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Dimensions of Situation Model Construction in Narrative Comprehension

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Several factors potentially influence the extent to which readers form a coherent mental representation during story comprehension. The main factors are argument overlap (i.e., connections between text constituents) and situational continuity (i.e., connections between the components of the referential situation model). The authors distinguished 3 dimensions of situational continuity: temporal, spatial, and causal continuity. Results of 2 reading-time studies involving naturalistic stories suggest that readers simultaneously monitor multiple dimensions of the situation model (particularly temporality and causality) under a normal reading instruction. In addition, the construction of a situation model does not critically depend on the presence or absence of argument overlap.

When people comprehend a story, they not only construct a mental representation of its words and sentences but also of the situations that are conveyed by these words and sentences. These representations have become known as situation models (van Dijk & Kintsch, 1983), or mental models (Johnson-Laird, 1983). There is evidence that readers construct situation models while reading stories under particular conditions (e.g., Anderson, Garrod, & Sanford, 1983; Ehrlich & Johnson-Laird, 1982; Fletcher & Chrysler, 1990; Franklin & Tversky, 1990; Glenberg, Meyer, & Lindem, 1987; Mandler, 1986; Mani & Johnson-Laird, 1982; Morrow, Bower, & Greenspan, 1989; Morrow, Greenspan, & Bower, 1987). Each of these studies has focused on a single aspect of situation models, such as the temporal order of events, the spatial layout of the situation, or the causal relations among the described events. As a consequence, we do not know whether readers simultaneously keep track of the temporal, spatial, and causal aspects of the situation (see also Morrow, 1994).

It is both theoretically and methodologically important to dissect the construction of multiple aspects of the situation model. In the theoretical arena, a major goal of cognitive psychologists has been to unravel processing operations and interactions of multiple levels of representation (Fodor, 1983; McClelland, 1979; Sternberg, 1969). Situation models are multidimensional representations. Therefore, we need to identify the critical dimensions of the situation model. We also need to understand how readers construct and monitor the multiple dimensions.

In the methodological arena, it is important to dissociate the various situational dimensions that readers keep track of. For example, suppose that readers keep track of both temporality and causality while comprehending narratives. If an experimenter is interested in how comprehension is affected by the causal relatedness of story events, it would be important to keep the temporal relatedness between story events constant. Otherwise, a confound between causal and temporal relatedness would arise. Our goal was to examine whether readers simultaneously monitor more than one situational dimension.

Another goal of this investigation was to examine the comprehension of ecologically valid materials, rather than experimenter-generated materials. Existing studies have primarily used short experimenter-generated passages. In our view, a viable theory of situation model construction would be capable of explaining processes that occur during the comprehension of naturalistic text.

Temporality, Spatiality, and Causality

Temporality, spatiality, and causality are inextricably linked when behavioral episodes unfold in the real world. For example, movement through space is impossible without time, and an effect never occurs before its cause. However, narrative structures are not necessarily constrained by the laws of nature. An omniscient narrator can move from one part of the world to another and can describe events that take place at the same time, which creates a spatial, but not temporal, discontinuity. Similarly, the narrator can move through centuries and describe events that take place in the same location, which creates a temporal, but not spatial discontinuity. An effect can be mentioned before its cause, or without the cause being mentioned at all. Such cases introduce a causal continuity

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break and may prompt readers to look for an explanation (van den Broek, 1990).

Discrepancies between real-world constraints and narrative structure are regarded as one of the hallmarks of literature (Bruner, 1986; Genette, 1983; Striedter, 1989; Tomashevsky, 1925/1965). These discrepancies in literary stories reap a side benefit for investigations of situation model construction. Specifically, the fact that the various dimensions of the situation model potentially approach orthogonal variation enabled us to examine the three dimensions of situation models simultaneously.

Situational Continuity

If readers construct situation models while reading stories, then comprehension should be facilitated to the extent that the story conveys a continuous situation, compared with a discontinuous situation. For example, it should be relatively easy to construct a representation of a situation that involves a chronologically ordered chain of causally related events and actions in one location. In such a case, incoming situational information can readily be integrated with the current situation model. However, in naturalistic stories, there are frequently temporal, spatial, and causal discontinuities. These discontinuities presumably make incoming situational information more difficult to integrate.

There currently is no general theory of situation model construction. However, Gernsbacher (1990) has proposed a framework of discourse comprehension, the structure building framework, that addresses different dimensions of situational continuity, such as temporality, spatiality, and causality. According to the structure building framework, readers construct mental structures while reading a text and they map incoming information onto the evolving structure. Situational continuities facilitate this process. Sentences that maintain a previously established time frame are more likely to be mapped onto developing structures, as are sentences that maintain a previously established location and sentences that are logical consequences of a previously mentioned action or event (cf. Gernsbacher, 1990, p. 63). Situational discontinuities prompt readers to shift from building one substructure to building another. These shifts tax resources available in working memory. In this study, we used the following conceptualizations of temporal, spatial, and causal discontinuity, which were derived from the existing literature.

Temporal continuity occurs when an incoming sentence in a story describes an event, state, or action that occurs within the same time interval as the previous sentence. A sentence is temporally discontinuous with the prior context if there is a time shift. Examples of temporal discontinuities are (a) jumps forward in time, for example, conveyed through a phrase such as "An hour later" or "The next day," (b) statements about events that took place in the distant past (flashbacks), and (c) statements about events that will take place in the future (flash forward). There is evidence that temporal discontinuities impede comprehension and slow down reading time (Anderson et al., 1983; Mandler, 1986; Ohtsuka & Brewer, 1992; Zwaan, 1994). An example of a temporal discontinuity is Sentence 3 in the Appendix.

Spatial continuity occurs when the text describes events, states, and actions that take place in the same spatial setting. A spatial setting is a room, scenario, or region that has distinctive features that are discriminable from alternative spatial settings in a story (see Mandler, 1984; Schank, 1982; Shanon, 1983). A spatial discontinuity occurs when the narrative "Here" (Morrow et al., 1989) or the *deictic center* (Bruder, Duchan, Segal, Shapiro, & Zubin, 1986) is moved to a new spatial setting; under this perspective, movements within the same spatial setting are considered spatially continuous. It is helpful to discuss spatial discontinuities in cinematographic terms. Whenever a new event or action cannot be captured by a smooth movement of the camera, there is typically an abrupt change to a shot of a new location. For example, a character is hit by a car. We see him lying on the street. An onlooker rushes to a street phone and dials 911. An ambulance arrives on the scene. In the next shot, we see the character in the ambulance, and in the next shot, he is lying in a hospital bed. Some of these scenes are spatially discontinuous. It should be noted that these scenes are also temporally discontinuous, but not causally as we discuss below. There is evidence that spatial discontinuities impair comprehension (Ehrlich & Johnson-Laird, 1982) and may make information about prior locations less accessible (Morrow et al., 1987, 1989). Sentence 9 in the Appendix conveys a spatial discontinuity: The narrative Here moves from the rear of the courtyard to inside the house where Elisenda and the sick child are.

Causal continuity occurs when there is a direct causal link between the current sentence and prior story information. In the absence of causal continuity, the reader attempts to infer a causal link and this requires extra processing time. There is extensive evidence that breaks in causal continuity require extra processing time (Bloom, Fletcher, van den Broek, Reitz, & Shapiro, 1990; Fletcher & Bloom, 1988; Graesser, 1981; Magliano, Baggett, Johnson, & Graesser, 1993; Singer, Halldorson, Lear, & Andrusiak, 1992; Suh & Trabasso, 1993; Trabasso & Sperry, 1985; Trabasso & van den Broek, 1986; van den Broek & Lorch, 1993). In determining whether an incoming event is causally continuous, readers must determine whether the prior story context provides a necessary and sufficient cause for the incoming event (Mackie, 1980). There is continuity if a plausible cause can be identified from the prior story context. Causal discontinuity occurs when a plausible cause cannot be identified from the prior story context. Under this condition, a plausible cause must be inferred. With regard to the car accident example above, the accident provides a plausible cause for the ambulance arriving on the scene. If the bystander calling 911 would have been omitted, then readers would have had to infer this or a similarly plausible event to explain the arrival of the ambulance. Sentence 8 in the Appendix is another example of a causal discontinuity. The prior text does not contain information that explains the presence of the old man in the courtyard, let alone the fact that he has wings.

