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Temporal and spatial distance in situation models

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In two experiments, we investigated how readers use information about temporal and spatial distance to focus attention on the more important parts of the situation model that they create during narrative comprehension. Effects of spatial distance were measured by testing the accessibility in memory of objects and rooms located at differing distances from the protagonist's current location. Before the test probe, an intervening episode was inserted in the narrative. Story time distance was manipulated by stating that the intervening episode lasted for either minutes or hours. Discourse time—that is, time spent reading from prime to test—was manipulated by describing the intervening episode either briefly or at length. Clear effects of story time distance and spatial distance on accessibility were found, whereas discourse time distance did not affect accessibility. The results are interpreted as supporting constructionist theories of text comprehension.

During the comprehension of narrative texts, comprehenders build multilevel representations of the information that the texts convey (see, e.g., Gernsbacher, 1990; Glenberg & Langston, 1992; Johnson-Laird, 1983; Kintsch, 1988, 1998; van Dijk & Kintsch, 1983; Zwaan, Langston, & Graesser, 1995). Here, we will investigate one such level of representation: the *situation model* or *mental model* of the text. Situation models are the level of text representation associated with "deep" understanding, and they serve to integrate the information stated in a text with the reader's world knowledge. In short, situation models "represent what the text is about, not the text itself" (Glenberg, Meyer, & Lindem, 1987, p. 70).

Situation models are presumed to be multidimensional; in them, many different aspects of a situation are hypothesized to be represented. These include temporal, spatial, and causal relations, as well as protagonists' goals and emotions (Zwaan, Langston, & Graesser, 1995; Zwaan, Magliano, & Graesser, 1995; Zwaan & Radvansky, 1998; Zwaan, Radvansky, Hilliard, & Curiel, 1998). Yet despite this multidimensionality of situation models, most experimental studies have addressed only single dimensions. Among these, spatial relations are the type of information examined most often (see Bower & Morrow, 1990; Graesser, Millis, & Zwaan, 1997; Morrow, 1994; and Zwaan & Radvansky, 1998, for reviews). In comparison, other aspects of situation models, particularly temporal ones, have received relatively little attention.

The emphasis on spatial relations has been especially obvious in research that explores how readers use and update their situation models during comprehension by focusing their attention on the most relevant aspects of the described situation. Spatial information represented in situation models would include not only the spatial layout of objects in the scene but also the present location of the protagonist, his or her movement path, important objects and other actors, and the appearance of the locations. Many studies have shown that readers focus attention on the protagonist and on his or her location and movements within the model. As a result, spatial distance from focus affects accessibility of objects in memory; known objects spatially close to the protagonist become more primed and accessible in memory than spatially distant objects. This effect has been referred to as the *spatial gradient of accessibility* or *spatial distance effect*, and it has been demonstrated repeatedly (see, e.g., Morrow, Bower, & Greenspan, 1989; Morrow, Greenspan, & Bower, 1987; Rinck & Bower, 1995; Rinck, Hähnel, Bower, & Glowalla, 1997; Rinck, Williams, Bower, & Becker, 1996; Wilson, Rinck, McNamara, Bower, & Morrow, 1993).

Most experiments that have revealed an effect of spatial distance on accessibility have followed the procedure introduced by Morrow et al. (1989) or a version of the paradigm developed by Rinck and Bower (1995). Participants first memorize the layout of a building with many rooms, each containing a number of critical objects. An example is depicted in Figure 1. They then read a series of brief narratives, each one describing a new protagonist's

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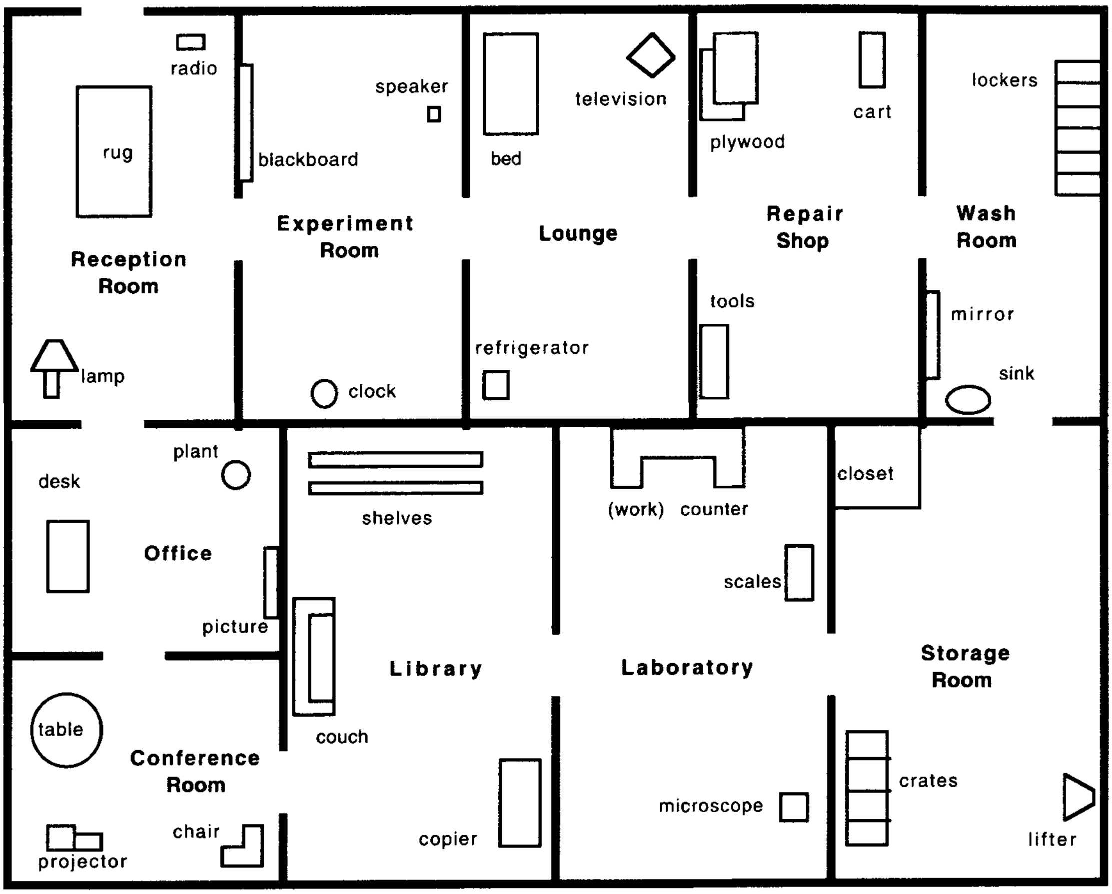

Figure 1. Layout studied by participants in both experiments.

activities in that building. The narratives contain critical motion sentences that describe how the protagonist moves from one room (*the source room*) through an unmentioned *path room* into another room (the *location room*)—for instance, *Calvin walked from the repair shop into the experiment room* (see Table 1 and Figure 1).

