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A Novel Study: A Situation Model Analysis of Reading Times

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One of the basic findings on situation models and language comprehension is that reading times are affected by the changing event structure in a text. However, many studies have traditionally used multiple, relatively short texts, in which there is little event consistency across the texts. It is unclear to what extent such changes will be observed when readers are given a longer, more coherent text, such as a novel. The current study discovered that while some of the characteristics of language comprehension found with multiple shorter texts also influence the reading of a novel, such as the introduction of new characters and causal breaks, there are several notable differences. In some cases, factors did not clearly influence comprehension, and a reverse influence was observed as with spatial and temporal shifts. Thus, more work is needed to develop situation model theory that can more readily account for complex, real-world comprehension.

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When people comprehend language, such as narrative texts, they create mental representations that capture the circumstances and events being described. These mental representations are situation models (Johnson-Laird, 1983; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998), which serve as mental simulations of what is being heard or read. One of the most well-established findings in the situation model literature is that when there is an event break of some sort, such as a shift in spatial location or a new character enters the situation, there is an increase in reading time (e.g., Zwaan, Magliano, & Graesser, 1995). This increase reflects the additional mental effort a person exerts during situation model updating because, to keep pace with the conveyed events, the comprehender needs to meaningfully alter their mental representation in a way that changes their understanding of the story.

Although this general pattern of reading times is well-established, it should be noted that the majority of these studies used multiple, unrelated texts that were relatively short, often allowing a participant to read a large number of these within the span of 1 hr. Moreover, these texts were often written by the experimenters with the aim of investigating the critical hypotheses at hand. Although such abbreviated materials can be useful to more easily tease apart various factors that can influence reading time, it is not clear if these findings can be applied to more real-world comprehension of longer texts.

There are a number of potential issues that can arise with such experimenter-produced materials. First, the fact that the materials are short, typically less than 40 sentences long, makes it difficult for a reader to develop a relatively complex situation model, such as would occur in the comprehension of longer texts. Second, because the topics are often drastically changing with each new text, the beginning of each new text essentially serves as a profound coherence break, which disrupts comprehension to some degree. Third, the materials used are often generated by experimenters who have clear theoretical ideas in mind when they are writing the stories. It is possible that such experimenter biases may creep into the structure of the stories, thereby biasing the observed pattern of results.

Although we think that the findings from experimenter-generated materials are valuable, and in some ways a better control for unwanted factors that could occur in a naturally occurring text, it is also the case that these factors should manifest themselves in naturalistic materials as well. There have been relatively few studies that have used long and naturalistic materials. One of these was a study that evaluated comprehension using two short stories that were each about 3,000 words long (Zwaan et al., 1995). That study was able to replicate some of the situation model effects that have been found in shorter texts, like an increase in reading time with a causal break or a shift in time. Although that study used more real-world materials, it did not completely capture how reading would proceed with the longer sorts of narratives found with complete

novels. Moreover, that study only measured three theoretical variables of the many others that could have been measured.

This study used reading time data for an entire novel, and assessed whether the findings from previous work are indeed observed by a wider range of measures. Before turning to the study itself, we outline various aspects of comprehension that have been assessed in the past and that are examined in the context of our study. First, we review aspects of comprehension that are affected by characteristics of the text itself. Second, we explore factors that are relevant at the situation model level. Note that, although there may be variation in how some of these components are operationalized in the literature, given the wide range of factors that we can examine and the very large number of observations available to us, the basic principles affecting comprehension should be manifested in our results.

TEXT-LEVEL FACTORS

One text-level factor is the number of syllables per sentence, where the more syllables there are in a sentence, the longer it takes to read. This is consistent with a wide range of research showing that it takes longer to process words that involve more syllables (e.g., Baddeley, Thomson, & Buchanan, 1975), and that reading time is affected by the number of syllables in a sentence (e.g., Cameron, 1913; Graesser & Riha, 1984; Just & Carpenter, 1980; Zwaan et al., 1995). A second text-level factor is the influence of word frequency. Here, lower frequency words take longer to retrieve from long-term memory because they are at some lower level of activation, which is also consistent with a number of studies in reading comprehension showing that reading times increase as mean word frequency of a clause or sentence decreases (e.g., Haberlandt & Graesser, 1985; Zwaan et al., 1995). A third text-level factor is the influence of serial position on comprehension. The further along in a text a person has progressed, the better the foundation of a person's mental representation is established, and the easier it is to integrate new information into it (Gernsbacher, 1994). As such, it has been observed across a wide range of studies that the greater the serial position, the faster the reading times.

SITUATION MODEL-LEVEL FACTORS

Research on situation models has suggested that people monitor multiple components of described events during comprehension. This is most clearly articulated in the event indexing model (Zwaan et al., 1995). According to this view, people monitor a number of dimensions of events continuously, including space, time,

entity, causality, and intentionality (goals); and when there is a shift or a break along any of these dimensions, the comprehender must update one's current situation model. The continuous updating of one's situation model of a text is an effortful process, usually resulting in longer reading times. In addition to the various model components identified by the event indexing model, there are other aspects of a text that also would involve processing at the situation model level. These include the processing of information that provides setting information about an event, actions that involve interaction with objects, and initiating events (e.g., Trabasso & Stein, 1994). We now consider each of the situation model-level components in more detail.