General Overview of the Experiments

We performed two experiments that examined the extent to which readers monitor temporal, spatial, and causal continu-

ity. We followed the same approach in both experiments. We selected two naturalistic stories that appeared to have sufficient variability on the three situational dimensions. The stories were segregated into sentences, and long sentences were segregated into smaller parts. Each story sentence was scaled on whether it was temporally, spatially, and causally continuous with prior information. It is quite possible that situational discontinuity is a matter of degree. However, for matters of simplicity, we decided to treat temporal, spatial, and causal continuity as dichotomous variables in the two experiments.[1] Each sentence was also analyzed on a number of auxiliary variables, such as the number of syllables it contained and its serial position in the story. The auxiliary variables have been demonstrated in previous research to be robust predictors of reading times. Our goal was to partial out the effects of these variables statistically so that we might obtain relatively conservative estimates of the effects of our situational variables. For example, if situational discontinuities tend to occur in longer sentences, then we are able to partial out the sentence-length effect by including the number of syllables in the multiple regression equation.

Sentence reading times were collected from participants as they read the stories at their own pace. The variables of the text analyses were used to predict reading times in multiple regression analyses. This allowed us to evaluate the contribution of one variable in predicting reading times, while the effects of the other variables were partialled out statistically. As with previous studies that have used multiple regression analyses of reading times, we assumed that the time it takes to read a sentence reflects the difficulty of integrating the sentence with the current representation (e.g., Bloom et al., 1990; Graesser & Riha, 1984; Haberlandt & Graesser, 1985; Haberlandt, Graesser, & Schneider, 1989; Just & Carpenter, 1980).

Two reading instructions were compared in both experiments: a normal reading instruction, which was assumed not to impose specific learning constraints, and a memory instruction. We anticipated that these two instructions would yield different patterns of reading times. The normal instruction tapped how readers monitored situational continuity when they are not following special strategies. The memory instruction, however, would presumably engender special strategies in the reader. At least three outcomes might occur. First, the memory instruction might prompt readers to construct a "maximalist" situation model. In this case, temporal, spatial, and causal discontinuities would all lead to significant increases in sentence reading times. On the other hand, the memory instruction might prompt readers to focus more on the text itself, rather than on the described situation (see Aaronson & Ferres, 1986). If this were the case, the findings should indicate that the readers in the memory construction do not monitor the situational dimensions to the same extent as the participants in the normal condition. An additional reason for varying reading instruction was to obtain information on the importance of monitoring a situational dimension. If a situational dimension is necessary for comprehension, then it should be impervious to reading instruction, assuming there is some attempt to interpret meaning. A final possibility is that the memory instructions will not have an impact on the construction of a situation model. If this is the case, then the patterns in reading times will be the same for participants in the normal condition and the memory condition.

Experiment 1

Method

Participants

Twenty-eight undergraduate psychology students at the University of Memphis participated for course credit. In this first study, we wanted to have participants who had some exposure to literature. A study of naturalistic text comprehension presupposes that the comprehension process under observation is to some extent natural to the participants. Thus, we wanted to optimize our chances of finding effects at this stage. The author recognition test (Stanovich & West, 1989) was administered to 270 students. This test measures exposure to print. The test consists of a list of 100 names, 50 of which are novelists or newspaper columnists, the other 50 names are distracters. The 28 participants were among the 20% of students who had a recognition score, number of hits minus number of false alarms, of 13 or higher. A score of 50 is the maximum score.

Materials

Two published short stories served as stimulus passages: "The Demon Lover," by the Irish author Elisabeth Bowen (1981), and "A Very Old Man with Enormous Wings," by Nobel Laureate Gabriel García Márquez (1972). The Appendix presents the opening sentences from "A Very Old Man With Enormous Wings." Both stories were approximately 3,000 words long. The stories were primarily descriptions of actions, events, and states. However, "The Demon Lover" also contained 14 sentences that conveyed dialogue and another small number of sentences that conveyed an interior monologue in the present tense, for example, "But it cannot be important, or they would know"; the rest of the story was in the past or past perfect tense. These unusual sentences were omitted from our analyses. As a consequence, the analyses were based on 145 sentences from the García Márquez story and 147 sentences from the Bowen story.

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[1] We also used nondichotomous variables that assessed the psychological distance of an incoming event with the previous events on a given dimension. The temporal distance between an incoming event and the previously mentioned event was rated on a 5-point scale ranging from *concurrent* (1), *directly subsequent* (2), *later, but after a short interval* (3), *later, but after a long interval* (4) to *much earlier (flashback)* (5). The spatial distance between an incoming event and the previous event was rated on a 4 point scale ranging from *in the same location (e.g., room), and no movement* (1), movement from one part of the location to another part (2), movement to an adjacent location (3) to *movement to a nonadjacent location* (4). The causal distance of an incoming event with prior information was rated on a 4-point scale ranging from *necessary and sufficient causal relation* (1), *multiple sufficiency* (2), *complex causation* (3) to *causally unrelated* (4).

We felt that these scales were plausible but problematic in that there was no independent information to determine whether they were really interval scales. Therefore, we decided to use the less problematic, but cruder, dichotomous variables. However, it should be noted that analyses involving the psychological distance variables were highly consistent with the analyses using the dichotomous variables. Only the latter are reported in this article.

Text Analysis

With one exception, sentences constituted the unit of analysis. The exception was that long sentences were segregated into different parts to make our analyses more fine grained. We made sure that each part expressed a completed thought; sentences were broken up only after semicolons or commas. Seventy-two sentences were segregated in this manner.[2]

The 292 story sentences were analyzed on a number of dimensions. There were three *theoretical variables:* temporal, spatial, and causal continuity. In addition, each sentence was scored on a number of auxiliary dimensions that were not directly relevant in this study, for example, number of syllables.

Theoretical variables. Each of the theoretical variables was dichotomous. Situationally continuous sentences were assigned a value of one, whereas situationally discontinuous sentences received a value of two. A sentence was considered temporally continuous if it described an event that (a) was concurrent with the previous event or (b) directly followed the previously mentioned event according to trained judges. In all other cases, there was a temporal discontinuity, and the sentence received a two. For example, Sentence 3 in the Appendix conveys a temporal discontinuity.

A sentence was considered spatially continuous if it did not specify a change of spatial setting. A spatial setting is a room, scenario, or region that has distinctive features that are discriminable from alternative spatial settings in a story (see Mandler, 1984; Schank, 1982; Shanon, 1983). A sentence was spatially discontinuous if it moved the narrative Here to another distinctive spatial setting.

A sentence was considered causally continuous if it had a direct necessary causal link with prior information (not necessarily the prior sentence). These analyses were based on van den Broek's (1990) causal inference maker model, which assumes that readers look for a causal connection between an incoming event and prior information. If there is a direct causal relation with the previous event, then there is no need to make an inference. However, if there is no link, then there is a causal continuity break and the reader will attempt to either infer a link to prior information in the situation model or generate an inference on the basis of knowledge from long-term memory. There was one further aspect to our causal analyses. In most naturalistic stories, there are sentences that do not invite the formation of a causal link because they appeal to real-world knowledge. For example, a sentence may specify a date or describe natural events or mechanical phenomena (e.g., "It was August, 1914," "The rain had stopped," or "The clock struck six"). It is pointless to ask "Why was it August 1914?" or "Why did the rain stop?" Therefore, sentences of this type were assigned a value of one. Sentence 8 is an example of a causal discontinuity.