The accessibility of objects located in the situation model has been assessed in several ways. In one, participants are asked to answer probe questions about the location of objects in the building; the time taken to answer these questions is the dependent variable. This measure was used in the present experiments: participants' reading was interrupted after the motion sentence, and a test probe consisting of an object name and a room name such as *bed–lounge* (see Table 1) was presented. The participants' task was to indicate whether the denoted object was located in the denoted room. These probe reaction times have been shown to yield a spatial distance effect; that is, the closer the object is to the protagonist's current location, the shorter are the probe reaction times.

Yet although the effects of spatial distance on the accessibility of situation model entities have been investigated in detail, other aspects of situation models and their influence on accessibility have rarely been addressed. We will investigate here whether temporal distance affects the accessibility of entities in situation models. Just as with spatial distance, objects and events close to the temporal "here and now" point of the protagonist (Morrow, 1994) should be more accessible than temporally distant ones (see also Anderson, Garrod, & Sanford, 1983; Carreiras, Carriedo, Alonso, & Fernández, 1997; Zwaan, 1996).

Regarding temporal distance in narratives, an important distinction to be made is that between *discourse time* and *story time* (Chatman, 1978). *Discourse time* refers to real time passing "outside" a narrative during text comprehension, whereas *story time* refers to fictitious time passing (by description) "inside" the narrative. These two types of time are quite different: Story time is a dimension of the model that readers create regarding the situation described by the text, whereas discourse time is coordinated with the participant's actual reading time. Story time and discourse time can be varied independently of one another. Narratives may contain discontinuities in time such as jumps forward to future times or flashbacks. Also, time passing inside a narrative can be shorter or longer than the time people actually take to read that bit of text. One can read about long-lasting events in a short amount of time. Alternatively, brief events may

Table 1
Excerpt of Sample Text and Test Probe Presented in Experiment 1

Calvin was one of the janitors at the research center.
Tonight he slowly changed into his work clothes in the wash room.
He didn't like the job much, but he had to keep it because he needed the money to stay in architecture school.
When he opened his locker, he noticed a note: Director of center has misplaced top secret report, must be found immediately!
He would have to make a thorough search of the center during his shift.
He went into the repair shop, but he couldn't see any papers there.
So he walked from the repair shop into the experiment room.

First Intervening Sentence

This room was a big mess, and Calvin would have to clean it up before he could go on.

Second to Fourth Intervening Sentence

Looking around, Calvin thought that someone must have had a party in here.
He saw empty pizza boxes, Coke cans, bottles of beer, and bits of pop corn everywhere.
There was also a puddle of beer on the floor because someone had dropped a bottle.

Final Intervening Sentence

Minutes: After ten minutes, Calvin was finally done cleaning up the room.
Hours: After two hours, Calvin was finally done cleaning up the room.

Test Probe

BED–LOUNGE

Note—Texts were presented without italics or underlining. Explanations are given in the text.

be described in considerable detail, so that the time described as passing in the narrative is shorter than the time that average readers would spend in reading about it.

The passage of time in narratives can be indicated by a variety of cues, including tense (*John sang*), aspect (*is singing*), adverbs of order (*Before he sang*), or temporal adverbial phrases (*After 5 hours*). Another way of indicating the order of events is simply to narrate them in successive phrases that follow the same order as the story events, as in *John looked at Mary, smiled, and spoke to her*. Several linguists have proposed that readers follow an *iconicity principle* in comprehension—namely, they assume that the story events are ordered in the same way as the successive phrases (Chafe, 1979; Givón, 1992; Hopper, 1979). There is considerable psycholinguistic evidence for this iconicity principle (e.g., Clark, 1971; Mandler, 1986; Ohtsuka & Brewer, 1992).

A stronger version of this iconicity principle was proposed by Dowty (1986) and Zwaan (1996)—namely, that as a default (in the absence of time adverbials), readers assume that the events described in successive sentences or phrases follow one another "almost immediately." Following earlier work by Anderson et al. (1983), Zwaan conjectured further that when the story time between successively mentioned activities is said to be long in relation to the duration of the first, then readers probably infer that a new episode is starting. They thus "close out" the mental representation of the preceding episode structure and set up a new substructure to encode the next episode, as in the "shifting" process proposed in Gernsbacher's (1990) structure building framework. This transition requires several mental operations, including deactivating conceptual entities used in the preceding episode, setting up a new episode node in memory, and assigning a time tag and other event indices to it (see Zwaan, Langston, & Graesser, 1995). These mental operations take time, so that readers should slow down their reading rate at such a boundary. Indeed, Zwaan found that while reading about a series of events, participants took longer to read sentences starting with *A day later* and *An hour later* than they did to read sentences that started with *A moment later.* In line with the hypotheses, he also found that concepts from the previous text were more accessible following *A moment later* but less accessible and equally so for the *hour later* and *day later* adverbials.

The experiments reported here were carried out to investigate further implications of these results using other, convergent behavioral measures of accessibility. Our first question was whether both story time and discourse time would have separate effects on accessibility of previously activated concepts; and if both factors should have an effect, how might they interact in maintaining or deactivating concepts from the previous event? A second question concerned the manner in which temporal proximity combines or interacts with spatial distance in causing the ebb and flow of activation on prior locations and/or prior activities in the situational model.

In the present experiments, spatial distance was manipulated by testing the accessibility of objects located at different distances from the protagonist's current location. Story time was manipulated by inserting an intervening episode between a protagonist's movement through several rooms and a test of the accessibility of those rooms and objects in them. The intervening activities were described to last either for a short time (e.g., 2 min) or for a much longer time (e.g., 2 h). Discourse time was manipulated by describing the intervening activities either briefly (e.g., in one or two sentences) or at length (e.g., in five or six sentences). Obviously, this manipulation causes a confound of discourse time with elaboration of the intervening episode: Reading six sentences rather than one not only takes longer, but also provides more information. Moreover, the additional information might leave the focus of attention on the current location of the protagonist or move it to another location, and the information might be related or unrelated to the protagonist's main goal. This does not pose a problem for purposes of the present study, because it is the natural situation involved in reading. Nonetheless, we will address ways to disentangle duration of discourse time, amount of elaboration, and type of elaboration in the General Discussion section.

