Distance Effects in Surface Structures and Situation Models

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We investigated the role of spatial distance in situation models, surface recency, and explicit mentioning of target items in the updating of situation models created from narratives. In 3 experiments, a distance effect on accessibility was observed: The accessibility of target items (objects and rooms) contained in the situation model decreased with increasing distance between the target and the reader's focus of attention. The first 2 experiments demonstrated that this distance effect was mainly spatial: Accessibility of targets depended on the number of rooms located between the target and the focus of attention, that is, the protagonist's location in the situation model. Recency in the surface structure of the narrative affected accessibility only when strong surface cues were available. Additionally, the high accessibility of objects located in the same room as the protagonist did not depend on the text explicitly stating the name of the room. The findings corroborate the importance of spatial distance represented in situation models, thereby supporting multilevel theories of text comprehension.

According to recent theories of text comprehension, readers build multilevel representations of texts during the comprehension process (e.g., Gernsbacher, 1990; Glenberg & Langston, 1992; Johnson-Laird, 1983; Kintsch, 1988, 1992; van Dijk & Kintsch, 1983; Zwaan, Langston, & Graesser, 1995). The level of representation...
investigated here is the situation model or mental model of the text. Situation models constitute the level of text representation associated most closely with "deep" understanding and serve to integrate the information stated in a text with general information supplied by 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). The experiments reported here address the question of how readers use and update their situation models during comprehension in order to focus attention on the most relevant aspects of the described situation (see also Bower & Morrow, 1990; de Vega, 1995; Morrow, Bower, & Greenspan, 1989).

Many different aspects of a situation may be represented in a situation model, for example, causal, temporal, and spatial relations as well as the protagonists' goals and emotions (Zwaan, Langston, & Graesser, 1995; Zwaan, Magliano, & Graesser, 1995). Spatial relations, however, are the type of information investigated most often; thus, the term spatial situation models is used frequently (for reviews, see Morrow, 1994; Zwaan & Radvansky, 1998). Spatial relations represented in situation models would include such information as the present location of the protagonist, important objects and actors, the appearance of the locations, and the movement path or goal of the protagonist. Many studies have shown that spatial models guide readers' allocation of attention because they focus attention on the protagonist and on his or her location and movements. As a result, an effect of spatial distance on accessibility arises; that is, 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. In this article, however, we use the more general term spatial distance effect because one of the aims of the experiments reported here was to find out how graded the effect really is. Spatial distance effects have been demonstrated repeatedly in studies in which participants learn a map (layout) before reading the narratives (e.g., Haenggi, Gernsbacher, & Bolliger, 1994; Haenggi, Kintsch, & Gernsbacher, 1995; Morrow et al., 1989; Morrow, Greenspan, & Bower, 1987; Morrow, Leirer, Altieri, & Fitzsimmons, 1994; Morrow, Stine-Morrow, Leirer, Andressy, & Kahn, 1997; Rinck & Bower, 1995; Rinck, Hähnel, Bower, & Glowalla, 1997; Wilson, Rinck, McNamara, Bower, & Morrow, 1993), as well as in studies in which the layout is learned from a verbal description (Rinck, Williams, Bower, & Becker, 1996, Experiment 1), or when there was no prior learning procedure (e.g., de Vega, 1995; Glenberg & Mathew, 1992; Glenberg et al., 1987; O'Brien & Albrecht, 1992).

Many of the experiments that revealed an effect of spatial distance on accessibility 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 objects. They then read a series of narratives, each one describing a protagonist's activities in that building. The narratives contain critical motion sentences describing how the protagonist moves from one room (the source room) through an unmentioned path room.
DISTANCE EFFECTS

into another room (the location room; e.g., "In despair, Sandra walked from the waiting room into the office"; see Table 1 and Figure 1). The accessibility of objects is then assessed by measuring the time participants take to read an anaphoric target sentence that follows the motion sentence. Each anaphoric target sentence contains a definite noun phrase that refers to a memorized object in one of the building's rooms (e.g., "She recalled an image of the notes lying beside the fax machine in the office"; see Table 1). If the object referred to is located in the location room (e.g., the fax machine in the office), comprehension of the anaphoric expression is easier and reading time (RT) is shorter than if it is located in the path room or the source room.

Although it seems that the importance of spatial distance for the accessibility of situation model components has been demonstrated many times, alternative, nonspatial explanations of the distance effect have been proposed. Rinck and Bower (1995, Experiments 3 and 4) were able to exclude two alternatives: The distance effect is neither due to the readers being surprised by references to distant objects nor to a confound of spatial distance between rooms and their temporal distance during learning of the building's layout. Thus, it is usually assumed that differing degrees of object accessibility are indeed caused by different levels of spatial distance between the object and the focus of attention, that is, the protagonist's current location (see Rinck et al., 1997, for a discussion of the types of distance involved). This conclusion, however, may be premature because a plausible alternative would explain the distance effect as caused by a type of distance other than spatial distance.

The alternative explanation is based on the generally accepted assumption that readers of a narrative represent the protagonist's locations and motions in their situation model of the narrative. In case of the narratives used here, readers would represent the protagonist's movement from the source room through the path room into the location room during comprehension of the motion sentence described earlier. For this representation, the order in which the three rooms are activated and processed is important: First, the reader's attention is focused on the source room (e.g., the waiting room; see Table 1). The room, as well as the objects and people located in it, is activated while the protagonist is located in the waiting room. Then, during comprehension of the motion sentence, the intermediate path room (e.g., the lounge) and its objects are activated briefly as the protagonist is imagined walking through it. Finally, the protagonist arrives at his or her destination, the current location room, for example, the waiting room, providing maximal attention and activation there. If the accessibility of objects in the source, path, and location room is probed while the protagonist is still in the location room, spatial distance in the situation model is confounded with recency of the last activation from memory: The source room and the path room are not only farther away from the focus of attention than the location room, the length of time elapsed since their last activation and the amount of information processed in the meantime are also greater. This alternative explanation seems quite credible because many theories of text compre-
TABLE 1
Translation of Sample Narrative Used in Experiment 1