The three situational variables were analyzed by Rolf A. Zwaan and Joseph P. Magliano together. A separate pair of trained judges, not involved in this study, rated a subset of the sentences for reliability. The reliability between the two pairs of raters was acceptable; Cronbach's alpha ranged from .75 (causality) to .91 (spatiality).

Auxiliary variables. Each sentence was scored on five auxiliary variables: number of syllables, serial position, number of new argument nouns, argument overlap, and the text from which the sentence came. Number of syllables is typically a very robust predictor of reading times (Just & Carpenter, 1980; Graesser & Riha, 1984) and may be regarded as a measure of sentence length. Serial position of a sentence is correlated with aspects of the situation model (Gernsbacher, 1990; Haberlandt, 1988) but was treated as an auxiliary variable in this study. Typically, readers speed up toward the end of a text. Number of new argument nouns and argument overlap are both indicators of textbase construction. The textbase is a network of propositions. Propositions consist of predicates and arguments. Verbs are typically predicates and nouns arguments. For example, "The man opens the can" can be propositionalized as (OPEN [man, can]). The number of new argument nouns is an indicator of the number of new textbase nodes that have to be created. Creating these nodes is resource consuming (Graesser, Hoffman, & Clark, 1980; Haberlandt, Graesser, Schneider, & Kiely, 1986). Readers construct a propositional textbase by linking incoming propositions that share one or more arguments, provided the propositions co-occur in working memory (Kintsch & van Dijk, 1978). Consequently, textbase construction should be facilitated to the extent that there is argument overlap between consecutive story sentences. Sentences that shared an argument with the previous sentence were assigned a one on argument overlap. Sentences that did not share an argument with the previous sentence were assigned a two. Finally, we dummy coded for text; the García Márquez text received a zero, and the Bowen text received a one.

Procedure and Design

Participants were randomly allocated to one of two conditions. Half of the participants were instructed to read the stories as they would normally read a short story for pleasure. The other half of the participants were instructed to read the texts for memory so that they would be able to give a detailed and vivid account of what happened in the story.

The texts were presented sentence by sentence on a computer screen. A sentence remained on the screen until the participant pressed the spacebar and then the next sentence appeared. The computer collected reading times for each sentence. Before the reading instructions appeared on the screen, the participants read a short practice story to familiarize themselves with the reading procedure. The order of presentation of the stories was counterbalanced across conditions.

After the participants finished reading the stories, an instruction appeared on the screen, telling the participant to write a summary for each story. The summary data were primarily used as a check of whether the participants had understood the texts; the summary data were not analyzed further. On the basis of the summary data, we judged that the participants had reached an acceptable level of understanding of both stories. The experiment lasted approximately 40 min.

Analysis of Text Materials

Table 1 displays the bivariate correlations between pairs of predictor variables. These correlations were used to detect potential problems of collinearity among our predictor variables. Because there were many correlations to examine, a conservative alpha level of .001 was used for each individual correlation. For all other analyses, however, an alpha level of .05 was used. The correlations were generally low or nonsignificant. The only substantial correlation was between number of syllables and number of new argument nouns. However, these variables assess different processes and the correlation was not extremely high. Therefore, we decided to maintain the new argument-nouns variable in subsequent analyses and examine whether it would make an independent contribution to predicting reading times, despite its high correlation with number of syllables.

It is important to note that the four dimensions of situational continuity were not significantly intercorrelated. This suggests that

[2] In preliminary regression analyses, we examined whether there was a difference in reading times between complete sentences and sentences that were broken up. These analyses involved the auxiliary variables and a variable coding for complete sentence versus sentence part. In both conditions, there was no effect of this variable ($ps > .5$).

Table 1
Bivariate Correlations Between Predictor Variables in Experiment 1

Variable	1	2	3	4	5	6	7	8
1. Syllables	—							
2. Serial position	−03	—						
3. New arguments	66*	−27*	—					
4. Text	−12	14	−22*	—				
5. Argument overlap	10	−05	03	06	—			
6. Temporal breaks	06	01	08	−20	01	—		
7. Spatial breaks	05	07	03	14	−13	15	—	
8. Causal breaks	12	−05	06	−06	−06	08	07	—

Note. Decimal points are omitted.
*$p < .001$.

these variables captured different aspects of situational continuity. One would expect strong covariations among time, space, and causation whenever they are observed in the real world. As discussed earlier, however, literary devices provide deviation from the tight covariation. For example, an effect often is described before its cause. There can be movement in space without an elapse in time: for example, "Jay made a joke about the President in Los Angeles. Meanwhile, in New York, Dave made a similar joke."

Tests were also performed to assess multicollinearity among the predictor variables. We conducted separate multiple regression analyses on each predictor variable, with the remaining predictors in the equation. The only two relatively high multiple correlations were for syllables (.49) and new argument nouns (.52); these analyses primarily reflected the relatively high bivariate correlation between these two variables. All other multiple correlations were less than .2. Therefore, we concluded that there were no serious multicollinearity problems in our set of predictor variables.

Descriptive statistics were collected to determine whether there was sufficient variability in the levels of each variable and whether there was homogeneity of variance. The means and standard deviations for the theoretical variables were as follows: time ($M = 1.36$ and $SD = 0.48$), space ($M = 1.22$ and $SD = 0.42$), causality ($M = 1.49$ and $SD = 0.50$). There was a satisfactory amount of variability in the scores of each variable. In addition, the standard deviations of these variables did not significantly differ ($F_{max} = 1.42$), so they were on equal footing in potentially affecting reading times.

Results and Discussion

We performed multiple regression analyses of reading times to assess the extent to which reading times could be predicted by the three theoretical variables and five auxiliary variables. In an item analysis, variability among items served as the error term in the multiple regression analyses. In subject analyses, a multiple regression analysis was performed on each participant's reading times and a beta weight was extracted for the variable under consideration. Single-sample t tests were used to determine whether the average beta weights in each condition were significantly different from zero (cf. Lorch & Myers, 1990). In these analyses, an alpha level of .05 was used, unless otherwise noted. The beta weights are an indicator of the relative robustness of a predictor variable in predicting sentence reading times. In the analyses reported below, t_1 refers to the analyses by subjects, and t_2 refers to the analyses by items. Standard errors are reported for the subject analyses only because standard errors of the beta weights are not available for the item analyses. Table 2 reports the b-weights from the multiple regression analyses. These are estimations of the change in sentence reading times per level of each predictor variable. For example, in the normal condition, sentence reading times increased by 170 ms for each extra syllable and causal discontinuities elevated reading times by 201 ms.

As Table 2 indicates, the auxiliary variables showed a consistent pattern across the two instruction groups, with number of syllables being the most robust predictor variable. Number of syllables has consistently been a robust predictor of reading times in previous research (e.g., Haberlandt & Graesser, 1985; Just & Carpenter, 1980). Serial position also reliably predicted reading times, which is consistent with prior findings (e.g., Just & Carpenter, 1980; Haberlandt & Graesser, 1985). The more readers progressed through the texts, the faster they read. Although the number of new argument nouns was highly correlated with number of syllables, it still made an independent and reliable contribution to predicting reading times (cf. Haberlandt et al., 1986, for similar findings). Argument overlap between consecutive sentences did not reliably reduce reading times, but the b-weight was in the expected direction. Finally, the García Márquez story was read significantly slower than the Bowen story.

The theoretical variables showed a number of informative trends. In the normal reading condition, temporal discontinuities caused sentence reading times to increase by 297 ms ($\beta = .041$), $t_1(13) = 5.07$, $SE = 0.008$; $t_2(282) = 2.55$, and causal discontinuities caused sentence reading times to increase by 201 ms ($\beta = .034$): $t_1(13) = 4.18$, $SE = 0.008$; $t_2(282) = 1.95$, $p = .05$. The 120-ms increase as a result of spatial discontinuities was not significant ($\beta = .014$): $t_1(13) = 1.64$, $p > .12$, $SE = 0.009$; $t_2(282) = 1.17$, $p = .24$. The important finding here is that readers apparently monitor multiple dimensions of the evolving situation model, time, and causality while reading without a special strategy.