The first event component we consider is spatial location in which the spatial framework serves to define the boundaries of an event, such as room, building, area (like a park or country), and so on. Spatial locations are important because when a narrative moves from one location to another, then the reader needs to break from a mental representation of events in one spatial framework, establish a representation based on the new spatial framework, maintain situation elements that are carried over from one spatial framework to the next, and remove any elements that were relevant in the prior location but will no longer be relevant in the new location. This location shifting can be effortful, and takes some mental effort to accomplish; and when spatial shifts occur, there may be an increase in reading time (Radvansky & Copeland, 2010).

Next, we consider another component of events that serves to place boundaries and define an event: temporal information. The time frame of an event defines when an event begins and ends; and is either explicitly provided in the text or, more often, can be inferred from the content of the text. As with spatial shifts, when a new temporal framework is introduced, a person must remove the prior framework, establish a new one, maintain elements that need to be carried over to the new framework, and remove elements from the prior framework that are no longer relevant. Again, as with spatial location, this updating process is effortful, and can be accompanied by an increase in reading time (Zwaan, 1996).

In our study, we make a distinction between two types of temporal information that can produce a need to update one's situation model: temporal shifts and temporal duration. Shifts in time convey when there is a jump from one temporal framework to another. For example, a statement such as "a moment later" is likely to be interpreted as referring to the same time frame, whereas a statement such as "a day later" is more likely to be interpreted as a shift in the temporal framework. The other kind of temporal information that we consider here is temporal duration or how long an event transpired, such as "for six days" or "for hours" (e.g., Zwaan, 1996).

Duration information is different from temporal shift information in that it does not convey information about a change in the ongoing events. Instead,

it provides the reader with information about the nature of the event being read about. This is an aspect of narrative events that, to our knowledge, has not been considered before in the context of situation models and language comprehension. However, research on scripts has shown that people take longer to verify information when there has been a greater delay in script elements (Bower, Black, & Turner, 1979)—that is, people need to mentally accommodate for longer temporal durations by inferring the missing information; and the greater the amount of time, the more effortful the process. It may be that a similar process is operating during narrative comprehension, and we use this study as an opportunity to test this idea.

In addition to providing information about the spatial and temporal framework that defines an event, a narrative may also provide setting information about the ongoing event. Examples of setting information would include the weather, age of a character, the arrangement of chairs in a room, and so on. Setting information does not provide information that defines the event *per se*, but does give substance to the situation. Because it is mentioned in the context of the narrative, it is possible to assess whether the incorporation of such information into the developing situation model is influencing the ease of processing during reading. It could be that the instructions to include such components into the model, as conveyed by the text, would require enough cognitive effort as to increase reading times. Thus, although this aspect has not been studied in previous situation model research, it was included in this analysis to determine the impact of such information.

Another important situation model component is the representation of the more important entities involved in a described event. Typically, the entities of primary concern are the characters, such as the story protagonist, who are important because they convey the storyline. The various causal elements in the story are often grounded in these entities in terms of their interaction with each other. In addition to the characters, critical objects, which play some sort of functional role in the story, may also serve as important entities for situation model construction. As such, although these have not been extensively assessed in situation model research, we decided to explore the possibility that they would influence performance here. We expected that if such information about objects is processed like important people in described events, then when such objects are encountered for the first time during the course of reading, reading times will increase as a person updates their situation model.

The events captured by situation models are often dynamic. Although the temporal relations, in terms of the order of events, are important, it is probably more important how such events influence one another—that is, people are very sensitive to causal structure of the larger situation. This often dictates how well information is remembered from a text (Trabasso, Secco, & van den Broek, 1984) and how easily it is comprehended (Radvansky & Copeland, 2000). For

example, information that has a clear causal role in a text is read more quickly than information that does not (Radvansky & Copeland, 2000). If a break in causal occurrence takes place, there typically is an increase in reading time while a person attempts to ascertain why the event has occurred, as there is no clear antecedent that has been read in the text. Thus, information that is relevant to the causal structure of a narrative should have a great deal of importance.

Related to ideas about causal structure is the impact of initiating events (Trabasso & Stein, 1994; Trabasso & van den Broek, 1985). These are events that occur in a narrative that start a sequence of events that follows from it. Initiating events are important because they often provide direction and motivation to many of the things that follow in a story.

A final important aspect of situation model processing is the tracking of character goals. These are important because they also feed into the causal structure of a text. Essentially, when a character has a goal, this provides the motivation and explanation for why they may do different things as the narrative unfolds. Research has shown that reading times increase when new goals are introduced in a narrative (Zwaan et al., 1995). Moreover, the availability of goals changes as the text changes its relevance to the previously stated goals (Lutz & Radvansky, 1997; Suh & Trabasso, 1993). Note that we measured the processing of goal information in the text, not the reader's goals (i.e., what the readers were trying to do as they read).