Sandra had been planning a new research project for quite a while. Now she was going to meet the director of the research center to talk about the project. She was nervous because she had to convince him of the project. She sat on the sofa in the library and tried to prepare herself for the meeting. She reached into her briefcase for her notes and discovered to her horror that the notes were missing. She quickly ran into the laboratory to look for her notes. There, however, she realized that she had to search in a systematic way. She tried to concentrate and think where the notes might be. Maybe she had left them on the bus she had taken this morning. Far activation of target room (one out of three possible sentences)
Location: Another possibility was that she had left the notes in the office.
+1 Room: Another possibility was that she had left the notes in the reception room.
+2 Room: Another possibility was that she had left the notes in the conference room.
She decided to search the whole building before she called the bus company to find out if someone had found her notes. So she walked into the storage room. She tried to remember where she had left her notes by mentally retracing her steps. Again and again, she had to think of the crowded bus she had used in the morning. Now she was sure that she had not left her notes there because she had watched her briefcase carefully to beware of pickpockets. The notes had to be somewhere in the research center, however, she could not find anything among all the junk in the storage room. Next she went into the lounge. She didn't find anything in her locker but an old sandwich, so she went on into the waiting room. Close activation of target room (one out of three possible sentences)
Location: Most probably, she had left her notes in the office after all and a colleague had picked them up.
+1 Room: Most probably, she had left her notes in the reception room after all, and a colleague had picked them up.
+2 Room: Most probably, she had left her notes in the conference room after all, and a colleague had picked them up.
Motion sentence
In despair, Sandra walked from the waiting room into the office.
Coherence sentence
Again, she tried to mentally retrace her steps to recall where she had left her notes in the morning.
Anaphoric target sentence (one out of three possible types)
Location: She recalled an image of the notes lying beside the fax machine.
+1 Room: She recalled an image of the notes lying beside the lamp.
+2 Room: She recalled an image of the notes lying beside the blackboard.
Following sentence
Suddenly, the phone rang right beside Sandra, and she was shaken out of her thoughts. At the same time, she heard someone call her name. The voice came from the experiment room and belonged to the secretary. Sandra turned around and saw the secretary coming out of the experiment room as fast as she could on her high heels. In her hand, she carried Sandra's notes. Sandra had left them on the desk in the office.

Question 1: Did Sandra meet the director of the research center to talk about job problems?
Question 2: Did Sandra search the lounge before the waiting room?
Question 3: Did the secretary find Sandra's notes on the desk in the office?

Note. Original materials were presented in German without any highlighting; explanations are given in the text.
hension (e.g., Kintsch, 1988; van Dijk & Kintsch, 1983) as well as models of human memory (e.g., Anderson, 1983) would predict that recently activated items are more accessible than items that were activated a longer time ago.

Recently, a variant of this alternative distance hypothesis was proposed post hoc to explain an unexpected effect observed by Rinck et al. (1996). In the first and second experiment of that article, the accessibility of objects in rooms already visited by the protagonist (the source, path, and location room), as well as rooms further ahead on the protagonist’s circular route, was probed. The rooms ahead were the next room on the route (the +1 room) and the room beyond the next room (the +2 room). Surprisingly, a spatial gradient of accessibility occurred only for rooms the protagonist had just passed through, that is, the source, path, and location room. For rooms ahead on the route of the protagonist, objects in the +2 room were more accessible than objects in the spatially closer +1 room. After closer inspection of the data, it turned out that this unexpected finding seemed true only for +1 rooms and +2 rooms that had already been mentioned at the beginning of the narrative. For these rooms, the +2 room had been explicitly mentioned more recently than the +1 room, so we conjectured that this recent activation may have made the +2 room and its objects more accessible than the +1 room and its objects.
Three different variables might account for the increased accessibility of recently activated items. For recently activated items, the number of concepts processed between the activation of an item and the test of its accessibility is lower. Second, the amount of time elapsed between activation and test is shorter for recently activated items. Third, the amount of time that is being described as passing in the narrative world between the activation of an item and its test is also shorter. Chatman (1978) referred to these two types of time as *discourse time* and *story time*, respectively. Discourse time denotes real time passing “outside” the narrative while readers process the text. Story time refers to the time that is passing (by description) “inside” the narrative. In principle, amount of information, discourse time, and story time are independent of each other. The alternative explanation of the distance effect described earlier, however, assumes that all three of them are confounded and may contribute to the increased accessibility of recently activated items. Therefore, the experiments reported here did not attempt to investigate these three variables in isolation. Instead, they were varied together in order to test the alternative distance explanation. In the following, we use the general term *surface recency* to refer to the distance between activating and testing of target items, in order to avoid references to amount of information, discourse time, or story time, in particular. Although beyond the scope of this article, independent variations of these three variables might be very interesting, and we discuss some promising avenues for further research in this area at the end of the article.

The first two experiments reported here were designed to assess both the effects of spatial distance and surface recency on the accessibility of situation model components. In doing so, the purpose of the experiments was twofold: First, the explanation put forward by Rinck et al. (1996) was tested. This was achieved by probing the accessibility of objects in the +1 room and the +2 room while controlling for prior mentioning of these rooms in the narratives. Second, the plausibility of the surface recency hypothesis as a general explanation of the distance effect was tested. To achieve this, spatial distance of rooms in the situation model and surface recency of their last activation were varied independently of each other. The results of Experiments 1 and 2 indicated that besides spatial distance and surface recency, surface level factors such as explicit mentioning of room names might affect the accessibility of rooms and objects located in them. Therefore, the third experiment was designed to assess the effects of activating a room by explicitly stating its name compared with merely implying it.

**EXPERIMENT 1**

Experiment 1 was designed to determine the relative effects of spatial distance and surface recency on the accessibility of situation model components. If the higher accessibility of objects and rooms close to the protagonist of the narrative is based
solely on the fact that these are spatially close, only an effect of spatial distance in
the situation model should be observed. If, on the other hand, rooms such as the path
room are more accessible because they were recently activated in memory, an ef-
fact of surface recency should be observed. In the most extreme case, recency of ac-
tivation should be the only variable affecting accessibility.