The pattern of results in the memory condition was some-

Table 2
B-Weights (in Milliseconds) From the Regression Analyses of Reading Times in Experiment 1

Variable	Reading instruction: Normal	Reading instruction: Memory
Theoretical		
Temporal breaks	297[a,b]	187[b]
Spatial breaks	120	234[b]
Causal breaks	201[a,b]	34
Auxiliary		
Syllables	170[a,b]	182[a,b]
Serial position	−5[a,b]	−5[a,b]
New arguments	221[a,b]	204[a,b]
Text	715[a,b]	840[a,b]
Argument overlap	−127[b]	−66[b]
R^2	.58	.63

Note. The subjects analyses were performed on the beta weights. Time and space in the memory condition approached significance in the item analysis ($ps < .06$).
[a]Variable was significant in the item analysis ($p < .05$). [b]Variable was significant in the subject analysis ($p < .05$).

what different from that in the normal condition. Temporal discontinuity led to elevated (by 187 ms) reading times, although the effect was only reliable by a subject analysis ($\beta = .032$): $t_1(13) = 4.05$, $SE = 0.008$; $t_2(282) = 1.92$, $p = .056$. Spatial discontinuities increased reading times by 234 ms, although the effect was only reliable by a subject analysis ($\beta = .029$): $t_1(13) = 2.97$, $SE = 0.010$; $t_2(282) = 1.91$, $p = .057$. In contrast to the normal condition, causal discontinuities led to a nonsignificant 34 ms increase in reading times ($\beta = .005$): $t_1(13) = 0.64$, $p = .53$, $SE = 0.008$; $t_2(282) = 0.40$, $p > .69$. Although the temporal and spatial variables were reliable in the item analysis, they did not reach the conventional significance level in the item analysis. In addition, because we did not find a reliable effect of causal discontinuities, it appears that the memory instruction was somewhat disruptive to situation model construction. Presumably, the memory instruction prompted the participants to allocate more processing resources toward encoding the explicit text rather than constructing a situation model. See Aaronson and Ferres (1986) for an example of a similar result.

To determine whether our results were generalizable across texts, we examined the interactions of the three theoretical variables with the text variable. None of these interactions reached significance in either condition. This is informative, given that the two texts that were used in the experiment were very different, both stylistically and thematically.

To summarize, the results indicate that readers monitor temporal and causal continuity under a normal reading instruction; the effect of spatial discontinuities was in the predicted direction but did not reach significance. The results for the participants in the memory condition suggest that this instruction was disruptive to situation model construction. In Experiment 2 we attempted to replicate these results with a different set of materials.

Experiment 2

In Experiment 1 we demonstrated that under normal reading instructions readers monitored multiple dimensions of the situation model while comprehending naturalistic stories. In addition, a reading-for-memory instruction appeared to be disruptive to the monitoring of the situational dimensions. However, limited conclusions can be drawn on the basis of Experiment 1 because of the restrictions on participants' selection and the limited number of texts that was used. One purpose of Experiment 2 was to address these concerns. First, we examined whether the results of Experiment 1, in which readers with a relatively high exposure to print were selected,[3] would generalize to a broader population of readers. Second, we examined whether our results would generalize to more stories, even though our unit of analysis was the sentence rather than the story. Two new stories were used, which differed in many ways from one another (thematically, stylistically, and period in which they were written) as well as from the stories used in Experiment 1. For example, the two stories used in Experiment 2 were first person stories, whereas the stories used in Experiment 1 were third person stories. The generalizability across texts was statistically tested in an overall analysis of the data sets of Experiments 1 and 2.

Experiment 2 was designed to examine how readers process situational discontinuities when rereading a story. We were interested in whether situational discontinuities that were not monitored during the first reading would be monitored during the second reading. During reprocessing of a story, readers can make use of their earlier constructed mental representation so that they can allocate resources to the construction of other dimensions. Participants in the normal reading condition, who monitored causal and temporal discontinuities during the first reading, may monitor spatial discontinuities during the second reading. Participants in the memory condition may allocate resources to situation model construction on the second reading and therefore monitor causal and temporal discontinuities.

Reprocessing tasks have been used in the area of expository texts (Haenggi & Perfetti, 1992; Millis & Simon, 1994). An important finding from these studies is that readers of expository texts appear to allocate more resources to textbase processes than to situation model processes on the first reading. On the second reading, more resources appeared to be available for the construction of a situation model. These results are plausible for expository texts, in which the readers' domain knowledge is typically low. One would not necessarily make the same prediction for narrative texts, however. Stories are typically read for pleasure, and it is difficult to see how constructing a textbase representation would create pleasure (see Graesser, Singer, and Trabasso, 1994, for a more elaborate discussion of this issue). The findings of Experiment 1 suggest that readers, under a normal reading instruction, monitor the temporal and causal dimensions of the evolving situation that is described in a story. The rereading data should provide information on the relative priorities of the situational dimensions in the normal and memory conditions.

Method

Participants

Twenty-eight undergraduate psychology students participated for course credit. The participants were recruited from a statistics course taught by Rolf A. Zwaan and a research methods course taught by Arthur C. Graesser.

Materials

Two published short stories served as stimulus passages: "The Tell-Tale Heart," by Edgar Allen Poe (1951) and "The Bass, the River, and Sheila Mant," by W. D. Wetherell (1985). Both stories were approximately 3,000 words long. Both stories were primarily descriptions of actions, events, and states, but they also contained several sentences that conveyed dialogue. These sentences were omitted from our analyses. As a consequence, the analyses were based on 114 sentences from the Wetherell story and 145 sentences from the Poe story.

[3] It is important to note, however, that the participants in Experiment 1 scored far below the maximum on the author recognition test.

Text Analysis

As in Experiment 1, long sentences were segregated into different parts. To ensure that each part expressed a completed thought, sentences were broken up only after semicolons or commas. The texts were analyzed in exactly the same manner as in Experiment 1. We also used the same set of auxiliary variables as in Experiment 1. Finally, we performed reliability analyses for the theoretical variables. The interrater reliability was acceptable (Cronbach's $\alpha > .87$).

Procedure and Design

Participants were randomly allocated to either the normal or the memory condition. The same instructions were used as in Experiment 1, with the addition that the participants were told that they would see each text twice. The procedure and the presentation of the texts were the same as in Experiment 1. The order of presentation of the stories was counterbalanced across conditions. Each participant first read both stories and then reread them. After the rereading task, an instruction appeared on the screen telling the participants to write a summary for each story. The summary data were primarily used as a check of whether the participants had understood the texts and were not analyzed further. On the basis of the summary data, we judged that the participants had reached an acceptable level of understanding of both stories. The experiment lasted approximately 1 hr.

Analysis of Text Materials

Table 3 displays the bivariate correlations between pairs of predictor variables. These correlations were used to detect potential problems of collinearity among our predictor variables. Once again, for each of the bivariate correlations, a conservative alpha level of .001 was used, but most correlations were low or nonsignificant. As in Experiment 1, there was a high correlation between number of syllables and number of new argument nouns. Temporal continuity was the only theoretical variable that had a relatively substantial correlation with an auxiliary variable. Its correlation with serial position was −.41, indicating that temporal discontinuities were primarily located in the early parts of the stories. Because of this correlation, we were sensitive to suppression effects in the multiple regression analyses. All other correlations were low, including those between the theoretical variables.