In Experiment 1, we examined the effects of discourse time and story time on the accessibility of unmentioned rooms and objects located along the protagonist's path. Story time, but not discourse time, affected accessibility. In Experiment 2, discourse time, story time, and spatial distance were varied independently of each other. In this case, accessibility was affected additively by story time distance and spatial distance. Again, discourse time distance had no effect.

EXPERIMENT 1

Experiment 1 was designed as a preliminary test of the effects of discourse time and story time on the accessibility of entities in a situation model. The experiment followed the procedure introduced by Morrow et al. (1989). Participants first studied the layout of a fictitious research center and then read narratives that described protagonists' activities in the building. Critical motion sentences in the narratives described how the protagonist moved from a source room through an unmentioned path room into a location room. After each motion sentence, the accessibility of an object located in the path room was measured. Object room test probes were presented to the participants, who judged whether the object was located in the room. Between the motion sentence and the test probe, an intervening episode might occur, described as an activity of the protagonist in the location room. Story time was manipulated by stating that this episode lasted for a few minutes versus for a number of hours. Discourse time was manipulated by using two or five sentences to describe the episode. In a control condition, no intervening episode was inserted between the motion sentence and the test probe.

Method

Participants. Forty students of Stanford University, most of them Psychology undergraduates, participated in the experiment, either to fulfill a course requirement or to receive a small monetary payment.

Layout learning. In the first part of the experiment, participants learned the layout of the research center depicted in Figure 1. They studied it for 1 min; then they turned it over and were given a blank diagram containing only the walls and doors of the building. They were asked to recall by writing all the room names and object names that they could remember at their correct locations on the diagram; they then compared their recall to the original layout and noted errors. The participants proceeded through such self-paced study–test cycles until they could perfectly reproduce all room and object names in their correct locations. Afterward, they answered 15 questions about locations of rooms and objects in the building. The participants required approximately 30 min to learn the layout and answer the questions perfectly.

Narrative reading. In the second part of the experiment, the participants read 16 narratives (1 practice narrative, followed by 15 experimental narratives) presented one sentence at a time on the CRT screen of a microcomputer, controlled by the RSVP software (Williams & Tarr, 1998). Presentation of the sentences was self-paced: The participants pressed the space bar of the computer's keyboard to advance from one sentence to the next. An excerpt of a sample experimental narrative used in Experiment 1 is given in Table 1. Each narrative was approximately 20 sentences long and described the actions of a protagonist who moved through the building trying to fulfill an overall goal (e.g., to have the research center cleaned up in preparation for important visitors). Distributed across the 15 experimental texts, 30 motion sentences were presented (see Table 1). Each motion sentence described how the protagonist moved from a source room (e.g., the repair shop) through an unmentioned path room (e.g., the lounge) into a location room (e.g., the experiment room). The 30 motion sentences were distributed equally over the 10 rooms of the building to ensure that each room served as source room, path room, and location room with equal frequency. As Table 1 illustrates, each motion sentence could be followed by an intervening episode, before an object room test probe was presented. The first sentence of the intervening episode introduced a new subgoal and an action of the protagonist in pursuit of it. If they were used, a second, third, and fourth sentence elaborated on the goal and the actions. The final intervening sentence wrapped up the episode and explicitly stated the duration of this intervening episode. The intervening episodes provided the means for manipulating temporal distance between the motion sentence and the subsequent testing of the accessibility of the prior room and its objects. To achieve diversity, the episodes varied considerably with regard to the focus of attention that they induced: About half of them left the focus inside the location room (see the example in Table 1), whereas the other half moved it someplace else in the research center or outside the center. Moreover, about half of the episodes were unrelated to the main goal of the protagonist (e.g., in Table 1, cleaning the room is unrelated to finding the lost report), whereas the other half were related to it.

Five different versions of the intervening episodes were used. In the *hours–2 sentences* condition, only the first and the final intervening sentences were presented, and the final sentence stated that the intervening activities had lasted for hours (a minimum of one hour was used). The *hours–5 sentences* condition was identical, except that all five intervening sentences were presented. The *minutes–2 sentences* and *minutes–5 sentences* conditions were identical to the corresponding *hours* conditions, except that the final intervening sentence stated that the intervening activities had lasted for only a few minutes (a maximum of 10 min was used). These four conditions resulted from full combination of story time distance (hours vs. minutes of intervening time) and discourse time distance (two vs. five intervening sentences). In all conditions, the protagonist remained in the location room throughout the intervening activities. All activities (e.g., cleaning up a room) could plausibly last for either minutes or hours. The fifth experimental condition was a control condition, in which nothing was inserted between the motion sentence and the following test probe.

The 30 experimental test probes presented to each participant always contained the name of an object from the path room and the name of the path room, presented in capital letters, for instance, BED–LOUNGE (see Table 1). As with all other test probes, participants had to decide whether or not the stated object was currently located in the stated room. They responded by pressing the key labeled "Yes" or the key labeled "No" on the computer's keyboard.

For each participant, each of the five intervening episode conditions was paired with six experimental test probes. Across participants, each test probe was used equally often with each of the five intervening episode versions. The intervening episodes and experimental test probes were divided into five sets of materials, and each set was presented to one fifth of the participants. For the experimental test probes, the correct answer was always "yes." The experimental narratives also contained a total of 29 filler test probes presented to all participants, a large majority (24) of which required a "no" response in order partially to offset the 30 critical "yes" probes. None of these filler probes tested the path room, but queried whether an object was located in the source room, the location room, or other rooms of the building. Besides previously learned objects, the filler probes contained the protagonist's name, newly introduced people, and new objects.

After reading each narrative, the participants answered three yes/no questions to test comprehension of the narrative. These questions queried such details as the reason for certain actions, the location of certain activities, and the order of actions. The participants were instructed to read carefully, but at their normal speed. Reading times as well as probe reaction times, question answering times, and correctness of the answers were recorded by the computer. After reading all 16 narratives, the participants completed a short questionnaire about their reading strategies and features of the narratives. It took the participants about 45 min to read the narratives and answer the questions.