The experiment was similar to the two-part experiments described by Rinck
and Bower (1995). In the first part, participants studied the layout of a fictitious
research center, including rooms and objects located in it. In the second part, they
read narratives about protagonists who performed actions in the research center.
Periodically, anaphoric target sentences contained in the narratives referred to
target objects that were located at differing distances from the current focus of at-
tention, that is, from the protagonist of the narrative. The objects referred to were
located either in the same room as the protagonist (location room), in the next
room ahead on the protagonist’s route through the building (+1 room), or in the
room beyond that one on the route (+2 room). Rooms ahead of the protagonist
were used for two reasons. First, we wanted to compare the results of this experi-
ment to those reported by Rinck et al. (1996) in order to test the post hoc explana-
tion offered by Rinck et al. Second, probing the accessibility of objects located in
the source room or path room would have rendered independent variations of spa-
tial distance and surface recency impossible. Surface recency between last activa-
tion of the target room (the room containing the target object) and a later reference
to an object located in it was varied by explicitly mentioning the target room in an
activation sentence either three sentences before the anaphoric target sentence
(close activation), 12 sentences before it (far activation), or not at all in the current
story (no prior activation).

Activation sentences always stated the name of the target room explicitly but
never contained an object name (e.g., “Another possibility was that she had left the
notes in the office”). The anaphoric target sentences, on the other hand, always
mentioned the target object explicitly but not the target room name (e.g., “She re-
called an image of the notes lying beside the fax machine”). The activation sen-
tences and anaphoric target sentences used in this experiment were chosen for sev-
eral reasons. First, mentioning the target room explicitly in the activation sentences
rather than merely implying it ensures that readers will indeed activate the rooms
during comprehension of the activation sentences. In this manner, the activation
sentences used in this experiment are comparable to those used by Rinck et al.
(1996). Second, target objects were not mentioned in the activation sentences be-
cause the alternative explanation of the distance effect outlined earlier refers to re-
cency of last activation of the target room components, not simply to recency of
their last explicit mentioning. Thus, we avoided an explicit name repetition of the
target object. Third, anaphoric target sentences did not mention the name of the tar-
get room in order to present an even stronger case for the role of surface recency.
Rinck and Bower (1995) showed that a spatial distance effect can be observed with
such sentences. Thus, they seemed appropriate for the investigation of surface recency as well. Finally, testing the accessibility of objects located in the target room instead of the accessibility of the target room itself should reveal whether activation of the room activates the objects contained in it as well.

Method

Participants. Forty-five students of the Technical University of Dresden participated in this experiment, compensated by course credit or a small monetary payment equivalent to $6. The data of two additional participants were excluded from all analyses. One was not a native speaker and indicated comprehension problems. The other one tried to learn the narratives by heart to answer the comprehension questions following the narratives perfectly. The remaining 45 participants had an average error rate of 5% to these questions.

Layout learning. In the first part of the experiment, participants learned the layout of a research center containing nine rooms with three critical objects in each room. Figure 1 displays the layout used in Experiment 1, translated from German into English. Participants studied it for 1 min, 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 they could remember at their correct locations on the diagram; they compared their work with the original layout and noted errors. 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 19 questions about locations of rooms and objects in the building. Participants required approximately 30 min to learn the layout and to answer the questions perfectly.

Narrative reading. In the second part of the experiment, participants read 10 narratives (1 practice narrative, followed by 9 experimental narratives) presented one sentence at a time on the screen of a microcomputer, controlled by the “VTx” software (Fezzardi, Hasebrook, & Glowalla, 1992). Presentation of the sentences was self-paced: Participants pressed both buttons of the computer's mouse to advance from one sentence to the next. A translated example of the experimental narratives 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 a goal, for example, to search for lost notes. At the end of each narrative, three yes/no questions were presented 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. To motivate careful reading, participants received a financial bonus equivalent to $3 for making at most four mistakes over the 10 narratives or a bonus equivalent to $6 for making a maximum of two mistakes on these questions. Participants answered yes/no to each question by pressing either the left or the right mouse button. After each answer, feedback about the correctness was provided on the screen. After a wrong answer, a message urging participants to read more carefully was displayed. Participants were instructed to read carefully but at their natural speed. RTs as well as question-answering times, and correctness of the answers, were recorded by the computer.

Near the end of each narrative, four critical sentences were included. These consisted of a motion sentence, a coherence sentence, an anaphoric target sentence, and a following sentence. Each motion sentence described a complete motion event, in which the protagonist walked from one room (source room) through an unmentioned room (path room) into the next room (location room). An example is given in Table 1: "In despair, Sandra walked from the waiting room into the office."

After each motion sentence, a coherence sentence was presented to motivate the mental event described in the upcoming anaphoric target sentence (e.g., "Again, she tried to mentally retrace her steps to recall where she had left her notes in the morning"; see Table 1). The coherence sentence was followed by the critical anaphoric target sentence containing a definite noun phrase that referred to some unique object in one of the rooms of the research center (e.g., "She recalled an image of the notes lying beside the fax machine"). As Table 1 illustrates, this object could be located in the location room (e.g., the fax machine in the office), the next room along the protagonist’s route (+1 room, e.g., the lamp in the reception room), or the room beyond that one (+2 room, e.g., the blackboard in the conference room). All anaphoric target sentences described some type of mental event such as thinking, remembering, or deciding about some aspect of the referent object. Each anaphoric target sentence contained the name of the target object referred to but did not state the name of the target room (e.g., the office in the case of the fax machine).