CURRENT STUDY

The aim of this study was to explore whether the factors that have been found to influence comprehension at the situation model level with multiple, shorter texts are also observed in a single novel. For this study, people were given a novel to read on a computer, and the reading times per sentence were recorded. After reading was complete, the readers were given a series of memory tests 1 week later. Analyses of these data are reported elsewhere (Copeland, Radvansky, & Goodwin, 2009; Radvansky, Copeland, & Zwaan, 2005). The focus here is on the reading time data and what they reveal about the online comprehension. If the patterns of data found in studies using multiple, shorter text are robust, then similar patterns of data should be observed here.

Although there is only a single text used in this study, it is much longer than the materials used in typical studies of narrative comprehension, often taking 10 sessions to read, rather than observing reading in a single session. As such, there is a substantial amount of reading time data for this one text. Moreover, the text was not written with the aim of testing specific experimental hypotheses. However, given that the research techniques are sufficiently matured to account for a wide range of factors that can influence comprehension, it should

be possible to observe in a novel text the effects that have been reported in more traditional studies that use shorter, contrived texts.

If similar patterns of influence are observed here, such evidence would attest to the robustness of the principles established by situation model theory to date. Specifically, based on prior research, we can derive the following hypotheses:

H1: Sentences with more syllables and lower frequency words should result in increases in reading times.
H2: When spatial and temporal shifts occur, reading times should increase.
H3: When longer temporal durations occur within the text, reading times should increase.
H4: Establishing setting information about an event should increase reading times as the event is elaborated on.
H5: When entity information (including character goals, as well as relations between characters and salient objects) is presented in the text, reading times should increase.
H6: When causal breaks occur in a text, readings times should increase.

We examined a 10-chapter novel both as a whole and in a chapter-by-chapter fashion to assess text comprehension processes across an entire novel.

METHOD

Participants

A total of 27 undergraduate students from the University of Notre Dame and Florida State University participated in the study in exchange for a paperback copy of the novel used for the task. Two participants were dropped for a failure to complete the task, leaving 25 participants.

Materials

The novel, *The Stone Diaries*, by Carol Shields (1994) was used as reading material in the study. This novel contains 10 chapters; 361 pages; 5,896 sentences; and a total of 96,389 words. All 10 chapters were scanned and saved on the computer as separate ASCII files, and each chapter file was further divided into sentences. These sentences omitted information about global text markers, such as paragraph breaks or chapter segmentations. In addition to being a Pulitzer Prize-winning novel, we selected *The Stone Diaries* because, although it is a work of fiction, the novel followed a life-course timeline for one particular character, much like that of an autobiography.

Procedure

For the reading task, participants read the novel one sentence at a time, as they were presented on a computer screen. Participants pressed the right button on the mouse to advance to the next sentence; each mouse click was used to record the reading time for each sentence. They were told that once they started a chapter, they had to finish it in one sitting, and that they could not read more than two chapters in one sitting. They were not allowed to have more than two sittings per day, and each sitting was separated by a minimum of 1 hr, for a maximum of four chapters per day. In general, participants read one chapter per sitting ($M = 1.3$), with one session per day. They were also constrained to have no more than 10 days between reading sessions, with an average of 3 days between sessions ($M = 2.9$). Upon completion of the novel, participants completed a series of memory tests. These memory data are reported elsewhere (Copeland et al., 2009; Radvansky et al., 2005).

Coding

We coded all 5,896 sentences on several dimensions. All coding variables, along with examples from the text, are summarized in Table 1. First, the sentences were coded for surface and text-based characteristics. These were the serial position of sentences in the chapter (i.e., 1 for the first sentence in each chapter, 2 for the next, etc.) and for the serial position of chapters in the book (chaps. 1–10). Sentences were also coded for the number of syllables ($M = 23.26$, $SD = 21.99$) and the mean word frequency ($M = 6{,}862.88$, $SD = 4{,}961.53$) using the Francis and Kucera (1982) word norms. Argument overlap was not coded for in this study because it has been shown to be unreliable (Trabasso & van den Broek, 1985; Zwaan et al., 1995; Zwaan, Radvansky, Hilliard, & Curiel, 1998). Because the amount of data was enormous, one researcher coded each dimension. This coding was then checked by M. Windy McNerney, and any disagreements were resolved by discussion with Gabriel A. Radvansky.

Spatial and temporal information. Sentences were also coded individually and for each of the 10 chapters for various situation model components. In terms of the spatial–temporal framework, sentences were coded as a 1 if there was a change in the spatial location; otherwise, they were coded as 0. The coding for temporal characteristics was more complicated because two separate dimensions were used. A sentence was coded with a 1 if it contained information about a shift in time (i.e., a new date), as well as the temporal duration (i.e., the event lasted for 5 min), and a 0 if it did not.