Design. For the main analysis, full combination of story time distance (minutes vs. hours of intervening time) and discourse time distance (two vs. five intervening sentences) yielded a 2 × 2 design. Both factors were varied within participants. To compare the experimental conditions with the control condition, an analysis with the single five-level factor *type of intervening episode* was computed. The dependent variable of interest was probe reaction time to the experimental test probes.

Results and Discussion

Reaction times (RTs) of correct responses to experimental test probes were analyzed after outlier RTs (5% of the RTs) were excluded from the data. Outliers were determined relative to each participant and each experimental condition. First, difference scores were computed by subtracting each participant's median RT from his or her RTs. Then, separately for each dependent variable and each experimental condition, the upper and lower 2.5% of the difference scores were determined, and the corresponding RTs were marked as outliers and replaced by the participant's median RT (Rinck, 1994). All analyses of variance (ANOVA) were computed twice, once with the 40 participants as a random factor, and once with the 30 test probe positions. Below, F_1 values refer to the by-participants analyses, whereas F_2 values refer to the by-materials analyses. All effect sizes reported for the by-participants analyses (with the f statistic) were determined from Cohen (1988). The RTs of Experiment 2 were treated in the same way. Error rates for the probe reactions were analyzed correspondingly. These analyses are not reported in the following, however, because they did not yield any significant effect: The error rates were uniformly low, averaging 4%.

Table 2
Mean Reaction Times (in Seconds) of Path Room Test Probes (With Standard Deviations) in Experiment 1

Story Time Distance	Discourse Time Distance in Sentences: 2		5		Control	
	M	*SD*	*M*	*SD*	*M*	*SD*
Hours	2.69	0.72	2.77	0.76		
Minutes	2.53	0.67	2.63	0.77		
No insert					2.50	0.67

The probe RTs observed in Experiment 1 are displayed in Table 2. The 2 × 2 ANOVAs of the four conditions involving intervening activities yielded a significant effect of story time distance; that is, RTs were longer after hours than after minutes of story time had passed [$F_1(1,39) = 8.80, p < .01, f = .23$; $F_2(1,29) = 6.03, p < .05$]. Discourse time distance, on the other hand, had no significant effect (both Fs < 1.94, n.s., $f = .11$): RTs were not reliably longer after five intervening sentences than after two intervening sentences. The interaction of story time and discourse time was not significant either (both Fs $< 1, f = .02$).

The complete ANOVAs of all five experimental conditions yielded a significant effect of the five-level factor *type of intervening episode* [$F_1(4,156) = 4.28, p < .01, f = .33$; $F_2(4,116) = 3.31, p < .05$]: Conditions involving intervening activities caused longer RTs than did the control condition, which had no intervening sentence between the movement and the probe test. Planned comparisons revealed that this difference was significant for hours–2 sentences [$t(39) = 2.63, p < .05$] and hours–5 sentences [$t(39) = 3.68, p < .01$], approached significance for minutes–5 sentences [$t(39) = 1.67, p < .11$], and missed statistical significance for minutes–2 sentences [$t(39) < 1$].

Some theoretical interest also centers on how long participants take to read and understand the last intervening sentence that wraps up the episode; when participants press the button upon finishing that sentence, the object–room probe item is presented. This last sentence contained the minutes versus hours adverbial phrase and followed either one or four preceding sentences describing the interrupting activity. A plausible hypothesis[1] is that readers will take more time while understanding the hours sentence, since an interruption of the main goal for that duration would seem to demand some more elaboration or explanation from the reader. By the same reasoning, reading four prior sentences before the wrap-up sentence would provide the requisite elaborations (or events), so that readers would not be so surprised by the hours interruption nor need to spend time explaining it. Contrariwise, following four prior sentences, readers might be surprised by the minutes wrap-up sentence and struggle to explain how these several events required only a few minutes to accomplish. Such explanatory processes would increase their reading time for the final intervening sentence.

Turning to the results, the average times to read the final intervening sentence were 2.54 sec for the hours–2 sentences condition, 2.52 sec for the minutes–2 sentences condition, 2.41 sec for the hours–5 sentences condition, and 2.39 sec for the minutes–5 sentence condition. These means have an average standard deviation of 0.66 sec. An ANOVA of these reading times yielded a significant speed-up for five as opposed to two sentences [means of 2.40 vs. 2.53 sec, $F(1,39) = 5.20, p < .05$], but no effect of the hours versus minutes variation [means of 2.47 vs. 2.46 sec, $F(1,39) < 1$]. Exactly the same pattern of final sentence reading times was observed in Experiment 2 and in a related experiment that was deleted to save journal space. We reserve for later some discussion of these results in elucidating the time adverbial effect. The main conclusion here is that readers are devoting the same amount of time to reading and comprehending the hours and minutes sentences that wrap up the interrupting activity.

To summarize, the results of the first experiment suggest that the accessibility of situation model entities (objects and rooms) faded (or was inhibited) with the passage of story time in the described situation. Importantly, the probed object and the path room were not explicitly mentioned in the story just before their accessibility was tested. Nevertheless, the protagonist's exposure to them was implied by his or her motion through the path room, and their accessibility faded the longer the time that was said to pass in the story world between this motion event and presentation of the test probe. Their accessibility was higher if an intervening episode was described as lasting for only a few minutes rather than several hours. Surprisingly, distance in discourse time did not have a comparable effect on accessibility. After five sentences of intervening activities, RTs were only slightly—and not significantly—longer than after two intervening sentences. This null result occurred despite the additional amount of information and the additional time spent reading five as opposed to two sentences, with the extra reading time averaging 6 sec. In comparison with the gradual effect of story time, the observed results suggest that discourse time had only an all-or-none effect on accessibility: Taken together, any intervening episode yielded longer RTs than did the control condition, which had nothing intervening. The following experiment was conducted to replicate and expand these results.

EXPERIMENT 2

Experiment 2 was designed as a replication and extension of the first experiment. It served to answer two main questions. First, might the null effect of discourse time distance observed in Experiment 1 merely imply that our manipulatioh of discourse time was not sufficiently extreme? To answer this question, a more extreme variation of discourse time was constructed: In Experiment 2, the intervening episode included either one or six sentences, rather than the two versus five sentences variation of the previous experiment. Second, how do spatial distance and temporal distance represented in the reader's situation model interact to increase the accessibility of situation model entities close to the here-and-now of the protagonist? Two alternatives seem plausible. First, both types of distance might have additive effects on accessibility. Additive effects were observed in an unpublished study (described briefly by Bower & Rinck, 1999a) that measured the effects of goal relevance and spatial distance on the accessibility of objects contained in the situation model. Alternatively, temporal distance and spatial distance might interact: If either factor causes high accessibility, the other factor might not be able to increase it any further. For instance, objects in the location room are known to be highly accessible, perhaps maximally so; therefore, a short duration of discourse time or story time might not be able to increase their accessibility even further. Such an interactive relation was observed by Rinck, Bower, and Wolf (1998) when they independently varied spatial distance and distance in the surface structure of the text. To investigate the additivity of effects here, spatial distance, story time distance, and discourse time distance were varied independently of each other in Experiment 2.