After each anaphoric target sentence, a following sentence was presented. This sentence introduced a new event in the location room and served to refocus the participant’s attention on the location room, no matter whether the preceding anaphoric target sentence had already referred to an object in the location room or whether the attention had to be shifted back from the referenced object in the +1 room or +2 room. Rinck et al. (1996) termed these sentences focus in location room sentences. They were included because for these sentences, only an effect of spatial distance was expected. Rinck et al. (1996) observed a distance effect on accessibility in the RTs of these following sentences that was comparable to the effect observed in the RTs of anaphoric target sentences. Apparently, shifting the reader’s attention from the protagonist’s location to a distant object involves the same processes as shifting it back. For the following sentences, surface recency between activation and testing of the rooms involved is always very short, however. This is the
case because the target room is always activated by the anaphoric target sentence, and the location room is always activated by the preceding motion sentence. Thus, one would not expect any effect of an additional mentioning of the target room earlier in the narrative.

Near the beginning of each narrative, a sentence mentioning the target room could be included (e.g., “Another possibility was that she had left the notes in the office”; see Table 1). This sentence served to activate the target room early in the narrative, long before the later anaphoric target sentence would be presented. In this far condition, the activation sentence always occurred 12 sentences before the target sentence. Also, during presentation of this activation sentence, the protagonist was located five rooms ahead of the later location room. Three different versions of the activation sentence were constructed to ensure that each participant would read the activation sentence that stated the room which would be the target room of the later anaphoric target sentence. For instance, if a participant were later to read the target sentence referring to an object in the office, the activation sentence mentioning the office would be presented to him or her (see Table 1). In the close condition, the activation sentence was always followed by two sentences before the target sentence was presented, and the protagonist was located only two rooms ahead of the later location room (i.e., in the source room). Again, three different versions of this close activation sentence were constructed to ensure correspondence between the activation sentence and the anaphoric target sentence presented to any given participant. All activation sentences mentioned the later target room explicitly but did not refer to any of the objects located in that room. In the no prior activation condition, no activation sentence was presented at all; thus, the narrative was shorter by one sentence.

Across the nine narratives, each participant read nine anaphoric target sentences, that is, one sentence in each experimental condition, as defined by the full combination of target room type (location room, +1 room, +2 room) and recency of activation (close, far, none). For any given narrative, each participant read only one of the three possible anaphoric target sentences and received only one of the three possible activation conditions. To counterbalance materials and experimental conditions, the nine narratives were divided into nine sets of materials, and each set was presented to five participants. After reading all 10 narratives, participants’ spatial knowledge was tested again by asking them to draw on a blank piece of paper the layout they had studied. All participants passed this test by correctly drawing the location of the nine rooms and the 27 objects. Finally, they completed a short questionnaire about their reading strategies and features of the narratives and were de-
briefed. It took participants about 45 min to read the narratives, draw the layout, and answer the questions.

**Design.** For anaphoric target sentences and the following sentences, combination of the factors target room type (location, +1, +2) and recency of activation (close, far, none) yielded a $3 \times 3$ design. Both factors were varied within subjects. The dependent variables of interest were the RTs of anaphoric target sentences and following sentences.

**Results and Discussion**

RTs of anaphoric target sentences and following sentences 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 (see Rinck, 1994). These RTs were subjected to analyses of variance (ANOVAs). All effect sizes reported later (with the $f$ statistic) were determined from Cohen (1988). The RTs observed in the following experiments were treated the same way.

**Anaphoric target sentences.** The mean RTs of anaphoric target sentences are shown in the upper part of Table 2 and are graphed in Figure 2. The upper part of Table 2 also contains the corresponding standard deviations. As Figure 2 suggests, a clear effect of spatial distance to the protagonist was observed, whereas surface recency did not affect the RTs. In particular, the two-way ANOVA of these RTs yielded a significant effect of target room type, $F(2, 88) = 7.13, p < .01, f = .14$. RTs of sentences referring to an object in the location room were shorter than those referring to objects in the +1 room, $F(1, 44) = 9.02, p < .01, f = .13$, which did not differ significantly from those of the +2 room, $F(1, 44) < 1, f = .03$. Most important, the RTs increased with increasing spatial distance for all three levels of surface recency (close, far, and none); no advantage of the +2 room over the +1 room was observed. Recency of prior activation had no significant effect on RTs, neither for the location room, the +1 room, the +2 room, nor for all three rooms combined, $F(2, 88) < 1, f = .05$. Contrasting only the two extreme conditions “close mentioning” and “no mentioning” did not yield a significant effect of surface recency either, $F(1, 44)$...
### TABLE 2
Mean Reading Times (With Standard Deviations) of Anaphoric Target Sentences and Following Sentences in Seconds in Experiment 1

<table>
<thead>
<tr>
<th>Target Room Type</th>
<th>Location Room</th>
<th>+1 Room</th>
<th>+2 Room</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sentence Type and Surface Recency</strong></td>
<td><strong>M</strong></td>
<td><strong>SD</strong></td>
<td><strong>M</strong></td>
</tr>
<tr>
<td>Anaphoric sentences</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Close</td>
<td>4.80</td>
<td>2.12</td>
<td>5.72</td>
</tr>
<tr>
<td>Far</td>
<td>5.36</td>
<td>2.24</td>
<td>5.53</td>
</tr>
<tr>
<td>None</td>
<td>5.11</td>
<td>2.19</td>
<td>5.98</td>
</tr>
<tr>
<td>M</td>
<td>5.09</td>
<td>2.18</td>
<td>5.74</td>
</tr>
<tr>
<td>Following sentences</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Close</td>
<td>5.03</td>
<td>2.56</td>
<td>5.32</td>
</tr>
<tr>
<td>Far</td>
<td>5.17</td>
<td>2.55</td>
<td>5.19</td>
</tr>
<tr>
<td>None</td>
<td>4.91</td>
<td>1.94</td>
<td>5.50</td>
</tr>
<tr>
<td>M</td>
<td>5.04</td>
<td>2.35</td>
<td>5.34</td>
</tr>
</tbody>
</table>

![Figure 2](https://example.com/figure2.png)

**FIGURE 2** Mean reading times of anaphoric target sentences observed in Experiment 1.
Moreover, spatial distance and surface recency did not interact, $F(4, 176) < 1, f = .06$. Thus, these RTs confirm the post hoc explanation offered by Rinck et al. (1996) by showing that a spatial distance effect can be observed for rooms ahead of the protagonist (+1 room and +2 room), just as for rooms recently visited by the protagonist (source room and path room), if recency of the last activation is controlled for. The validity of recency of last activation as a general explanation for the spatial distance effect seems questionable, however, because it did not affect RTs at all.