Setting. Although not strictly considered spatial–temporal framework information, sentences were also coded for whether they provided setting information

TABLE 1
Summary of Coding Scheme Used for Analysis

Category	*Code*	*Description*	*Example*[a]
Surface and Text Based	Chapter	Which chapter the sentence belonged to	
	Chapter position	Sentence order based off of position in the chapter	
	Novel position	Sentence order of the entire novel	
	Number of syllables	Total number of syllables in the sentence	
	Mean frequency	Average frequency of all the words in the sentence	
Spatial time	Spatial shift	When the events begin in one location and move to another	"... they were together at Tudor Hall in Indianapolis, and then going off to Long College ..." (p. 107)
	Time	Information about dates or clock time or reference to time relative to events in the story	"And just one year ago, a fine June morning, he presented an inspiring address ..." (p. 86)
	Duration	Mention of how long an event lasted for	"Here he paused for a moment, staring out at the rain ..." (p. 50)
Place	Setting	Background information about the story	"She was only thirty years old when she took sick, a boiling hot day ..." (p. 1)
Entity	Character	The introduction of a new character or the return of an old character	"Mrs. Flett next door let her have some currants ..." (p. 2)
	Object interaction	Anytime a character meaningfully interacts with an object	"... she puts on her reading glasses and reads the newspaper ..." (p. 326)
Causality	Goal	Initiation or conclusion of the intention to accomplish a goal	"And this is what he always intended to do, present it to his dear child ..." (p. 182)
	Causal break	An unexplained event that has no causal connectivity	"Hey guess what?—I am going to the Orkney Islands on a research project" (p. 283)
	Initiating event	The beginning of a new event or action that does not involve a goal	"... Fraidy got herself on a train and went to Ottawa for a week's visit" (p. 183)

[a]See Shields (1994).

that described other aspects of the circumstances at a given point in time within the novel. As with many other variables, sentences were coded on the setting variable with a 1 if they conveyed setting information, and 0 otherwise.

Entity. Because the event descriptions in the novel were largely focused on the people and the things they interacted with, we also coded the stories for entity information. Specifically, we had two entity variables. First, sentences

were coded with a 1 if a character was introduced, and 0 if not. Second, there was a variable that was used to code if a character meaningfully interacted with an object, again coded with a 1 if there was a meaningful interaction, and 0 if not.

Causality. The final category of variables included causal relations. First, the sentences were coded if there was a causal break when the sentence described events that did not have a clear antecedent in the text (Trabasso et al., 1984). Such sentences were coded with a 1 if there was a causal break, and 0 if not. Second, sentences were coded for a series of goal-based sequences, which included whether the sentence described some initiating event from which a series of events followed. Sentences were coded with a 1 if it conveyed an initiating event, and 0 if not. In terms of explicit goals, sentences were coded as 1 when goal of a character was stated or completed, and 0 otherwise.

RESULTS AND DISCUSSION

The reading time data were first trimmed to remove the effects of extremely short and long times. Because number of syllables is a major factor in reading time length, these data were divided by the number of syllables. Any sentences that had reading times per syllable greater or less than 3 *SD*s from the mean for a given participant were replaced with the value 1,000 ms and 40 ms per syllable, respectively. This was done to preserve in the analysis any items that may bias people to read especially fast or slow. These altered data points were then reconverted to raw reading times by multiplying them by the number of syllables for that sentence. This occurred in 1.1% of the data. All of the coded variables were then correlated with each other to check for violations of multicolinearity (average correlation = 0.05; range = −.021 to 0.99). The highest correlations were between novel position and chapter position, as well as between chapter and novel position, which were not surprising and not of theoretical interest. However, the correlation between spatial shift and setting ($r = .54$) was fairly high, so results regarding these two variables should be interpreted with caution.

Next, the trimmed reading time data for each participant were submitted to a regression analysis containing all of the coded variables: number of syllables, mean frequency, novel position, chapter position, time, duration, setting, spatial shift, character, object interaction, causal break, initiating event, and goal. The standardized regression coefficients were recorded for each variable. The regression weights across all of the participants were then subjected to a one-sample t test to assess if the values were significantly different from zero. The mean regression coefficients can be seen in Table 2.

TABLE 2
Mean Regression Coefficients and Standard Deviations for the Overall Analysis by Coded Variables

Variable	*M*	*SD*
Syllables	0.860	0.099*
Frequency	−0.019	0.011*
Novel position	−0.040	0.022*
Chapter position	−0.030	0.017*
Space	−0.014	0.009*
Time	−0.016	0.018*
Duration	0.001	0.008
Setting	0.003	0.013
Character	0.025	0.013*
Object	0.014	0.013*
Cause	0.014	0.009*
Initiating event	−0.007	0.008*
Goal	0.001	0.009

*$p < .001$.

As a further investigation of the data, the variables that had a significant relation with reading time were divided by chapter and analyzed using the same regression technique described earlier. The only exception was that novel position was not included because it is redundant with chapter position. *The Stone Diaries* (Shields, 1994) consists of 10 chapters, and this analysis was done to determine if some chapters drive the effects or if there are differences between the beginning of the novel, where participants are forming situation models, and the end of the novel, where situation models are more complete. The mean regression coefficients for all of the chapters can be seen in Table 3.

In evaluating the various factors that may affect comprehension, we adopted a criterion of designating a factor as having a meaningful impact on performance if it (a) was significant in the overall analysis and (b) significantly affected performance in the same direction in at least 6 of the 10 chapters. Otherwise, we designated the factor as having either no effect or an inconsistent effect.