Method

Experiment 2 was very similar to the previous experiment; therefore, only the new features will be described.

Participants. Forty-eight students at Stanford University participated in the experiment, either to fulfill a course requirement or to receive a small monetary payment. None of had participated in the previous experiment.

Layout learning and narrative reading. The layout used in this experiment was identical to the one of the previous experiment. The narratives were very similar, differing only with regard to the intervening episodes, which consisted of either one sentence or six sentences. The one-sentence condition was created by changing the two-sentence conditions used in Experiment 1. For instance, the first and final intervening sentences shown in Table 1 were combined to yield *This room was a big mess, but it took Calvin only a minute to clean it up* in the *minutes–1 sentence* condition and *This room was a big mess, and it took Calvin two hours to clean it up* in the *hours–1 sentence* condition. In the six-sentence conditions, a sixth sentence was added to the five-sentence conditions of the previous experiment. For the sample text shown in Table 1, the sentence *Calvin thought that he hated the people who were responsible for this mess* was inserted right before the final intervening sentence. Incidentally, because the last intervening sentences differ so greatly between the one- versus six-sentence conditions, their reading times cannot be compared in a controlled manner. Unlike in the previous experiment, no control condition was used in Experiment 2. Six intervening episodes were deleted from the narratives because only 24 instead of the previously used 30 intervening episodes were needed in Experiment 2.

The object room test probes were very similar to those in the first experiment, differing by only two features. First, test probes consisting of an object from the location room together with the name of the location room (e.g., CLOCK–EXPERIMENT ROOM), were used in addition to the previously used path room probes. Second, only 24 experimental test probes were presented to each participant. Therefore, each participant encountered 3 test probes in each of the eight experimental conditions that resulted from full combination

Table 3
Mean Reaction Times (in Seconds) of Test Probes (With Standard Deviations) in Experiment 2

		Discourse Time Distance in Sentences			
		1		6	
Target Room	Story Time Distance	*M*	*SD*	*M*	*SD*
Location room	Hours	2.57	0.71	2.56	0.67
	Minutes	2.40	0.61	2.40	0.52
Path room	Hours	2.72	0.71	2.71	0.67
	Minutes	2.47	0.51	2.52	0.46

of two values each of story time distance, discourse time distance, and spatial distance. As before, all test probe types and all intervening episode types were fully crossed to avoid confounds of conditions and materials. In addition to the 24 experimental probes, which required a "yes" response, 27 filler test probes were presented to all participants, 23 of which required a "no" response.

Design. Full combination of story time distance (minutes vs. hours of intervening time), discourse time distance (one vs. six intervening sentences), and target room type (location, path), yielded a 2 × 2 × 2 design. All factors were varied within participants. As in Experiment 1, probe RT to the experimental test probes was used as the main dependent variable.

Results and Discussion

The probe RTs observed in Experiment 2 are displayed in Table 3. The 2 × 2 × 2 ANOVAs of the RTs yielded only two significant effects—namely, target room type [$F_1(1,47) = 5.62, p < .05, f = .12$; $F_2(1,23) = 4.82, p < .05$] and story time distance [$F_1(1,47) = 9.69, p < .01, f = .16$; $F_2(1,23) = 7.29, p < .05$]. These effects accorded with the predictions: Objects from the location room yielded faster responses than did objects from the path room, and responses were faster after minutes as opposed to hours of story time had passed during the intervening episode. Discourse time distance (one vs. six sentences), on the other hand, had no significant effect (both Fs < 1), and none of its interactions was statistically significant (all Fs < 1). Two additional ANOVAs, computed separately for each level of spatial distance, confirmed these results. For objects from the path room, the 2 × 2 ANOVA yielded a significant effect of story time distance [$F_1(1,47) = 8.82, p < .01, f = .21$; $F_2(1,23) = 6.90, p < .05$], whereas discourse time distance and the interaction were not significant (all Fs < 1). Similar results were observed for objects located in the location room: Story time distance was significant in the by-subjects analysis and marginally significant in the by-materials analysis [$F_1(1,47) = 4.47, p < .05, f = .15$; $F_2(1,23) = 4.07, p < .10$], whereas discourse time distance and the interaction were not (all Fs < 1). As before, analyses of the error rates did not yield significant effects. The error rates were uniformly low, averaging 6%.

In Experiment 2, we did not analyze reading times of the final intervening sentence in a 2 × 2 ANOVA as we did in Experiment 1, because the different discourse time conditions involved rather different final sentences (see the examples above). Therefore, comparisons could be made only for story time distance in the same controlled manner as in Experiment 1. These comparisons revealed that the story time adverb did not have a significant effect on reading times of the final intervening sentences. This was true both for the one-sentence conditions [minutes vs. hours: 3.27 vs. 3.32 sec, $t(47) < 1$] and the six-sentence conditions (minutes vs. hours: 2.11 vs. 2.19 sec, $t(47) = 1.19$, n.s.]. This lack of an effect of story time on reading times of the final intervening sentences replicates the pattern of results observed in Experiment 1. We will come back to the theoretical significance of these data in the General Discussion section.

The present results regarding the probe RTs replicate and clarify the results observed in the first experiment. First, the effect of spatial distance on probe RT observed here replicates the spatial gradient of accessibility observed in many previous studies. Second, the effect of story time on the accessibility of situation model entities replicates the effect observed in Experiment 1, indicating that accessibility of objects and rooms depended on the amount of time that passed in the story world. Again, accessibility was higher if an intervening episode was described as lasting for a few minutes rather than several hours. As in Experiment 1, accessibility was probed directly after the intervening episode—that is, before the beginning of a new episode. Third, despite the more extreme variation introduced in Experiment 2, distance in discourse time had no effect on accessibility. This clear-cut result clarifies the weak effect of discourse time observed in Experiment 1. Instead of being replicated, the effect of discourse time disappeared completely: After one or six sentences describing an intervening activity, probe RTs were practically identical. Finally, no interactions were observed in Experiment 2. Most importantly, story time distance and spatial distance had additive effects on accessibility, much like goal relevance and spatial distance in the study described by Bower and Rinck (1999a). Thus, even highly accessible objects in the location room were more accessible after a short duration of discourse time than after a long duration.