Following sentences. The mean RTs of the sentences that followed the anaphoric target sentences are shown in the lower part of Table 2. As expected, a spatial distance effect was observed, but no effect of recency of prior activation. The two-way ANOVA of these RTs yielded a significant effect of target room type, $F(2, 88) = 5.27, p < .01, f = .13$, no effect of surface recency, $F(2, 88) = 1.15, ns, f = .03$, and no interaction of the two factors, $F(4, 176) < 1, f = .05$. Thus, these RTs mirror those of the anaphoric target sentences almost perfectly. Different from the target sentences, however, we expected the following sentence RTs to show no effect of recency of prior activation.

The results of Experiment 1 lend credibility to the explanation Rinck et al. (1996) offered for the unexpectedly high accessibility of objects in the +2 room observed in their experiments. Rinck et al. argued that the +2 room was more accessible than the +1 room only, if both rooms had been mentioned earlier in the narrative and the +2 room had been mentioned more recently than the +1 room. If prior mentioning—and prior activation in general—is held constant, as in this experiment, the +2 room is not more accessible than the +1 room. Thus, a distance effect can be observed for rooms still ahead of the protagonist just as for rooms he or she passed through already. Surface recency, however (i.e., recency of last activation), does not seem a likely explanation for the distance effects on accessibility observed in earlier experiments. If spatially close rooms, such as the path room, were more accessible than more distant rooms, such as the source room, because they were activated more recently, an effect of surface recency should have also been observed in this experiment.

It might be the case, however, that existing effects of surface recency were obscured in this experiment by our rather indirect measure of accessibility, namely, anaphor resolution time. To avoid an explicit repetition of the target room name, the anaphoric target sentences did not contain the name of the target room. Instead, they only referred to an object located in the target room. In defense of this method, we note that the significant effect of spatial distance in this experiment and in Experiment 2 of Rinck and Bower (1995) indicates that sentences such as these are sufficient for correctly identifying the target object referred to. To measure effects of surface recency, however, this "elegant" procedure might have been too indirect,
especially if prior mentioning of the target room activates the room itself but not the objects located in it. In this case, it might be more appropriate to repeat the target room name in the anaphoric target sentences. Experiment 2 was conducted to test this hypothesis.

EXPERIMENT 2

Experiment 2 was designed as a replication of Experiment 1, with only one major difference between the experiments. Unlike the first experiment, the anaphoric target sentences contained both the name of the target object and the target room. For instance, in the anaphoric sentences shown in Table 1, fax machine, lamp, and blackboard were replaced by fax machine in the office, lamp in the reception room, and blackboard in the conference room, respectively. Otherwise, the two experiments were equivalent. By using anaphoric target sentences that contain both the name of the target object and the target room, the results of Experiment 2 can more easily be compared with those of several preceding studies (e.g., Morrow et al., 1997; Rinck & Bower, 1995; Rinck et al., 1996, 1997) that used the same type of sentences to measure accessibility.

Method

Participants. Forty-five students of the Technical University of Dresden participated in this experiment, compensated by course credit or a small monetary payment equivalent to $6. The data of one additional participant were excluded from all analyses because the participant’s unusually high error rate to the questions following the narratives indicated comprehension problems. The remaining 45 participants had an average error rate of 4% to these questions. None of them had participated in Experiment 1.

Layout learning, narrative reading, and design. The procedure of this experiment was identical to Experiment 1. The only significant difference between the experiments was introduced by inserting target room names into all anaphoric target sentences as described earlier. For instance, the anaphoric target sentence “she recalled an image of the notes lying beside the lamp” was changed into “she recalled an image of the notes lying beside the lamp in the reception room.” In addition, a few minor stylistic improvements to the narratives were made. None of these were related to the critical sentences of the narratives. The design was identical to that of the first experiment, except that the RT of anaphoric target sentences was the only dependent variable.
Results and Discussion

The mean RTs of anaphoric target sentences are shown in Table 3 and Figure 3. Table 3 contains the corresponding standard deviations as well. In this experiment, both surface recency and spatial distance affected the RTs of anaphoric target sentences: Increasing distance caused longer RTs. Accordingly, the two-way ANOVA of these RTs yielded significant effects of recency of activation, $F(2, 88) = 3.29, p < .05, f = .13$, and target room type, $F(2, 88) = 8.96, p < .001, f = .20$. The interaction fell short of statistical significance, $F(4, 176) = 1.43, ns, f = .10$, however, most probably because of the small number of observations per condition for each participant. For target room type, planned contrasts showed that objects in the location room were more accessible than objects in the +1 room, $F(1, 44) = 8.47, p < .01, f = .14$. The difference in access time to objects in the +1 room and the +2 room was only marginally significant, $F(1, 44) = 3.47, p < .10, f = .10$. Planned comparisons for the recency of activation factor revealed marginally faster RTs after far activation sentences than after no activation sentences, $F(1, 44) = 2.95, p < .10, f = .08$, whereas the difference between far and close sentences was not significant, $F(1, 44) < 1$.