Surface Form and Text-Based Features

The analyses revealed that the surface form and text-based features all had mean regression coefficients that were significantly different than zero, which is consistent with many studies using multiple, shorter texts (Zwaan et al., 1995; Zwaan et al., 1998). First, there was a large, positive coefficient for the number

TABLE 3
Means and Standard Deviations for Significant Variables, Broken Down by Chapter

	Chap. 1		*Chap. 2*		*Chap. 3*		*Chap. 4*		*Chap. 5*	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Syllables	0.871	0.088***	0.841	0.122***	0.843	0.115***	0.869	0.099***	0.856	0.092***
Frequency	−0.008	0.018*	−0.015	0.016***	−0.019	0.015***	−0.011	0.016**	−0.012	0.023*
Chapter position	−0.090	0.068***	−0.020	0.059†	−0.058	0.050***	−0.021	0.031**	−0.041	0.048***
Space	−0.015	0.029*	−0.014	0.029*	−0.013	0.035†	−0.009	0.035	−0.031	0.033***
Time	−0.016	0.018*	0.005	0.025	0.010	0.025*	−0.005	0.030	0.018	0.024***
Character	0.025	0.013	0.003	0.040	0.052	0.042***	0.036	0.023***	0.024	0.031***
Object	0.017	0.032*	0.026	0.036***	0.024	0.037**	−0.014	0.030*	−0.003	0.023
Cause	0.011	0.020*	0.012	0.036*	0.009	0.015**	−0.011	0.017**	0.033	0.023***
Initiating event	−0.004	0.013	−0.017	0.035*	−0.009	0.014**	0.011	0.027*	−0.001	0.021

	Chap. 6		*Chap. 7*		*Chap. 8*		*Chap. 9*		*Chap. 10*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Syllables	0.850	0.102***	0.859	0.201***	0.878	0.104***	0.875	0.124***	0.942	0.061***
Frequency	−0.019	0.033**	−0.025	0.023***	−0.032	0.023***	−0.023	0.015***	−0.028	0.030***
Chapter position	−0.010	0.037†	−0.010	0.026†	−0.040	0.034***	−0.033	0.049**	−0.024	0.033***
Space	−0.021	0.035**	−0.020	0.029**	0.008	0.031	−0.017	0.030**	−0.001	0.052
Time	−0.042	0.033***	−0.018	0.025***	−0.004	0.027	−0.001	0.024	0.024	0.043**
Character	0.050	0.025***	0.038	0.026***	0.029	0.078†	0.004	0.011	0.044	0.033***
Object	−0.003	0.023†	−0.004	0.011	−0.009	0.032	0.006	0.030	0.025	0.025***
Cause	0.022	0.031**	0.001	0.013	0.001	0.013	0.017	0.009***	0.027	0.019***
Initiating event	0.015	0.025**	−0.014	0.015***	−0.015	0.016***	−0.014	0.011***	0.001	0.020

*$p < .05$. **$p < .01$. ***$p < .001$. †$p < .10$.

of syllables, $t(24) = 43.50$, $p < .001$ ($SE = 0.019$), with readers taking longer to read longer sentences. Separate analyses of the individual chapters revealed a similar relation in all 10 chapters (all ps $< .001$).

Also, there was a clear, negative relation between reading times and mean word frequency for a sentence, $t(24) = -9.02$, $p < .001$ ($SE = 0.002$), with readers taking longer to read sentences with lower frequency words. As with number of syllables, this relation was also found when the data were divided by chapters. These patterns of data were expected, and are consistent with a wide range of studies that use multiple, shorter texts.

The coefficient values for both chapter position, $t(24) = -8.77$, $p < .001$ ($SE = 0.003$); and novel position, $t(24) = -8.99$, $p < .001$ ($SE = 0.004$), were significant in the negative direction. When broken down by chapter, a negative relation was found in all 10 chapters, but this was only marginally significant for chapters 2, 6, and 7. This suggests that the further readers got in the chapter or in the book, the faster their reading times. These results are consistent with other research showing that people are building a mental representation of the events described in the narrative; and the further along in the text readers are, the easier it is for them to integrate this information into that representation (e.g., Gernsbacher, 1994). These surface form and text-based results are all in the expected direction based on prior research.

Spatial Framework

Turning our attention now to the situation model components, we first see that there was a significant, negative coefficient for spatial shift, $t(24) = -7.50$, $p < .001$ ($SE = 0.002$). This indicates that reading times decreased for sentences that conveyed a spatial shift. Individual chapter analyses revealed significant negative relations for chapters 1, 2, 5, 6, 7, and 9; and a marginally significant relation for chapter 3. No significant relation was found in chapters 4, 8, and 10. This pattern of results runs counter to prior research, which has shown that spatial shifts can result in increases in reading time (Zwaan et al., 1998). The explanation in the literature has been that increased reading times reflect an effort to update the spatial framework of the situation model. That said, it should also be noted that there are studies that have failed to find any influence of spatial shifts on reading time (Zwaan et al., 1995).

A recent explanation for this pattern of findings is that even when there is no increase in reading times, data from other measures, such as recognition probes, suggest that people had successfully updated their situation models (Radvansky & Copeland, 2010). The idea is that readers find it relatively easy to process spatial shifts; therefore, less disruption may be observed. Moreover, in studies where there is a positive spatial location effect, the spatial structure is heavily emphasized in the task, such as having people memorize a map (Zwaan et al.,

1998). In addition, by presenting readers with a large number of shorter texts in which there is not much to build on, it is easier to disrupt the situation model (Glenberg, Meyer, & Lindem, 1987).