Tests were also performed to assess multicollinearity among the predictor variables. We conducted separate multiple regression analyses on each predictor variable, with the remaining predictors in the equation. The only two relatively high multiple correlations were for syllables (.54) and new argument nouns (.56); these analyses primarily reflected the relatively high bivariate correlation between these two variables. All other multiple correlations were <.27. Therefore, we concluded that there were no serious multicollinearity problems in our set of predictor variables.

Table 3
Bivariate Correlations Between Predictor Variables in Experiment 2

Variable	1	2	3	4	5	6	7	8
1. Syllables	—							
2. Serial position	−02	—						
3. New arguments	71*	−22*	—					
4. Text	−24*	−03	−24*	—				
5. Argument overlap	09	−15	08	−02	—			
6. Temporal breaks	08	−41*	18	05	−01	—		
7. Spatial breaks	29*	07	23*	−26*	−03	00	—	
8. Causal breaks	−05	−17	00	−14	−09	19*	—	

Note. Decimal points are omitted.
*$p < .001$

Table 4
B-Weights (in Milliseconds) From the Regression Analyses of Reading Times in Experiment 2

Variable	First reading		Second reading	
	Normal	Memory	Normal	Memory
Theoretical				
Temporal breaks	189[a,b]	172[b]	141[a,b]	150[a,b]
Spatial breaks	107[b]	−18	166[a,b]	128[b]
Causal breaks	216[a,b]	163[b]	83	154[a,b]
Auxiliary				
Syllables	156[a,b]	167[a,b]	108[a,b]	105[a,b]
Serial position	−3[a,b]	−3[a,b]	−2[a,b]	−1[b]
New arguments	43[b]	91[a,b]	40[b]	16
Text	−2	−3	61	103[a,b]
Argument overlap	18	−32	−70	−29
R^2	.77	.77	.67	.70

Note. The subject analyses were performed on the beta weights. In the item anlayses for the memory conditions, time approached significance on the first reading, $p < .08$, and space approached significance on the second reading ($p < .06$).
[a]Variable was significant in the item analysis ($p < .05$). [b]Variable was significant in the subject analysis ($p < .05$).

Descriptive statistics were collected to determine whether there was sufficient variability in the levels of each variable and whether there was homogeneity of variance. The means and standard deviations for the theoretical variables were as follows: time ($M = 1.41$ and $SD = 0.49$), space ($M = 1.20$ and $SD = 0.40$), causality ($M = 1.26$ and $SD = 0.44$). There was a satisfactory amount of variability in the scores of each variable. The standard deviations of these variables did not significantly differ ($F_{max} = 1.50$).

Results and Discussion

We performed multiple regression analyses of reading times to assess the extent to which reading times could be predicted by the three theoretical variables and five auxiliary variables. Analyses by participants and items were performed as in Experiment 1. Table 4 presents the b-weights from these analyses.

Auxiliary Variables

As Table 4 indicates, the auxiliary variables showed a consistent pattern across the two instruction groups and the reading versus rereading conditions. The eight predictor variables explained even more variance than in Experiment 1, number of syllables being the most robust predictor. The effect of serial position was not as strong as in Experiment 1. This may partly be a suppression effect as a result of the correlation between serial position and the temporal variable, which was noted earlier. Number of new argument nouns was a much less robust predictor than in Experiment 1. This may be due to the somewhat higher correlation between new argument nouns and number of syllables than in Experiment 1. The stories in this experiment were read about equally fast. Finally, as in Experiment 1, there was no effect of argument overlap.

First Reading

The data from the first reading can directly be compared with the data from Experiment 1. The pattern of effects in the normal condition was highly consistent with the pattern observed in Experiment 1. There were reliable effects of temporal discontinuities, which led to a 189-ms increase in reading times ($\beta = .035$), $t_1(13) = 4.94$, $SE = 0.007$; $t_2(250) = 2.18$, and eausal discontinuities, which led to a 216-ms increase in reading times ($\beta = .032$): $t_1(13) = 3.71$, $SE = 0.009$; $t_2(250) = 2.40$. Spatial discontinuities led to a 120-ms increase in sentence reading times, which was reliable in the analysis by subjects, but not in the item analysis ($\beta = .016$): $t_1(13) = 2.25$, $SE = 0.007$; $t_2(250) = 1.06$, $p > .28$. Once again, participants appeared to monitor multiple dimensions of the situation model while reading without a specific strategy. The b-weights for spatial and causal discontinuities are strikingly similar to those obtained in Experiment 1. The effect of temporal discontinuities was somewhat smaller in Experiment 2. This may be caused by the fact that one of the texts in Experiment 1, "The Demon Lover," contained relatively large temporal discontinuities.

The pattern of results in the memory condition was consistent with Experiment 1 in that there were no reliable effects of temporal, spatial, or causal discontinuities in both the subject and the item analysis. The 172-ms increase in reading times as a result of temporal discontinuities was reliable in the analysis by subjects but only approached significance in the analysis by items ($\beta = .031$): $t_1(13) = 3.69$, $SE = 0.009$; $t_2(250) = 1.78$, $p = .078$. There was no effect of spatial continuity breaks ($\beta = -.001$): $t_1(13) = -0.21$, $SE = 0.010$; $t_2(250) = -.16$. The causal variable led to a 163 ms increase in reading times, which was reliable only in the analysis by subjects ($\beta = .025$): $t_1(13) = 2.18$, $SE = 0.011$; $t_2(250) = 1.60$, $p > .11$. Again, the reading times for the memory condition suggest that these instructions were disruptive to the monitoring of situational continuity.

Second Reading

The data for the second reading provided useful additional information. In the normal condition, the temporal variable remained a reliable predictor ($\beta = .032$), $t_1(13) = 3.40$, $SE = 0.009$; $t_2(250) = 2.43$, although the increase in reading times was smaller, 141 ms, than in the first reading. Causal discontinuities now led to a nonsignificant 83-ms increase in reading times ($\beta = .017$): $t_1(13) = 1.40$, $SE = 0.012$; $t_2(250) = 1.36$. Conversely, spatial discontinuities now led to a reliable 166-ms increase in reading times ($\beta = .031$): $t_1(13) = 2.76$, $SE = 0.011$; $t_2(250) = 2.44$. Of special note, in the second reading, sentence reading times increased as a function of temporal discontinuities but did not increase as a function of causal discontinuities. One possible explanation is that the readers did not have to reinfer the causes for unexplained events in the story world. In contrast, the readers still may have had to construct a fully fledged temporal representation. The increase in sentence reading times as a function of spatial discontinuity suggests that the reader may allocate resources to monitoring situational dimensions that were not processed during the first reading of a story.

The pattern of results in the memory condition is very interesting in that it was the only condition in which evidence for maximalist situation-model construction could be observed. Temporal discontinuities led to a reliable 150-ms increase in reading times ($\beta = .036$): $t_1(13) = 2.76$, $SE = 0.013$; $t_2(250) = 2.59$. Spatial discontinuities led to a 128-ms increase in reading times, which was only marginally significant in the item analysis ($\beta = .033$): $t_1(13) = 3.30$, $SE = 0.010$; $t_2(250) = 1.89$, $p = .06$. Causal discontinuities led to a reliable 154-ms increase in reading times ($\beta = .031$): $t_1(13) = 2.86$, $SE = 0.011$; $t_2(250) = 2.54$. These results suggest that readers allocated resources toward situation model construction when rereading a story. Of special note, these results are consistent with rereading studies that involved expository texts (Haenggi & Perfetti, 1992; Millis & Simon, 1994). The memory instructions may have induced comprehension strategies that are similar to those used when understanding expository text. Readers may have placed a high priority on encoding the explicit text at the expense of constructing a situation model. However, the memory instruction apparently had only a disruptive effect on the monitoring of situational continuity during the first reading.

There were no significant interactions between any of the theoretical variables and the text variable (all $ps > .09$ and mean $p > .48$). Therefore, as in Experiment 1, our findings generalize across the two very different stories that were used in this experiment. We report below a more direct test of generalizability across texts.