GENERAL DISCUSSION

To summarize, the experiments reported here indicate that readers use temporal information in addition to spatial information to focus their attention on the most relevant parts of their situation model—that is, on the here and now of the protagonist. Experiment 1 showed that story time—that is, the time passing "inside the story" during an intervening episode, affected the accessibility of prior objects and rooms represented in the reader's situation model. Experiment 2 replicated this result and showed that story time distance and spatial distance had additive effects on accessibility: Objects and rooms were most accessible in memory if they were located in spatial proximity to the protagonist and, independently, if the intervening activities were described as lasting for only a few minutes rather than several hours. In marked contrast to story time and spatial distance, varying amounts of temporal distance in discourse time (number of intervening sentences) had no effect on accessibility over the one- to six-sentence range investigated here (obviously, there will be some upper limit to this). Prior objects and rooms were no less accessible after five or six intervening sentences than after one or two. Discourse time distance affected accessibility in only an all-or-none manner in Experiment 1: If no sentence was interpolated after the motion event, accessibility was higher than when an episode of any duration intervened before the probe.

Given this pattern of results, the obvious question is why it was observed. In particular, why did spatial distance and story time distance affect accessibility of rooms and objects along an implied path in the situation model, and why did discourse time distance have no effect on accessibility? We have recently suggested an associative network model to explain spatial distance effects in situation models (Bower & Rinck, 1999b, in press). That model assumes that spatial layouts like the building map of Figure 1 are encoded as link–node hierarchies in long-term memory, with nodes representing rooms and objects in containment relationships, and with nodes linked by adjacent spatial relationships. The paths through doors between rooms are represented as simple adjacency links.

We further assume that readers use this memory structure as a referent as they read the stories taking place there. In particular, when participants read a sentence such as *Calvin walked from the repair shop into the experiment room*, they activate the corresponding concept nodes in the map representation. That activation spreads to the objects linked (associated) to those rooms. Thus, references to those room objects or questions about their location will be answered quickly. In addition, participants are presumed to derive inferences regarding the character's current location and the likely path of motion by which he or she has arrived there. Activating the concepts in these inferred propositions spreads additional activation to the current location room and some smaller amount to the path room. These assumptions regarding inferences and spreading activation suffice to explain the robust distance effect in spatial priming that we have found repeatedly.

But how are we to understand the differential effects found here for story time versus discourse time? We suspect that these differences arise from their differing importance to the story world, as opposed to the real world. It seems compelling that gradual variations of situation model variables—namely, spatial location and story time—affected readers' allocation of attention, whereas variations of a surface variable, namely, discourse time passing during reading, did not. This suggests that readers use quite sophisticated focusing strategies during narrative comprehension: Rather than rely on external features such as time passing while they are reading, they focus attention within the situation model by using clues to critical features of the story world itself. Among these features, temporal cues will be particularly critical in the story world just as they are in the real world. For instance, temporal cues about the duration of events and intervening activities indicate the current here-and-now point of the situation model (Morrow, 1994), they mark the continuity of the current episode or the beginning of a new one, and they signal the relative importance of people, objects, and rooms that are part of the situation model (Anderson et al., 1983; Bestgen & Vonk, 1995; Carreiras et al., 1997; Zwaan, 1996). Moreover, temporal relations are critical for the order of events, and therefore, for conjecturing the causal relations among those events (Mandler, 1986; Ohtsuka & Brewer, 1992). This strategy, emphasizing story time rather than discourse time, is clever and usually successful because features of the situation model are indeed more helpful for the allocation of attention within the story model than are mechanics of the person's actual reading. After all, the events of the story world determine the importance of narrative entities such as its characters, objects, and locations. Because of the noninteractive nature of print materials, these entities are independent of the particular reader situation—for instance, of the place, time, and duration of reading.

How are we to understand the difference in prior room priming due to an intervening activity that is claimed to take hours versus minutes? In the associative network theory, this can be rendered simply as a greater suppression or inhibition of earlier nodes or concepts in the mental model when readers encounter the *hours* versus *minutes* signal. Such fast acting inhibition or suppression of activation is a frequent assumption in several theories of language processing (see, e.g., Gernsbacher, 1990; Swinney, 1979). But "fast inhibition" seems merely to re-describe the result without providing a satisfactory explanation of it. The passage of time itself causes nothing; rather, it is events or processes that occur *in time* that can produce psychological effects. But what might those be? In personal communications, Tom Trabasso (who was one of our reviewers) suggested that the long versus short times for the interrupting activity lead readers to engage in more or less elaborations and explanations for the time taken. As a consequence, readers draw differing inferences regarding the relative importance of the character's original, main goal in comparison with the subordinate goal that motivates the interrupting activity.

We found Trabasso's hypothesis appealing and sought evidence for it. One line of evidence, added belatedly to our report of Experiment 1, was the reading time for the final intervening sentence, which contained the time adverb that wrapped up the interrupting episode, just before the probe. Recall that no effect on reading time of the hours versus minutes adverbial was found in either Experiment 1 or Experiment 2, and that null result was replicated in a third (unpublished) experiment. With one prior set-up sentence, we would have expected the hours sentence to require more elaborations than the minutes sentence (*Why is Calvin taking so much time doing this?*). But no such difference was found. Similarly, with four or five prior sentences (and/or events) before the wrap-up, we would have expected the minutes sentence to require more explanations than the hours sentence (*How could he do all that in so few minutes?*). But again no such difference was observed. To counter such results, one might argue that reading time may not accurately reflect explaining time. An alternative assessment would be to ask participants to "think aloud" about what is going on with the short as opposed to the long time passages. But we would still need to explain the lack of differences in reading time, given conjectured differences in explanatory requirements.

Trabasso's other hypothesis (personal communication, 1999) is that the short as opposed to long times may signal differences in urgency of the character's top-level goal versus the interrupting goal. That may then cause different connections to be forged and activated in the reader's "causal network" of the story, as proposed in the theory of Langston and Trabasso (1999; also, Langston, Trabasso, & Magliano, 1998). As a consequence, more or less activation is passed to the memory representations of the prior rooms and their contents. Independently, the causal network theory also explains our spatial distance effect by treating rooms and their objects as enabling conditions for actions. However, in the theoretical simulations that we have seen (Trabasso, personal communication, 1999), the spatial distance effect appears to be produced by supposing that readers produce inferences similar to those that our model also assumes (i.e., inferring an unmentioned path room and its objects). However, it is not appropriate for us to explicate Trabasso's theory here; we expect him to do so himself elsewhere far better than we can.