As Figure 3 and further analyses suggest, each type of distance had a strong effect on the RTs, only when the other type of distance was large. For instance, surface recency had no effect on RTs if the target object was located in the location room, $F(2, 88) < 1, f = .03$. This was expected because the location room was always explicitly stated in the motion sentence preceding the anaphoric target sentence. Thus, any additional mentioning prior to the motion sentence could have only a diminished effect. For objects located in the +1 room, the effect of surface recency was larger but not significant, $F(2, 88) = 1.34, ns, f = .13$. But for objects located in the +2 room, a medium-sized and statistically significant effect of surface recency was observed, $F(2, 88) = 5.29, p < .01, f = .25$. Accordingly, spatial distance had no effect on the accessibility of objects located in rooms that had been mentioned re-

<table>
<thead>
<tr>
<th>Target Room Type</th>
<th>Location Room</th>
<th>+1 Room</th>
<th>+2 Room</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface Recency</strong></td>
<td><strong>M</strong></td>
<td><strong>SD</strong></td>
<td><strong>M</strong></td>
</tr>
<tr>
<td>Close</td>
<td>4.95</td>
<td>1.47</td>
<td>5.10</td>
</tr>
<tr>
<td>Far</td>
<td>4.78</td>
<td>1.88</td>
<td>5.32</td>
</tr>
<tr>
<td>None</td>
<td>4.91</td>
<td>1.84</td>
<td>5.60</td>
</tr>
<tr>
<td><strong>M</strong></td>
<td>4.88</td>
<td>1.73</td>
<td>5.34</td>
</tr>
</tbody>
</table>
cently (close condition: $F(2, 88) < 1, f = .08$). For the far condition, the effect of spatial distance was significant, $F(2, 88) = 3.99, p < .05, f = .19$, and it was even stronger for the control condition, which involved no prior mentioning of the target room, $F(2, 88) = 6.50, p < .01, f = .31$. This pattern of results seems to indicate that each type of distance can increase the accessibility of objects located in the model only if the other type has not already done so. This interpretation is consistent with models of text understanding that assume a threshold of accessibility above which concepts are readily available in working memory, but there are no further differences in availability among these concepts (e.g., Fletcher, 1986; van Dijk & Kintsch, 1983). The interpretation is advanced only tentatively, however, because the interaction of recency of activation and target room type missed statistical significance.

Taken together, the results of Experiment 1 and Experiment 2 indicate that spatial distance as well as surface recency (i.e., recency of prior activation) can affect the distance effect observed in previous studies of narrative understanding. Surface recency by itself, however, does not suffice as an explanation of the spatial gradient because in Experiment 1, only spatial distance affected accessibility and, in Experiment 2, an effect of spatial distance in addition to surface recency occurred. Thus, we may conclude that the spatial distance effect is not a spurious effect caused by
surface factors; rather, it seems to be an effect of spatial distance in situation models that can be affected by surface factors such as recency of explicit mentioning. Also, effects of recency of last activation occurred only if accessibility of the activated concept itself—in this case, the target room—was probed by explicitly mentioning it in both the earlier activation sentence and the later anaphoric target sentence. Using a more indirect measure of accessibility, that is, anaphoric target sentences referring only to an object in the target room but not to the room itself, caused the effects of surface recency to disappear. We discuss implications of this result in the General Discussion section.

EXPERIMENT 3

Two aspects of the results observed in Experiment 1 and Experiment 2 seem particularly noteworthy. First, surface recency of activation affected the accessibility of rooms represented in a situation model only when the name of the activated room was explicitly stated in the activation sentence as well as in the later anaphoric target sentence that referred to an object in that room. When the room name was deleted from the anaphoric target sentence, surface recency had no statistically significant effect. This result indicates that surface level variables such as explicit mentioning might interact with the effects of situation models more than research on text comprehension has acknowledged so far. Second, both experiments, like many others before, yielded a categorical all-or-none location effect (Morrow, 1994) rather than a continuous spatial gradient of accessibility: Although RTs of the anaphoric target sentences increased monotonically with increasing spatial distance, the only statistically significant differences occurred between the location room and the other rooms. This pattern seems to arise often in research on spatial distance effects (e.g., see Morrow et al., 1987, 1989; Rinck & Bower, 1995). In part, this may be a problem of insufficient statistical power because the experiments did not test enough participants to find significant differences between rooms other than the location room (see Cohen, 1988). For instance, Rinck and Bower (1995) found highly significant differences between the path room and the source room (as well as between the source room and an even more distant “other room”) only in a joint analysis of four experiments, involving a total of 168 participants.

Combining the two results just described leads to the question whether and to what extent the particularly high accessibility of the location room and its objects is caused by surface level factors such as explicit mentioning of the location room name rather than spatial proximity in the situation model. According to this explanation, the location room would be highly accessible because its name is always explicitly stated in the motion sentence that precedes the anaphoric target sentence. Unfortunately, the experimental results reported so far do not allow us to exclude this rather trivial explanation of the location effect. Morrow et al. (1987, Experiment 2) compared mo-
tion sentences of the type "the protagonist walked from the source room into the location room" to sentences of the type "the protagonist walked into the location room from the source room." They found that these two different orders of mentioning the rooms yielded the same spatial distance effect. A similar result was reported by Rinck and Bower (1995, Experiment 2), who varied whether the motion was explicitly described. They pitted standard motion sentences of the type "the protagonist walked from the source room into the location room" against sentences of the type "the protagonist's next stop was the location room." Again, very similar distance effects were observed after both types of motion sentences.

These results were taken as evidence for the assumption that readers represent the protagonist's motion in their situation model independent of the surface form of the motion sentence. Unfortunately, however, all the different variations of the motion sentence mention the location room explicitly. Therefore, it remains unclear whether objects in the location room would still be particularly accessible if the location room has to be inferred instead of being explicitly stated. Experiment 3 was designed to answer this question. To do so, two different versions of the motion sentence were presented to the participants. One was the standard version of the type "the protagonist walked from the source room into the location room"; the other one was of the type "the protagonist walked from the source room through the path room into the next room." Thus, one type of motion sentence left the path room implicit while explicitly mentioning the source room and the location room. The other type mentioned the source room and the path room but not the location room. After the motion sentence and a coherence sentence, an anaphoric target sentence was presented that measured the accessibility of an object in the source, path, or location room. If explicit mentioning of the location room in the motion sentence is crucial for the high accessibility of that room and its objects, the accessibility should be lower after the motion sentences that do not contain the name of the location room. Similarly, the accessibility of the path room should be higher after such motion sentences because they mention the path room explicitly. Anaphoric target sentences referring to objects in the +1 room or the +2 room were not used because the variation of the motion sentences did not pertain to these rooms.