Additional Analyses of Data Sets From Experiments 1 and 2 Combined

In a final set of analyses, we combined the data sets from Experiments 1 and 2 (first reading only) to address some important remaining theoretical and methodological issues. In the first analysis we examined the generalizability of our results across texts. Second, we examined the relations between the situational dimensions. That is, do they interact or are their effects additive? In the third analysis we addressed the question of whether the reading instructions differentially affected reading times. A final analysis was performed to test a prediction that was derived from those models of text comprehension that claim that text comprehension is primarily guided by text cohesion, rather than by situational continuity (Kintsch, 1992; Kintsch & van Dijk, 1978; McKoon & Ratcliff, 1992). We call this the *textbased prediction.*

Generalizability Across Texts

Even though only four texts were used, it was possible to perform statistical tests to determine whether our findings are generalizable across texts. Analogously to the subject analysis, we performed four regression analyses, one on each of the texts separately. The beta weights were extracted from these analyses and subjected to single-sample t tests. In the normal condition, both time ($\beta = .045$), $t(3) = 4.81$, $SE = 0.009$, and causality ($\beta = .031$), $t(3) = 4.63$, $SE = 0.007$, were significant with text as the random factor; spatiality approached significance ($\beta = .015$), $t(3) = 2.50$, $p = .072$, $SE = 0.006$. In the

memory condition, only time was significant across texts ($\beta = .037$), $t(3) = 4.44$, $SE = 0.008$. These results suggest that the temporal and causal dimensions were consistently monitored across stories in the normal condition, given the fact that the four texts used in the experiments were so different, especially the results for the normal condition are encouraging.

Relations Between Situational Variables

We examined whether there were interactions among our situational variables by entering the three interaction terms into the multiple regression analyses. In the normal condition, temporality did not significantly interact with spatiality or with causality (all $|t|$s < 1). The only significant interaction was between spatiality and causality: $t_1(27) = 3.05$, $SE = 0.03$; $t_2(537) = 2.28$. An analysis of this interaction revealed that the increase in reading times as result of a causal discontinuity was larger when there was also a spatial discontinuity than when there was no spatial discontinuity. However, causal discontinuities lead to slower reading times than causal continuities at both levels of the spatial variable. From the perspective of the spatial variables, there was a crossover interaction. Spatial discontinuities led to faster reading times, compared with spatial continuities, for causally continuous sentences but led to slower reading times for causally discontinuous sentences. However, at neither level of the causal variable did the spatial variable have a significant effect, all ps $> .1$, so we do not put much stock in the interaction. In the memory condition, none of the interactions reached the significance level (all ps $> .15$). Finally, the three-way interactions among the situational variables were nonsignificant in both conditions (ps $> .25$).

Effects of Reading Instruction

In this article, we have varied the instructions under which participants read the stories. However, up to now, we have not directly tested whether the normal and the memory instructions differentially affected sentence reading times. In our first analysis we addressed overall reading rate. The sentence reading times were faster in the normal condition ($M = 4{,}431$ ms) than in the memory condition ($M = 4{,}747$ ms). Analyses of variance (ANOVAs) were performed on the average reading times per participant and per item (sentence). In both analyses, reading instruction and experiment were the independent variables; reading instruction was varied between participants and within items. Only the main effects of reading instruction and the interaction are reported. In both analyses, there was a highly significant main effect of experiment, reflecting the uninteresting fact that the sentences were shorter in Experiment 2 than in Experiment 1. According to the analysis by subjects, the 316-ms difference between the two instruction conditions was not significant, $F_1(1, 52) = 1.40$, $MSE = 1{,}007{,}164$. In addition, there was no significant interaction between reading instruction and experiment ($F_1 < 1$). The analysis by items revealed a highly significant effect of reading instruction, $F_2(1, 549) = 162.12$, $MSE = 170{,}969$. Obviously, the item analysis is much more powerful than the analysis by subjects because of the greater number of degrees of freedom and because reading instruction was a within-item but not a within-subject variable. There was no significant interaction between experiment and reading instruction, $F_2(1, 549) = 1.93$. The conclusion from these analyses is that the memory instruction tended to lead to longer reading times than the normal instruction. Presumably, the memory instruction prompted the participants to read the text more carefully than they would normally do. This pattern was found in both experiments.

In a subsequent set of analyses we examined whether any of our predictor variables had a differential effect across reading instructions. As a first step, we conducted a multiple regression analysis with items as the random variable. We used the results of this analysis as a basis for further analyses. We constructed a new variable by subtracting for each item the mean reading time in the normal condition from the mean reading time in the memory condition. We then conducted a multiple regression analysis on this new difference variable. The set of predictor variables explained a significant 12% of the variability in the difference scores, $F(10, 540) = 7.04$. Two variables were responsible for this effect, number of syllables, $t(540) = 4.88$, and causality, $t(540) = -2.70$. The negative sign for causality indicates that causality was a significantly stronger predictor in the normal condition than in the memory condition. On the basis of this result, we performed analyses to determine whether the differential effect of causality was reliable across subjects. We conducted an ANOVA on the beta weights for causality, with condition (normal vs. memory) and experiment as the between-subjects variables. According to this analysis, causality had a differential effect across the two conditions, $F_1(1, 52) = 4.33$, $MSE = 0.0001$; there was no main effect of experiment, $F_1 < 1$, nor was there an interaction between condition and experiment, $F_1(1, 52) = 1.41$. Similar analyses performed on the beta weights for the other variables revealed no other significant effects of reading instruction. To summarize, the normal and memory conditions differed in that causal discontinuities elevated reading times in the normal condition to a larger extent than they did in the memory condition. This result is interesting in light of the fact that sentence reading times tended to be slower in the memory condition. Apparently, the participants in the memory condition did not use the longer processing times to construct a more elaborate situation model.

Test of the Textbased Prediction

We examined a prediction that we derived from various models that claim that readers are primarily guided by local text cohesion under normal reading conditions (e.g., Kintsch, 1992; Kintsch & van Dijk, 1978; McKoon & Ratcliff, 1992). The prediction is that situational discontinuities should not lead to elevated reading times under a normal reading instruction if there is argument overlap between consecutive sentences. We tested this prediction by limiting our analysis to the sentences that had argument overlap with the previous sentence. The textbased view would predict a null effect here: Because there is argument overlap, readers do not monitor situational continuity. Contrary to this prediction, temporal and causal discontinuities still led to longer reading times in

the normal condition, temporality: $\beta = .042$, $t_1(27) = 6.77$, $SE = 0.006$; $t_2(380) = 1.86$, $p < .06$; causality: $\beta = .031$, $t_1(27) = 5.72$, $SE = 0.005$; $t_2(190) = 2.96$. In the memory condition, temporal discontinuities led to longer reading times, even with argument overlap present ($\beta = .039$): $t_1(27) = 5.44$, $SE = .007$; $t_2(190) = 2.02$. These results suggest that the monitoring of temporal and causal continuity in the normal condition and the monitoring of temporal continuity in the memory condition were not critically dependent on the local cohesion between consecutive sentences. In our view, this argues against textbased models of comprehension.

General Discussion

In this study, we examined the effects of temporal, spatial, and causal discontinuity on sentence reading times in naturalistic story comprehension. The results enable us to draw some general conclusions about the construction of situation models in narrative comprehension.

