsistent and consistent conditions and strongly support the notion that readers are highly capable of detecting violations of global coherence when reading stories, even when the current sentence is completely coherent with the immediately preceding sentence (i.e., when local coherence exists). Of greatest interest, however, is the similarity in the times between the consistent and modified qualification conditions. This result replicates the findings from Experiment 1 and supports the here-and-now view. Participants did not show elevated reading times on the target sentence in the modified qualification condition despite the fact that the introduction of the passage contained content that was inconsistent with the content of the target sentence. This inconsistent content led to significant comprehension disruption in the inconsistent condition. However, the presence of the qualification statement neutralized the disrupting effects of that content.

GENERAL DISCUSSION

Over two experiments, we found support for Zwaan and Madden's (2004) claim that the here-and-now perspective is a viable description of the mechanism by which readers update situation model information when reading stories. We remedied the plausibility problem that characterized the O'Brien et al. (1998) series of experiments. We also fixed the primary weakness inherent in the items used by Zwaan and Madden. With these changes, we have reliably demonstrated that readers suffered no comprehension disruption when reading a sentence that was consistent with an updated model of the story's protagonist but was inconsistent with information initially stated in the passage. This finding is consistent with the here-and-now view, which states that when individuals read stories they will carry along with them the most recently stated version of the situation model.

Perhaps even more important, this view states that readers will not be affected by text information that is inconsistent with the most recent model that may have been stated earlier in the passage. In the current experiments, readers had virtually no difficulty reading the line "Mary ordered a cheeseburger and fries" when they knew that Mary occasionally ate greasy food. The participants experienced no lack of reading difficulty in spite of earlier content pertaining to Mary being a "health nut" and being a vegetarian for the past 10 years.

The primary claim we are making is that the observed results are highly consistent with the here-and-now perspective. However, we also concur with O'Brien et al. (2004) in stating that equivalent reading times between the consistent and modified qualification conditions do not mean conclusively that the initially stated situation model information was not consulted. Memory-based processing is a passive process that operates automatically, hence unconsciously, most of the time. It is possible that passive, automatic activation was taking place in the modified qualification condition but this information failed to influence participants' reading time.

However, the present results are consistent with those found by Zwaan and Madden (2004), which places the here-and-now perspective as a viable explanatory mechanism for situation model updating. In the present experiment, we also showed that by increasing the plausibility of the qualification condition, reading behavior was affected more than was shown in O'Brien et al. (1998). So, although we cannot completely rule out the memory-based processing view as an explanatory mechanism, we have reliably demonstrated a limiting condition of passive resonance. As stated in O'Brien et al. (2004), demonstrations such as these are highly important to advance theoretical development in models of reading behavior and comprehension in the context of narratives.

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