Method

Participants. Thirty-six students of the Technical University of Dresden participated in this experiment, compensated by course credit or a small monetary payment equivalent to $7. The data of three additional participants were excluded from all analyses because their error rates to the comprehension questions following the narratives exceeded 20%. The remaining 36 participants had an average error rate of 8% to these questions. None of them had participated in any of the previous experiments.
Layout learning and narrative reading. The procedure of this experiment was similar to the preceding ones; therefore, only the differences are described here. First, the participants studied the layout of a research center similar to the one shown in Figure 1. It contained 10 rooms with three objects in each room. Afterward, they read 17 narratives that took place in the building, that is, one practice narrative followed by 16 experimental ones. Half of the experimental narratives had been used in Experiment 1 and 2, the other half were new. As before, the narratives contained motion sentences followed by coherence sentences and anaphoric target sentences. In this experiment, the critical variation pertained to the motion sentences: Half of them mentioned the source and location rooms for the motion event but left the path room implicit. The other half mentioned the source and path rooms but left the location room implicit. For instance, the protagonist’s motion from the waiting room through the experiment room into the office (see Figure 1) could be described as “Sandra walked from the waiting room into the office” or as “Sandra walked from the waiting room through the experiment room into the next room.” Expressions such as “into the next room” or “into the room beyond the path room” were used to create motion sentences that did not explicitly mention the location room. The anaphoric target sentences following the motion sentences referred to an object in the source room, the path room, or the location room. All anaphoric target sentences contained both the name of the target object and the target room (e.g., “She recalled an image of the notes lying beside the coffee machine in the waiting room”). Prior mentioning of the target room was not varied in this experiment: The source room was always stated explicitly in the part of the narrative that preceded the motion sentence, whereas the path room and the location room were never mentioned before the motion sentence.

Each participant read a total of 30 anaphoric target sentences distributed over the 16 experimental narratives, that is, five sentences in each of the six experimental conditions, as defined by the full combination of motion sentence type (location room implicit or path room implicit) and target room type (location room, path room, source room). To counterbalance materials and experimental conditions, the 16 narratives were divided into six sets of materials, and each set was presented to six participants. After reading all narratives, participants’ spatial knowledge was tested again by asking them to draw on a blank piece of paper the layout they had studied. All participants passed this test by correctly drawing the location of the 10 rooms and the 30 objects. Finally, they completed a short questionnaire about their reading strategies and features of the narratives and were debriefed. Participants required about 90 min to learn the layout, read the narratives, draw the layout, and answer the questions.

Design. Combination of motion sentence type (location room implicit or path room implicit) and target room type (location room, path room, source room)
yielded a 2 × 3 design. Both factors were varied within subjects. The dependent variable of interest was the RT of anaphoric target sentences.

Results and Discussion

The mean RTs of anaphoric target sentences observed in this experiment are shown in Table 4 and Figure 4. Table 4 also contains the corresponding standard deviations. As Figure 4 indicates, very similar RT patterns occurred after both types of motion sentences. The two-way ANOVA of these RTs yielded a significant effect of target room type, \( F(2, 70) = 34.04, p < .001, f = .28 \), whereas neither the main effect of motion sentence type, \( F(1, 35) < 1, f = .01 \), nor their interaction, \( F(2, 70) = 1.24, ns, f = .05 \), reached significance. A statistically significant spatial distance effect was observed for motion sentences with an implicit location room, \( F(2, 70) = 14.50, p < .001, f = .25 \), just as for motion sentences with an implicit path room, \( F(2, 70) = 22.70, p < .001, f = .31 \). Table 4 shows that references to objects in explicitly mentioned target rooms were understood slightly faster than references to objects in implicit rooms. This difference, however, was very small and not statistically significant. Accordingly, a 2 × 2 ANOVA excluding RTs of the source room condition revealed no significant interaction, \( F(1, 35) = 2.06, ns, f = .06 \), of motion sentence type and target sentence type. Moreover, objects in the location room were more accessible than objects in the path room, even when the location room was implicit and the path room was explicit, \( t(35) = 2.26, p < .05, f = .11 \). These results clearly indicate that the high accessibility of the location room and its objects is not due to surface level variables such as explicit mentioning of the room in the motion sentence.

<table>
<thead>
<tr>
<th>Implied Room</th>
<th>Location Room</th>
<th>+1 Room</th>
<th>+2 Room</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M )</td>
<td>( SD )</td>
<td>( M )</td>
</tr>
<tr>
<td>Location room</td>
<td>5.17</td>
<td>1.94</td>
<td>5.59</td>
</tr>
<tr>
<td>Path room</td>
<td>4.97</td>
<td>1.43</td>
<td>5.83</td>
</tr>
<tr>
<td>( M )</td>
<td>5.07</td>
<td>1.69</td>
<td>5.71</td>
</tr>
</tbody>
</table>
The three experiments reported here investigated the focusing of attention in situation models created from narratives. In particular, the spatial distance effect observed in many previous studies was investigated, and different explanations for its occurrence were tested. From the results of the three experiments, several conclusions regarding the importance of spatial distance, surface recency, and explicit mentioning for the spatial distance effect can be drawn. Two characteristics of the spatial distance effect turned out to be especially important: First, the room in which the protagonist is currently located and the objects in this location room are highly accessible. This is what Morrow (1994) termed the location effect. Second, there is a reliable though weaker distance effect, indicating that the accessibility of situation model components, that is, rooms and objects, decreases with increasing spatial distance between the component and the focus of attention, that is, the protagonist. This effect arises for objects in rooms either ahead of or behind in the movement route of the protagonist.
The results of Experiment 3 show very clearly that the location effect is not due to surface variables such as the motion sentence explicitly mentioning the location room just before its accessibility is tested. Even when the location room was only implied by a sentence that described the protagonist's movement into it, references to objects in the implied location room were understood more quickly than references to objects in other, explicitly stated rooms. These results agree with earlier failures to find effects of surface level variables on the accessibility of situation model components, for example, the order of mentioning rooms (Morrow et al., 1987) or the implicit versus explicit description of movements (Rinck & Bower, 1995). In general, characteristics of the situation model, for example, the spatial relations represented in the model, seem to affect the accessibility of discourse entities more strongly than surface features such as the wording of the text.