In shorter texts, it may not be clear why a given spatial shift was made, as there typically is very little information provided in the text to motivate why a story character has moved from one location to another. As such, a spatial shift may, to some degree, act as a causal break in these shorter texts. In comparison, in the context of this study, people are reading a longer, more complex, coherent, single text in which spatial location shifts accompany the demands of the story's causal structure and other factors. Therefore, if readers can easily spatially update, and this updating is consistent with the flow of the story, people can actually process this information more easily.

Temporal Framework

Temporal shifts also had significant, negative relations with reading times, $t(24) = -4.38$, $p < .001$ ($SE = 0.004$). However, when the data were broken down by chapter, it was noticed that there was a very strong, negative relation for chapter 6. This chapter has many letters that are dated, which may be driving the results here. To assess this impact, the overall analysis was done again, with chapter 6 removed. Although this did decrease the magnitude of the relation (mean $\beta = -.011$, $SD = .018$), it was still negative and significant, $t(24) = -2.91$, $p = .008$ ($SE = 0.004$). Overall, these data indicate that people read sentences faster if they conveyed a temporal shift than if they did not.

This has also been observed in prior research. Specifically, Radvansky, Copeland, and Zwaan (2003) found that when people read texts that were presented as descriptions of historical events, people showed an increase in reading speed for temporal shift sentences. It may be that the historical character of this novel may have led readers to treat this information similarly, and essentially ignore such information. It should also be noted that this is not a consistent pattern. Specifically, in chapters 3, 5, and 10, there were significant, positive correlations; and there were no significant relations in chapters 2, 4, 8, and 9. Thus, there is no stability in the pattern of reading time data for temporal shifts as typically is observed in prior research with shorter texts. Within the context of one novel, our results suggest that the influence of temporal shifts on comprehension can vary substantially as a function of the nature of the materials used. The differences between the various chapters, in this regard, are unclear; and further research is needed to explore this particular point.

Temporal Duration

The temporal duration variable was included because other lines of research,

such as that done with scripts, have shown that when longer time durations occur, there is a concomitant increase in response time consistent with the idea that people are mentally filling in the missing portions of the event (Bower et al., 1979). If this earlier script research is generalizable, then one would expect duration to have an influence on reading time. However, our analysis revealed that there was no relation between reading time and temporal duration ($t < 1$). Thus, the amount of elapsed time in the narrative world had no meaningful impact on reading times.

Setting Information

In terms of setting information, the overall analysis was not significant, $t(24) = 1.13$, $p = .27$ ($SE = 0.003$). Providing background information about the event circumstances also did not meaningfully influence reading times.

Entity

Another important element of narrative events is the characters that serve to populate the story world. Effective comprehension requires that the readers keep track of who is present in a given narrative event. For the characters described in this story, the regression coefficient was positive and significant, $t(24) = 9.87$, $p < .001$ ($SE = 0.003$). This impact of the introduction of characters to a narrative event is likely due to the great importance of entities to the story line. After all, the story is about the characters. The causal structure is largely built around them—their goals, emotions, and other properties; as well as what these characters do. The same pattern is seen when the data are broken down into the individual chapters, although this effect was only marginally significant for chapter 8, and did not reach significance for chapters 1 and 9.

In addition to the characters involved in the story, there was also an influence of other entities—specifically, the objects with which the characters interacted. In essence, these were descriptions of functional interactions between people and objects, which are important for building the causal structure of a story (Radvansky & Copeland, 2000). Readers spent more time and effort processing and integrating this information, $t(24) = 5.40$, $p < .001$ ($SE = 0.003$).

Individual chapter analyses revealed significant effects in the beginning and end of the book. Chapters 1, 2, and 3 were associated with significant, positive relations with object coding. On the other hand, the regression coefficients were negative for chapters 4 through 8, but this was only significant for chapter 4 and marginally significant for chapter 6. The last two chapters, again, were associated with positive coefficients, but this was only significant for chapter 10. Thus, the effects of this factor were unreliable and inconsistent.

Causality

A number of aspects of the reading time data may reflect, in some way, issues related to the causal structure of the story and how this is involved in the creation and updating of a situation model. For the causal breaks in this novel, there was a positive relation with reading time, $t(24) = 7.72$, $p < .001$ ($SE = 0.002$), with causal breaks resulting in increases in reading time. Individual chapter analyses revealed a consistent, positive relation, with the exception of chapter 4, which showed a significantly negative relation, and chapters 7 and 8, which were not significant. Again, reading times slowed when readers encountered an event that did not have a clear cause in the prior text. Our results are in line with evidence in the narrative comprehension literature, which suggests that causal structure is the backbone of a person's narrative understanding. Moreover, in the memory assessment for this novel reported by Radvansky et al. (2005), recognition memory was facilitated for causally important events.