First, readers normally monitor multiple dimensions of the evolving situation. Specifically, temporal and causal discontinuities lead to significant elevations of sentence reading times under a normal reading instruction. The fact that temporality appears to be a very important dimension of situation models is informative because temporality has been the least well-researched dimension in the text comprehension literature (however, see Anderson et al., 1983; Ohtsuka & Brewer, 1992; Mandler, 1986; Zwaan, 1994). The finding that causality is monitored under normal reading conditions is consistent with various other studies (e.g., Fletcher & Bloom, 1988; Graesser, 1981; Keenan, Bailett, & Brown, 1984; O'Brien & Myers, 1987; Singer et al., 1992; Trabasso & Sperry, 1985; Trabasso & van den Broek, 1985; Singer et al., 1992; Suh & Trabasso, 1993; van den Broek & Lorch, 1993). However, our results are informative in that they demonstrate that readers monitor causal continuity in naturalistic story comprehension in addition to and independently from temporal continuity.

The results did not reliably suggest that readers are strongly involved in monitoring the spatial dimension of situation models when reading a story for the first time, although the results were in the predicted direction. However, readers do apparently monitor spatial discontinuity when rereading a story. It is too early at this point to draw strong conclusions about the monitoring of spatial information in story comprehension. It is quite likely that the degree to which spatial information is conveyed varies more across stories than is the case for temporality and causality. Zwaan and van Oostendorp (1993) have listed several characteristics of spatial descriptions in stories that may facilitate the construction of spatial representations, such as continuity, condensation, and determinacy. The four stories used in this study varied along these dimensions. For example, one of our stories, "The Bass, the River, and Sheila Mant" describes a canoe trip on a river. Obviously, a river does not have the clearly defined regions that a house or a town has. Future studies might have to examine a relatively large number of stories to be able to find stable effects for spatiality.

A second conclusion is that the situational dimensions were essentially uncorrelated in naturalistic stories and tended not to interact with respect to reading times. That is, temporal, spatial, and causal discontinuities tended to occur at different locations in the stories and the situational dimensions did generally not interact. Furthermore, both temporal and causal discontinuities lead to elevated reading times, and these dimensions appear to have been monitored independently of one another. This finding has an important methodological implication for studies of temporality and causality. If investigators examine the effects of causal relatedness in an experimental design, they should ensure that the sentences do not also vary in temporal relatedness across the levels of causal relatedness.

A third conclusion is that the effects of situational discontinuities are independent of the status of textual cohesion. We found effects of temporal and causal discontinuities in sentences that share an argument with the preceding sentence. According to some models (e.g., Kintsch, 1992; Kintsch & van Dijk, 1978; McKoon & Ratcliff, 1992), readers are primarily guided by textual cohesion. As long as incoming information is locally cohesive, readers do not engage in further processing. However, if there is a breach of local cohesion, readers will look for global information to bridge the local gap. Our results show that readers monitor global temporal and causal information regardless of whether there was local cohesion. We do not want to claim that local cohesion does not play a role in text comprehension. Our conclusion is simply that it may not be the guiding principle that it is sometimes believed to be.

A fourth conclusion is that reading instructions may have differential effects on the construction of situation models. According to our findings, causal discontinuities have a significantly stronger impact on reading times under a normal reading instruction than under a memory instruction. This finding has an interesting implication in light of the fact that sentence reading times in the memory condition tended to be longer than those in the normal condition. Apparently, the construction of a more elaborate situation model is not always more time consuming. Causal discontinuities did have a strong impact on reprocessing times under a memory instruction. This particular finding is consistent with recent findings involving the reprocessing of expository texts (Haenggi & Perfetti, 1992; Millis & Simon, 1994). Readers appear to construct a coherent textbase representation during the first reading, whereas they engage more in the construction of a situation model on the second reading. Presumably, our memory instruction has evoked a study perspective in the participants, which produced a similar pattern in reading behavior. An analogous finding has been reported by Aaronson and Ferres (1986), who found that a memory instruction was disruptive of deeper comprehension.

A fifth conclusion is that readers further elaborate a situation model when rereading a story. That is, readers allocate resources to monitoring situational dimensions that were not initially monitored during the first reading. In doing so, readers construct a temporally, causally, and spatially rich representation of the story event. When readers use a comprehension strategy that is disruptive to situation model construction, when rereading a story, they will allocate resources to situation model construction.

Our results are consistent with Gernsbacher's (1990) struc-

ture building framework. However, the results also suggest that the structure building framework has to be modified somewhat to account for naturalistic story comprehension. According to the structure building framework, temporal, spatial, and causal discontinuities may prompt readers to shift from building a main mental structure to building a substructure, which is resource consuming. Our results suggest that readers construct multilayered structures, which include at least a temporal and a causal layer and may also include a spatial layer. In addition, our results provide some initial evidence that it may depend on a reader's comprehension goals which dimensions are monitored (see also Zwaan & van Oostendorp, 1993). Presumably, reading goals prompt readers to allocate resources to specific dimensions. To gain further insight in this issue, the effects of reading instructions will have to be examined more extensively.

The method we have used combines analyses of naturalistic stories with multiple regression analyses of reading times. The advantage of using naturalistic stories is that the different dimensions of the situation model, temporality, spatiality, and causality, are not highly intercorrelated and are also not highly correlated with textual variables. This will probably be somewhat different in simple narratives. Our method has proven to be fruitful in that it has provided us with the first sketch of a multidimensional model of situation model construction.

References

Aaronson, D., & Ferres, S. (1986). Reading strategies for children and adults: A quantitative model. *Psychological Review, 93,* 89–112.

Anderson, A., Garrod, S. C., & Sanford, A. J. (1983). The accessibility of pronominal antecedents as a function of episode shifts in narrative texts. *Quarterly Journal of Experimental Psychology, 35,* 427–440.

Bloom, C. P., Fletcher, C. R., van den Broek, P., Reitz, L., & Shapiro, B. P. (1990). An on-line assessment of causal reasoning during comprehension. *Memory & Cognition, 18,* 65–71.

Bowen, E. (1981). The demon lover. In C. Brown (Ed.), *The Collected Stories of Elizabeth Bowen* (pp. 661–666). New York: Alfred Knopf.

Bruder, G. A., Duchan, J. E., Segal, E. M., Shapiro, S. C., Zubin, D. A. (1986). Deictic centers in narrative: An interdisciplinary cognitive-science project (Technical Report 86-20). State University of New York at Buffalo, Department of Computer Science.

Bruner, J. (1986). *Actual minds, possible worlds.* Cambridge, MA: Harvard University Press.

Ehrlich, K., & Johnson-Laird, P. N. (1982). Spatial descriptions and referential continuity. *Journal of Verbal Learning and Verbal Behavior, 21,* 296–306.

Fletcher, C. R., & Bloom, C. P. (1988). Causal reasoning in the comprehension of simple narrative texts. *Journal of Memory and Language, 27,* 235–244.

Fletcher, C. R., & Chrysler, S. T. (1990). Surface forms, textbases, and situation models: Recognition memory for three types of textual information. *Discourse Processes, 13,* 175–190.

Fodor, J. A. (1983). *The modularity of mind: An essay on faculty psychology.* Cambridge, MA: MIT Press.

Franklin, N., & Tversky, B. (1990). Searching imagined environments. *Journal of Experimental Psychology: General, 19,* 63–76.

García Márquez, G. (1972). A very old man with enormous wings. In G. García Márquez, *Leaf storm and other stories* (pp. 105–112). New York: Harper & Row.

Genette, G. (1983). *Narrative discourse: An essay in method.* Ithaca, NY: Cornell University Press.

Gernsbacher, M. A. (1990). *Language comprehension as structure building.* Hillsdale, NJ: Erlbaum.

Glenberg, A. M., Meyer, M., & Lindem, K. (1987). Mental models contribute to foregrounding during text comprehension. *Journal of Memory and Language, 26,* 69–83.

Graesser, A. C. (1981). *Prose comprehension beyond the word.* New York: Springer-Verlag.

Graesser, A. C., Hoffman, N. L., & Clark, L. F. (1980). Structural components of reading time. *Journal of Verbal Learning and Verbal Behavior, 19,* 131–151.