Experiment 1 and Experiment 2 extend this conclusion by showing that surface level factors such as explicit mentioning can have indirect effects, however. Taken together, the two experiments indicate that, under certain conditions, the distance effect observed in previous studies of narrative comprehension can be attributed to both spatial distance and surface recency of last explicit mentioning. Surface recency between the activation of a target room and the later testing of its accessibility cannot be the sole explanation of the distance effect, however, because in Experiment 2, both spatial distance and surface recency affected accessibility. Furthermore, in Experiment 1, no effect of surface recency occurred, whereas an effect of spatial distance did. Thus, it seems safe to conclude that the distance effects observed heretofore are indeed mainly due to spatial characteristics of the situation model, not to spuriously correlated surface features of the text. Variables other than spatial distance may contribute to the distance effect if they are confounded with spatial distance. As Experiments 2 and 3 show, recent activation of the target room or the explicit statement of its name may indeed make the room slightly more accessible. These surface-level effects were very small, however. Furthermore, a clear effect of spatial distance in situation models occurred even when spatial distance was not confounded with these variables.

Even though surface recency of last activation is an unlikely explanation for the spatial distance effect in general, it fares well as a specific explanation for the unexpected results reported by Rinck et al. (1996). In two experiments, they had found unexpectedly that objects in the +2 room were more accessible than objects in the +1 room. This order arose, however, only when both rooms were mentioned earlier in the narrative and when the +2 room was mentioned more recently than the +1 room. Experiment 1 and Experiment 2 of this article untangle this confound and reveal that when prior activation of the two rooms is held constant, the +2 room is never more accessible than the +1 room. In this case, a spatial distance effect is observed for rooms still ahead on the protagonist's route just as for rooms he or she previously passed through.
Another important result was that effects of surface recency between activating and probing target items were observed only when the previously activated item was probed directly. This was the case in Experiment 2, when accessibility of the target room was probed directly by explicitly mentioning it in both the earlier activating sentence and the later anaphoric target sentence. When a more indirect measure of accessibility was used in Experiment 1, that is, anaphoric references to objects in the target room instead of references to the room itself, no effect of surface recency occurred. This pattern of results would appear to be readily explained by associative network models of memory (e.g., Anderson, 1983). These models would assume that the situation model is represented in memory as a relationally structured hierarchy with a network of nodes representing rooms and objects, and links representing their spatial relations. The results indicate that prior mentioning of a room name increased activation of the room node but did not spread sufficient amounts of activation to the object nodes connected to it.

In contrast to network theories, it would seem difficult for analogue theories of mental models to accommodate this pattern of results (e.g., Glenberg, Krueley, & Langston, 1994; Johnson-Laird, 1983, 1996). These theories would predict that the objects located in a target room should be activated when the attention is focused on the room. A strong version of this type of theory would even predict that readers cannot avoid noticing the objects while focusing on the room that contains them. Results recently reported by Langston, Kramer, and Glenberg (1998), however, strongly discourage the assumption that this type of incidental noticing occurs. Further against analogue models, Rinck et al. (1997) found that spatial distance is represented in situation models as categorical (room) distance rather than Euclidean distance. In their experiments, effects on RT of distance between the focus of attention and a target item were best accounted for by the number of intervening rooms, not by the metric size of the distance. Note, however, that this argument does not exclude an analogue representation of the learned layout. The situation model itself may be nonmetric, even though part of the knowledge that is integrated with text information during creation and updating of the situation model has metric properties.

The observed pattern of results also runs counter to a theoretical conception proposed by Radvansky and Zacks (1991; see also Radvansky, Spieler, & Zacks, 1993). These authors assumed that rooms and objects located in it are represented as an integrated mental model that can be stored and retrieved as a single unit from memory. The results observed here indicate that rooms and their objects are probably stored independently as different units. The results, however, would be in agreement with a slightly different version of the integration assumption, in which only the objects are stored in an integrated mental model, whereas the room around them is represented as a separate unit. To test this modified assumption, one would have to activate objects systematically and then test the accessibility of the acti-
vated object, other objects from the same room, and objects from other rooms. This comparison was beyond the scope of the experiments reported here.

As noted earlier, these experiments varied both discourse time, that is, real time passing outside the narrative during text comprehension, and story time, that is, fictitious time passing (by description) inside the narrative. These two types of time are quite different from another, however, and they can vary independently of each other (see Chatman, 1978). Narratives may contain discontinuities in time, that is, jumps forward in time or flashbacks. Also, time passing inside a narrative can be shorter or longer than real time passing while that narrative is read. Often, one can read about long-lasting events in a short amount of time, or the relation might be reversed, as when short events are described in much detail so that the time described as passing in the narrative is far shorter than the time the reader spends reading about it. So far, very little is known about the influence of both types of time in narrative understanding. Some studies of narrative time have been reported (e.g., Anderson, Garrod, & Sanford, 1983; Bestgen & Vonk, 1995; Zwaan, 1996). For instance, Zwaan (1996) found that time shifts described in narratives by phrases such as “an hour later” or “a day later” are represented in the readers’ situation model of the narrative. Readers use these cues to establish a new substructure in memory (e.g., a new episode in the situation model) rather than to continue elaborating the existing one (see Gernsbacher, 1990). Therefore, processing time-shift descriptions takes longer than processing descriptions of continuous time, and events from the episode preceding the time shift become less accessible. Increases in RT also occur when discourse time and story time do not coincide, for example, when texts contain flashbacks (Mandler, 1986; Ohtsuka & Brewer, 1992). Despite these very interesting results, however, more research is needed regarding the interaction of discourse time and story time in text comprehension. It will be an interesting avenue for further research to explore variations in both types of time and the way they affect comprehension speed and quality.

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