Before closing, we should mention some limitations of our results. First, our experiments confounded distance in discourse time and the amount of descriptive elaboration of the intervening activity: Reading additional sentences takes longer, and the additional sentences per force contain some extra information. In this regard, the present study mimics the natural situation in reading. Fortunately, this confound need not impair interpretation of the observed effects, because duration of discourse time had no effect on accessibility of situation model entitites in the present experiments. Of course, that might reflect offsetting effects of other variables that cancel out. Therefore, it might be useful to disentangle the two variables in future studies investigating phenomena other than the allocation of attention in situation models. This might be achieved, for instance, by presenting the sentences for a controlled duration rather than allowing participants to read at their own pace. By this means, elapsed discourse time (i.e., presentation time of an intervening episode before the probe) could be varied independently of the number of sentences describing the episode. However, we doubt that these manipulations would have strong effects, given that in our study the combined effect of both variables was quite small.

Another potential complication may arise from the fact that the extra information given in the intervening episodes varies in content. Different intervening episodes might leave the focus of attention on the current location of the protagonist or move it to another location, and the intervening episodes might be related or unrelated to the protagonist's main goal. For example, suppose that while supervising the cleaning of the laboratory, the character stops to telephone his wife about the day's events at home and the call takes a long or short time. That discussion would illustrate an intervening episode that moves the focus of attention elsewhere (to the wife) and is unrelated to the character's main goal (cleaning the lab rooms). Obviously, such differences in the contents of the episodes and in their relation to the situation model might affect comprehension and focusing of attention during updating of the model—for instance, by changing the narrative goal structure (see Langston & Trabasso, 1999).

However, post hoc analyses of materials in both experiments did not reveal any differences in prior room activation between different types of intervening episodes. These analyses showed that the general pattern of results—effects of spatial distance and story time distance but no effect of discourse time distance—held whether the intervening episode kept the focus within the location room or moved outside it, and whether the interrupting goal was related as a subgoal of the character's overall goal, or whether the interrupting goal was quite distinct. Thus, among our texts, these differences seem uncritical for the priming effects studied here, although we did not specifically manipulate these features. Therefore, it might be useful to vary the contents of inserts and elaborations systematically in future studies.

A final and less serious confound arises from our use of both object names and room names in the test probes. This makes it impossible to ascertain whether accessibility of the rooms or of the objects located in them was affected by temporal distance and spatial distance. However, previous research suggests that probably both effects occur. Rinck et al. (1996, Experiment 2) found spatial distance effects on the accessibility of rooms, and many experiments done with test probes consisting of object pairs have indicated effects on the accessibility of objects in the rooms (e.g., Morrow et al., 1989; Morrow et al., 1987; Wilson et al., 1993). The present experiments were designed to maximize possible effects of temporal distance rather than to estimate separately the effects on rooms and objects. The latter could be easily achieved in future experiments, for instance, by using object–object test probes or anaphoric target sentences referring to rooms following varying lapses of time.

The present results confirm and extend those reported in previous studies of how temporal information influences narrative comprehension. For example, having situated the protagonist in some well-known scenario (e.g., eating a restaurant meal, attending a movie), Anderson et al. (1983) showed that a sentence asserting the passage of story time longer than the typical duration of that scenario (e.g., "After 5 hours") caused rapid deactivation of the scenario-dependent characters and objects (e.g., the waiter or the projectionist, respectively). Similarly, Carreiras et al. (1997) found that if a present tense story contains a reference to a past attribute of the protagonist (e.g., *Jane used to work as an economist*), that past attribute shows weaker activation than if the story states it as a present attribute. That is, features of past states were less accessible than features of present states. In both studies, the authors investigated shifts in story time large enough to clearly signal the end of a previous episode and the beginning of a new one. Thus, these authors studied the effects of the passage of story time sufficiently long to cross an episode boundary.

In the experiments reported here, on the other hand, we examined within-episode effects: story time duration and discourse time duration of the intervening activity were varied without crossing the time boundaries of the episodes. For instance, cleaning a room may take a few minutes or almost two hours (see Table 1). But in either case, the cleaning episode is still the current one, and a new one has not yet begun. Therefore, the present results are most closely related to those reported by Zwaan (1996). He compared the adverbial phrases *A moment later*, *An hour later*, and *A day later* in their effects on the accessibility of concepts mentioned in the sentence preceding the time shift. Most importantly, he found that accessibility was reduced (causing slower recognition memory for earlier concepts) by the hour time lapse as opposed to the moment time lapse, even though the typical duration of the critical episodes (e.g., a cocktail party) extended beyond an hour. Thus, Zwaan's results reveal within-episode effects of story time, and his effects are quite compatible with those observed here. Beyond compatibility with these findings, the present results advance matters by showing that the same effect of story time (but not discourse time) on accessibility occurs for *inferred* rooms and objects along a path that were not explicitly mentioned in the previous text, but were activated by inference within the reader's situation model.

Which theory of narrative comprehension might explain the pattern of results observed in this study? It seems that the clear and graded effects observed for story time distance and spatial distance in combination with the negligible effect of discourse time distance clearly favor constructionist models of text comprehension (Gernsbacher, 1990; Graesser, Singer & Trabasso, 1994; Singer, Graesser & Trabasso, 1994). Both story time and spatial location of the protagonist are important aspects of the situation described or implied by the text rather than aspects of the text itself. Thus, they are represented in the reader's situation model instead of the text base or the surface representation (see Kintsch, 1988, 1998).

The experiments reported here add to the small but growing number of studies investigating different dimensions of situation models simultaneously. Despite the multidimensionality of situation models, most experimental studies have addressed only single dimensions. Exceptions are the studies by Bower and Rinck (1999a) and Rinck et al. (1998) mentioned above, as well as the study by Haenggi, Gernsbacher, and Bolliger (1994), who manipulated both emotional and spatial inconsistencies contained in short narratives. The most comprehensive multidimensional studies were reported by Zwaan and his colleagues (Zwaan, Langston, & Graesser, 1995; Zwaan, Magliano, & Graesser, 1995; Zwaan et al., 1998) in support of the event-indexing model of narrative comprehension. In these studies, the authors investigated discontinuities of temporal, spatial, and causal relations, as well as discontinuities related to the protagonist and his or her goals. These studies were correlational rather than experimental in nature, however, using a verb-clustering task and measuring reading times, which were then fit by multiple regression equations. Conclusions about effective variables were based on the sizes of the regression coefficients. We believe that in the future, more experimental studies will be needed that vary different dimensions of situation models independently of one another, as we have done here for spatial and temporal variations.