In addition to causal breaks, we also analyzed the influence of the initiating events that started a sequence of actions. There was a decrease in reading time with an initiating event, $t(24) = -4.32$, $p < .001$ ($SE = 0.002$). However, in the individual chapter analyses, five chapters showed a negative effect, three showed no relation, and two chapters showed a positive effect. Thus, we conclude that initiating events, although they may seem important theoretically, do not have a clear consistent influence on reading times.

Finally, we examined the role of intentionality, or character goals, on comprehension. In comparison to research with multiple, shorter texts in which reading times increase with new character goals (e.g., Lutz & Radvansky, 1997; Suh & Trabasso, 1993), there was no overall impact of new goals on comprehension in this study ($t < 1$). As such, individual chapter analyses were not done. Thus, it appears that the introduction of character goals in the context of a larger study does not have a major influence on comprehension. This may be because many of the goals that are mentioned in the novel often have a fleeting or temporary character. In addition, many of the larger goals, such as "wanting to be happy," are often implicit in the storyline itself and are not directly stated. This contrasts to laboratory studies in which the materials are designed and created so that the character goals are clear and explicit.

Relation of Reading to Memory

One issue that can be raised is the degree to which patterns of performance that are observed in the reading time data are reflective of performance on later memory. This is of particular concern for the spatial and temporal shifts, which were found to be negatively related with reading times in this study—

that is, people read sentences with spatial or temporal shifts faster than would otherwise be expected, rather than slowing down their reading, as other research has indicated. One possibility for those results is that readers were skipping important spatial and temporal information during those shifts, resulting in faster reading times than expected. To address this issue, we examined some cued recall data that had been gathered, and compared performance on these cued recall tests with the regression coefficients derived from the reading time data. If readers were skipping information during their reading of spatial and temporal shifts, then we would expect poor memory performance for spatial and temporal information. We first present an overview of the cued recall data, followed by a comparison with the reading time data.

The cued recall task was taken from data whose results are reported elsewhere (Copeland et al., 2009; Radvansky et al., 2005). This task was administered 1 week after reading of the final chapter was completed. For this task, people were given different types of cues, including location names, time periods, or character names, to assess the degree to which they would elicit memories of events that were described in the novel. As each cue appeared on the computer screen, participants typed in as many events as they could remember in response to that cue. There were 48 location cues, 39 time cues, and 28 person cues; and there was complete data for 23 out of the 25 participants. Thus, we are only able to compare reading times and memory performance on these three dimensions for 23 participants. The average number of events recalled to any one of these cues was 1.20 ($SD = 0.43$) for the location cues, 0.38 ($SD = 0.24$) for the time cues, and 1.67 ($SD = 0.67$) for the person cues. To compare performance on reading and the cued recall test, we calculated the correlation between the reading time regression coefficient for a person along the dimension of concern and the average number of items recalled for a person on that dimension for each type of cue. These analyses revealed no significant correlations for location, time, or person cues: rs(21) = .06, −.24, and .09, respectively; all ps > .05. Thus, there is no evidence that people were skipping over the spatial and temporal information, resulting in faster reading time and poorer memory and understanding of the novel.

DISCUSSION

The aim of this study was to assess whether factors that influence reading comprehension that have been observed in typical laboratory studies with multiple, shorter, and experimenter-generated materials would also influence the comprehension of a single, longer text, such as with a real-world narrative novel. Our results revealed that, in some cases, the pattern of influences were similar; whereas, in other cases, there were substantial differences.

In terms of similarities, our reading time data were consistent with data from studies using experimenter-created materials for all of the text-based features, including longer reading times with more syllables and with lower frequency words (e.g., Haberlandt & Graesser, 1985; Zwaan et al., 1995). Moreover, as people progressed through the novel, their reading times became faster.

However, when we turn to the situation model-level factors, we see that the level of consistency with shorter, experimenter-created materials is less clear. Some of the previously identified factors were found to influence comprehension in this study. Specifically, reading times increased—reflecting increased processing time—during the introduction of new characters to a situation and when there were causal breaks in the text. In both of these cases, the aspects of the situation model-level processing that are most affected are those aspects of the novel that one could argue are most important—namely, the people and the circumstances they found themselves in and had to deal with.

There were also a number of inconsistencies between our results and those in prior research. In some cases, the reading time data failed to reveal effects that have been previously reported; and, in others, the pattern of data observed was the opposite of what has been previously reported. One possible explanation for these findings is that some chapters had more of an emphasis of one factor than other factors, making measurements less reliable. To address this possibility, the mean number of occurrences for each of the situation model variables were determined for both the overall analysis and broken down by chapter. In the overall analysis, duration ($M = 0.029$), setting ($M = 0.145$), and goal ($M = 0.037$) were not significant. Although duration and goal might appear low, so was initiation event ($M = 0.031$), which was significant. In addition, setting did have a number slightly higher than character ($M = 0.121$), and that was significant. When the means were broken down by chapter (see Table 4), a similar pattern was observed. Although a low number of occurrences may account for some null findings (i.e., chap. 10), there were also chapters that had larger means, but were still not significant. Therefore, this explanation is not likely to be the reason why some effects were not replicated.