Graesser, A. C., & Riha, J. R. (1984). An application of multiple regression techniques to sentence reading times. In D. E. Kieras & M. A. Just (Eds.), *New methods in reading research* (pp. 183–218). Hillsdale, NJ: Erlbaum.

Graesser, A. C., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review, 101,* 371–395.

Haberlandt, K. F. (1988). Component processes in reading comprehension. In M. Daneman, G. E. MacKinnon, & T. G. Waller (Eds.), *Reading research: Advances in theory and practice* (Vol. 6, pp. 67–108). San Diego, CA: Academic Press.

Haberlandt, K. F., & Graesser, A. C. (1985). Component processes in text comprehension and some of their interrelations. *Journal of Experimental Psychology: General, 114,* 357–374.

Haberlandt, K. F., Graesser, A. C., & Schneider, N. J. (1989). Reading strategies of fast and slow readers. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 815–823.

Haberlandt, K. F., Graesser, C., Schneider, N. J., & Kiely, J. (1986). Effects of task and new arguments on word reading times. *Journal of Memory and Language, 25,* 314–322.

Haenggi, D., & Perfetti, C. A. (1992). Individual differences in reprocessing of text. *Journal of Educational Psychology, 94,* 182–192.

Johnson-Laird, P. N. (1983). *Mental models.* Cambridge, England: Cambridge University Press.

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review, 87,* 329–354.

Keenan, J. M., Bailett, S. D., & Brown, P. (1984). The effects of causal argument overlap on comprehension and memory. *Journal of Verbal Learning and Verbal Behavior, 23,* 115–126.

Kintsch, W. (1992). How readers construct situation models for stories: The role of syntactic cues and causal inferences. In A. F. Healy, S. M. Kosslyn, & R. M. Shiffrin (Eds.), *From learning processes to cognitive processes: Essays in honor of William K. Estes* (Vol. 2, pp. 261–278). Hillsdale, NJ: Erlbaum.

Kintsch, W., & van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review, 85,* 363–394.

Lorch, R. F., & Myers, J. L. (1990). Regression analyses of repeated measures data in cognitive research. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 149–157.

Mackie, J. L. (1980). *The cement of the universe: A study of causation.* Oxford, England: Clarendon Press.

Magliano, J. P., Baggett, W. B., Johnson, B. K., & Graesser, A. C. (1993). The time course of generating causal antecedent and causal consequence inferences. *Discourse Processes, 16,* 35–53.

Mandler, J. M. (1984). *Stories, scripts, and scenes: Aspects of schema theory.* Hillsdale, NJ: Erlbaum.

Mandler, J. M. (1986). On the comprehension of temporal order. *Language and Cognitive Processes, 1,* 309–320.

Mani, K., & Johnson-Laird, P. N. (1982). The mental representation of spatial descriptions. *Memory & Cognition, 10,* 503–518.

McClelland, J. L. (1979). On the time relations of mental processes: An examination of systems of processes in cascade. *Psychological Review, 86,* 287–330.

McKoon, G., & Ratcliff, R. (1992). Inference during reading. *Psychological Review, 99,* 440–466.

Millis, K. K., & Simon, S. (1994). Rereading scientific texts: Changes in resource allocation. In H. van Oostendorp & R. A. Zwaan (Eds.), *Naturalistic text comprehension* (pp. 115–133). Norwood, NJ: Ablex.

Morrow, D. G. (1994). Constructing spatial models from text. In H. van Oostendorp & R. A. Zwaan (Eds.), *Naturalistic text comprehension* (pp. 57–78). Norwood, NJ: Ablex.

Morrow, D. G., Bower, G. H., & Greenspan, S. L. (1989). Updating situation models during comprehension. *Journal of Memory and Language, 13,* 441–469.

Morrow, D. G., Greenspan, S. L., & Bower, G. H. (1987). Accessibility and situation models in narrative comprehension. *Journal of Memory and Language, 26,* 165–187.

Ohtsuka, K., & Brewer, W. F. (1992). Discourse organization in the comprehension of temporal order in narrative texts. *Discourse Processes, 15,* 317–336.

O'Brien, E. J., & Myers, J. L. (1987). The role of causal connections in the retrieval of text. *Memory & Cognition, 15,* 419–427.

Poe, E. A. (1951). The tell-tale heart. In T. O. Mabbott (Ed.), *Selected poetry and prose of Poe* (pp. 244–248). New York: Random House.

Schank, R. C. (1982). *Reading and understanding: Teaching from the perspective of artificial intelligence.* Hillsdale, NJ: Erlbaum.

Shanon, B. (1983). Answers to where-questions. *Discourse Processes, 6,* 319–352.

Singer, M., Halldorson, M., Lear, J. C., & Andrusiak, P. (1992). Validation of causal bridging inferences in discourse understanding. *Journal of Memory and Language, 4,* 507–524.

Stanovich, K., & West, R. (1989). Exposure to print and orthographic processing. *Reading Research Quarterly, 24,* 402–433.

Sternberg S. (1969). The discovery of processing stages: Extentions of Donders' method. *Acta Psychologica, 30,* 276–315.

Striedter, J. (1989). *Literary structure, evolution, and value: Russian formalism and Czech structuralism reconsidered.* Cambridge, MA: Harvard University Press.

Suh, S., & Trabasso, T. (1993). Inferences during reading: Converging evidence from discourse analysis, talk-aloud protocols, and recognition priming. *Journal of Memory and Language, 24,* 595–611.

Tomashevsky, B. (1965/1925). Thematics. In L. T. Lemon & M. J. Reis (Eds.), *Russian formalist criticism: Four essays* (pp. 65–95). Lincoln, NB: University of Nebraska Press. (Original work published 1925)

Trabasso, T., & Sperry, L. L. (1985). Causal relatedness and importance of story events. *Journal of Memory and Language, 24,* 595–611.

Trabasso, T., & van den Broek, P. (1985). Causal thinking and importance of story events. *Journal of Memory and Language, 24,* 612–630.

van den Broek, P. (1990). The causal inference maker: Towards a process model of inference making in text comprehension. In D. A. Balota, G. B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 423–445). Hillsdale, NJ: Erlbaum.

van den Broek, P., & Lorch, R. F. (1993). Network representations of causal relations in memory for narrative texts: Evidence from primed recognition. *Discourse Processes, 16,* 75–98.

van Dijk, T. A., & Kintsch, W. (1983). *Strategies of discourse comprehension.* New York: Academic Press.

Wetherell, W. D. (1985). The bass, the river, and Sheila Mant. In W. D. Wetherell, *The man who loved Levittown* (pp. 57–64). Pittsburgh, PA: University of Pittsburgh Press.

Zwaan, R. A. (1994). *Processing narrative time shifts.* Manuscript submitted for publication.

Zwaan, R. A., & van Oostendorp, H. (1993). Do readers construct spatial representations in naturalistic story comprehension? *Discourse Processes, 16,* 125–143.

Appendix

Opening Sentences From "A Very Old Man With Enormous Wings," by Gabriel García Márquez

(1) On the third day of rain they had killed so many crabs inside the house that Pelayo had to cross his drenched courtyard and throw them into the sea,
(2) because the newborn child had a temperature all night and they thought it was due to the stench.
(3) The world had been sad since Tuesday.
(4) Sea and sky were a single ash-gray thing and the sands of the beach, which on March nights glimmered like powdered light, had become a stew of mud and rotten shellfish.
(5) The light was so weak at noon that when Pelayo was coming back to the house after throwing away the crabs,
(6) it was hard for him to see what was moving and groaning in the rear of the courtyard.
(7) He had to go very close to see that it was an old man,
(8) a very old man, lying face down in the mud, who, despite his tremendous efforts couldn't get up, impeded by his enormous wings.
(9) Fightened by that nightmare, Pelayo ran to get Elisenda, his wife, who was putting compresses on the sick child,
(10) and he took her to the rear of the courtyard.
(11) They both looked at the fallen body with mute stupor.

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