REFERENCES

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

Bestgen, Y., & Vonk, W. (1995). The role of temporal segmentation markers in discourse processing. *Discourse Processes*, **19**, 385-406.

Bower, G. H., & Morrow, D. G. (1990). Mental models in narrative comprehension. *Science*, **247**, 44-48.

Bower, G. H., & Rinck, M. (1999a). Goals as generators of activation in narrative understanding. In S. R. Goldman, A. C. Graesser, & P. van den Broek (Eds.), *Narrative comprehension, causality, and coherence: Essays in honor of Tom Trabasso* (pp. 111-134). Mahwah, NJ: Erlbaum.

Bower, G. H., & Rinck, M. (1999b). Priming access to entities in mental models. In W. Hacker & M. Rinck (Eds.), *Proceedings of the 41st Congress of the German Psychological Association in Dresden, 1998* (pp. 74-85). Lengerich, Germany: Pabst Science Publishers.

Bower, G. H., & Rinck, M. (in press). Selecting one among many referents in spatial situation models. *Journal of Experimental Psychology: Learning, Memory, & Cognition*.

Carreiras, M., Carriedo, N., Alonso, M. A., & Fernández, A. (1997). The role of verb tense and verb aspect in the foregrounding of information during reading. *Memory & Cognition*, **25**, 438-446.

Chafe, W. (1979). The flow of thought and the flow of language. In T. Givón (Ed.), *Syntax and semantics: Vol. 12. Discourse and syntax* (pp. 159-181). New York: Academic Press.

Chatman, S. (1978). *Story and discourse: Narrative structure in fiction and film*. Ithaca, NY: Cornell University Press.

Clark, E. V. (1971). On the acquisition of the meaning of before and after. *Journal of Verbal Learning & Verbal Behavior*, **10**, 266-275.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.

Dowty, D. R. (1986). The effects of aspectual class on temporal structure of discourse: Semantics or pragmatics? *Linguistics & Philosophy*, **9**, 37-61.

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

Givón, T. (1992). The grammar of referential coherence as mental processing instructions. *Linguistics*, **30**, 5-55.

Glenberg, A. M., & Langston, W. E. (1992). Comprehension of illustrated text: Pictures help to build mental models. *Journal of Memory & Language*, **31**, 129-151.

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

Graesser, A. C., Millis, K. K., & Zwaan, R. A. (1997). Discourse comprehension. *Annual Review of Psychology*, **48**, 163-189.

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

Haenggi, D., Gernsbacher, M. A., & Bolliger, C. A. (1994). Individual differences in situation-based inferencing during narrative text comprehension. In H. van Oostendorp & R. A. Zwaan (Eds.), *Naturalistic text comprehension* (pp. 79-96). Norwood, NJ: Ablex.

Hopper, P. J. (1979). Aspect and foregrounding in discourse. In

T. Givón (Ed.), *Syntax and semantics: Vol. 12. Discourse and syntax* (pp. 213-241). New York: Academic Press.

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

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction–integration model. *Psychological Review*, **95**, 163-182.

Kintsch, W. (1998). *Comprehension.* New York: Cambridge University Press.

Langston, M. C., & Trabasso, T. (1999). Modeling causal integration and availability of information during comprehension of narrative texts. In H. van Oostendorp & S. Goldman (Eds.), *The construction of mental representations during reading* (pp. 29-69). Mahwah, NJ: Erlbaum.

Langston, M. C., Trabasso, T., & Magliano, J. P. (1998). A connectionist model of narrative comprehension. In A. Ram & K. Moorman (Eds.). *Computational models of reading and understanding* (pp. 181-226). Cambridge, MA: MIT Press.

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

Morrow, D. G. (1994). Spatial models created 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 narrative comprehension. *Journal of Memory & Language*, **28**, 292-312.

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

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

Rinck, M. (1994). *Treatment of outliers in reaction time data.* Unpublished manuscript. Technical University of Dresden.

Rinck, M., & Bower, G. H. (1995). Anaphora resolution and the focus of attention in situation models. *Journal of Memory & Language*, **34**, 110-131.

Rinck, M., Bower, G. H., & Wolf, K. (1998). Distance effects in surface structures and situation models. *Scientific Studies of Reading*, **2**, 221-246.

Rinck, M., Hähnel, A., Bower, G. H., & Glowalla, U. (1997). The metrics of spatial situation models. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **23**, 622-637.

Rinck, M., Williams, P., Bower, G. H., & Becker, E. S. (1996). Spatial situation models and narrative understanding: Some generalizations and extensions. *Discourse Processes*, **21**, 23-55.

Singer, M., Graesser , A. C., & Trabasso, T. (1994). Minimal or global inference during reading. *Journal of Memory & Language*, **33**, 421-441.

Swinney, D. A. (1979). Lexical access during sentence comprehension: (Re)consideration of context effects. *Journal of Verbal Learning & Verbal Behavior*, **18**, 545-569.

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

Williams, P., & Tarr, M. J. (1998). *RSVP: Experimental control software for MacOS* (Version 4) [Online]. Available: psych.umb.edu/rsvp/ [1998, October 27].

Wilson, S. G., Rinck, M., McNamara, T. P., Bower, G. H., & Morrow, D. G. (1993). Mental models and narrative comprehension: Some qualifications. *Journal of Memory & Language*, **32**, 141-154.

Zwaan, R. A. (1996). Processing narrative time shifts. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **22**, 1196-1207.

Zwaan, R. A., Langston, M. C., & Graesser, A. C. (1995). The construction of situation models in narrative comprehension: An event-indexing model. *Psychological Science*, **6**, 292-297.

Zwaan, R. A., Magliano, J. P., & Graesser, A. C. (1995). Dimensions of situation model construction in narrative comprehension. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **21**, 386-397.

Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin*, **123**, 162-185.

Zwaan, R. A., Radvansky, G. A., Hilliard, A. E., & Curiel, J. M. (1998). Constructing multidimensional situation models during reading. *Scientific Studies of Reading*, **2**, 199-220.

NOTE

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