Other possible explanations include the amount of attention used during reading and the nature or the goals in the author's writing style. As noted earlier, the attention paid to various objects mentioned in the story may be a function of how readers progress through the narrative, and this is supported by memory data that have been reported elsewhere (Copeland et al., 2009). A study by Smallwood, McSpadden, and Schooler (2008) investigated the effects of mind-wandering on situation model construction. They found that "zoning out" during reading, especially early in the text, created a lapse in attention, which made it difficult for participants to link information with their situation model. Therefore, situation models were incomplete and not useful for understanding the text. In

TABLE 4
Means and Standard Deviations of Number of Events Coded by Chapter

	Chap. 1		*Chap. 2*		*Chap. 3*		*Chap. 4*		*Chap. 5*	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Space	0.111	0.315	0.160	0.366	0.096	0.295	0.115	0.319	0.094	0.292
Time	0.022	0.147	0.040	0.197	0.023	0.151*	0.026	0.159	0.041	0.199*
Character	0.035	0.184	0.076	0.266	0.051	0.220	0.050	0.219	0.033	0.190
Object	0.014	0.346	0.109	0.130	0.045	0.207	0.073	0.260*	0.060	0.239
Cause	0.017	0.128	0.038	0.192	0.008	0.088	0.006	0.080*	0.019	0.137
Initiating event	0.042	0.202	0.053	0.224	0.040	0.197	0.037	0.189*	0.022	0.148
	Chap. 6		*Chap. 7*		*Chap. 8*		*Chap. 9*		*Chap. 10*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Space	0.089	0.283	0.097	0.296	0.082	0.276	0.059	0.236	0.028	0.165
Time	0.229	0.421	0.325	0.469	0.195	0.396	0.108	0.311	0.091	0.289*
Character	0.251	0.434	0.210	0.407	0.223	0.417	0.198	0.399	0.089	0.285
Object	0.005	0.068*	0.058	0.234	0.041	0.198	0.030	0.171	0.005	0.071
Cause	0.008	0.088	0.009	0.096	0.012	0.107	0.014	0.117	0.015	0.123
Initiating event	0.029	0.169*	0.045	0.207	0.023	0.151	0.012	0.111	0.008	0.870

*$p < .05$.

such a long text as *The Stone Diaries* (Shields, 1994), there was more of a risk for mind-wandering, possibly during parts of the text that describe background information, such as space, time, and setting information. This could result in no change or an increase in reading time.

The absence of an influence of character goals may be due to a difference in the nature of the goals that are explicitly mentioned in the novel (more trivial) and those left implicit (more guiding and important). The absence of an influence of setting information or initiating events suggests that people do not find it difficult to process information about a new situation in the text. This makes sense in that the situation model that is being developed is new and does not need to be modified. As such, when setting and initiating event information are encountered in this context, it can be processed more fluidly, giving way to few or no disruptions in reading times. It should also be noted that, although it typically is not coded in narrative comprehension research, earlier work on scripts suggested that the duration between events might have an influence on processing time (Bower et al., 1979). However, no such relation was observed in our study.

Finally, some of the effects observed in this study are the opposite of those seen in prior studies using shorter, experimenter-created texts. Specifically, with regard to spatial and temporal framework information, rather than showing an increase in reading times for event framework shifts, people actually read this information more quickly than what would be expected. The explanation for this follows from other work on spatial and temporal shifts suggesting that people may actually process such information quite easily (and quickly) when provided with the right circumstances (Radvansky & Copeland, 2010; Radvansky et al., 2003). For example, in this case, movements through space and time were more peripheral to the flow of the story, and were likely often more predictable than would be the case when a series of unrelated texts are used. Moreover, as noted by one of our reviewers, it should also be kept in mind that the author of the novel is an accomplished writer. This may allow the texts to be written in such a way that it makes the texts easier to process, making it less likely that disruptions in comprehension, as revealed by reading times, would be observed. Objectively identifying what makes for such good writing is unclear at this juncture.

Overall, the results of this study suggest that, although theories of language comprehension have developed substantially over the past several years, when these principles that have been derived using multiple, shorter, laboratory-oriented materials are applied to a substantially longer and more naturalistic text, some findings hold up nicely. However, not all of the situation model variables were found to be operating in a longer, single novel text; and some variables even showed a reverse influence. Thus, we suggest, perhaps not surprisingly, that there is continued room for theoretical development to better capture the qualities of language that influence the ease with which it is understood.

In the cases where the effects were absent, it may be that the occurrences of such event-related changes were too subtle in the text to be detected by more traditional analyses. Such effects might emerge when the text more directly and clearly conveys such changes, as may be the case in experimenter-generated texts. In comparison, for the cases where the effects were in the opposite direction of those that have been traditionally observed, it may be that the broader range of information available to readers influenced the ease with which these event updates were handled. These results show that more work needs to be done in situation model theory to better predict the patterns of reading and comprehension that will be observed across a broad range of texts. Research in attention has already begun to utilize more real-world settings (i.e., Kingstone, Smilek, Ristic, Friesen, & Eastwood, 2003; Smilek, Birmingham, Cameron, Bishof, & Kingstone, 2006); and has shown, not only, that more realistic materials can be applied to study cognitive psychology, but also that utilizing this material can gain new insights into the cognitive world. Future studies should hopefully consider more realistic options when designing experiments.

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