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GOAL-BASED ACCESSIBILITY OF ENTITIES WITHIN SITUATION MODELS

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I. Introduction

One goal of cognitive science is to gain a better understanding of text comprehension. The consensus is that reading requires many cognitive components that are active concurrently and in coordination—encoding words, grouping words into surface grammatical constituents to extract initial meaning, retrieving from short-term memory concepts and entities mentioned in the recent text, and retrieving from long-term memory information about the topic under discussion (e.g., Gernsbacher, 1994; Glenberg & Langston, 1992; Johnson-Laird, 1983; Kintsch, 1988, 1995; van Dijk & Kintsch, 1983; Zwaan, Langston, & Graesser, 1995). One view is that the information extracted from a text can be partitioned into three coordinated levels: (1) the surface structure of the text on the page; (2) the encoded propositional base which contains the asserted logical relations among the concepts, predicates, and arguments; and (3) the referential representation (often called the mental model or situation model) that the reader constructs, characterizing what the text is referring to and what it is about (van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998).

The mental model constructed by the reader connects the concepts of the text to things in the real world (e.g., in a news article) or an imaginary one (e.g., in narrative fiction). The model can be used to integrate information about co-referring expressions (e.g., “The first United States’ President” and
“George Washington”). In addition, the model establishes the framework of time and space within which the activities described in the text occur. The model is used for deriving inferences, for interpreting the text, for supplying what the text may describe in only a cryptic manner, and for evaluating statements (e.g., as contradicting earlier knowledge). Statements in the text serve as cues for updating or altering the entities and their relationships in the model. The situational model is important because it is largely what people remember about a text. They remember not what the author wrote but what he or she wrote about—the gist of the text.

A. COMPONENTS OF A NARRATIVE

Most recent research on situational models has used simple narratives as the experimental materials (e.g., Bower & Morrow, 1990; Gernsbacher, 1994; Graesser, Singer, & Trabasso, 1994; Graesser, Millis, & Zwaan, 1997; Schank & Abelson, 1977). These materials have several advantages for experimental purposes: (1) They are intrinsically interesting to subjects; (2) their composition can be easily varied to arrange whatever textual variations are to be compared in a counterbalanced manner; and (3) narratives typically use concepts and describe situations and human affairs that are familiar to nearly all educated readers. Therefore, the materials are likely to be processed in the same manner by randomly chosen college students who are assumed to have about the same background knowledge and “expertise” in these domains. This is an important assumption of subject homogeneity since different levels of background knowledge would introduce undesirable subject variability to any results.

The mental model of a narrative consists of at least three main components. First is the physical situation in which the actions occur; these provide a set of constraints on what actions are possible. Second is the cast of characters who will act in the drama. Third is a series of episodes in which the characters perform activities within the spatio-temporal framework of the model. The characters are assigned goals and problems to solve that are associated with their occupations or roles (e.g., husband, teacher, police detective). These goals motivate a series of action episodes that comprise the main path of a simple story.

B. UNDERSTANDING ACTIONS IN STORIES

In theorizing narrative comprehension, it is assumed that readers understand narratives about actors in the same manner as they understand actions in everyday life (Black & Bower, 1980; Bower, 1978, 1982; Schank & Abelson, 1977). They apply a “naïve commonsense psychology” to explain how and why characters in narratives act as they do. Readers perform a simple casual analysis of why things happen as the narrative describes them. This thesis, initiated by Schank and Abelson (1977) and Wilensky (1978, 1983), has been advanced most convincingly in experiments by Tom Trabasso and his collaborators (Trabasso & Sperry, 1985; Trabasso & Suh, 1993; Trabasso & van den Broek, 1985). The claim is that readers understand a story by extracting from it the goals of the characters and by relating the characters’ actions to their own goals. In this way, readers are able to comprehend how and why characters execute plans, and how they overcome the myriad problems and complications those plans encounter.

By stitching together a series of such explanations, readers construct in memory a causal network of story parts, reflecting how one action enabled another action or was carried out to cause a particular outcome. The causal network so constructed is important in determining people’s judgments about what is important in a story, what will be remembered, how the story will be summarized, and so on. The causal network of a story may be viewed as the gist of a story that readers extract.

Considerable research by Trabasso, his collaborators, and others has supported this view of narrative understanding and memory (see Graesser, Millis, & Zwaan, 1997). Furthermore, Langston and Trabasso (1998) and Langston, Trabasso, and Magliano (1998) have explained many of the behavioral results of narrative comprehension (e.g., memory for different narrative elements, priming within narratives, importance ratings, summaries, etc.) using a simulation model that postulates spreading activation among the mental representations of the propositions in the causal network of the narrative. In some respects, their model is the most impressive and comprehensible theoretical development in this literature (see also Kintsch, 1998).

C. FOCUS IN MENTAL MODELS

In telling a story, narrators focus the reader’s attention on a succession of characters and the flow of events as they transpire in different locations. We may think of these characters and locations as being momentarily brought into the foreground of the reader’s attention and occupying “center stage” in the unfolding drama. From the viewpoint of cognitive psychology, tokens of these entities are being created (or placed) or “moved around” in the reader’s short-term, working memory. As a result, information in memory about these foregrounded elements should be primed and more accessible than when they were not foregrounded.

We have performed a series of experiments examining the properties of this priming of foregrounded elements (see Bower & Morrow, 1990; Bower & Rinck, 1999); the present studies fit within that ongoing series. These
experiments have followed a standard format in which college student participants first memorize a map of a building before they read some stories about events occurring within that building (see Fig. 1). We expect their memory of this building to serve as the referential field to which statements of the later stories can be connected. In order to study the effects of focal attention within a mental model, it is easiest and cleanest to examine the consequences of moving the focus from one location to another. Assuming that readers focus on the main character, the focus should move within the model when the text describes the character as moving, for example, from a starting room through an intermediate ("path") room into an ending ("current location") room.

In our experiments, after the movement sentence, we quickly tested the accessibility of previously memorized objects in rooms within this movement path as well as in rooms at varying distances from the current focus. One method of testing is to interrupt the subject’s reading (after the movement sentence) with a yes/no question, either to verify an object’s location, as in “Is there a VCR in the experiment room?”, or to verify that two objects are in the same location, as in “Are the VCR and Xerox machine in the same room?” (see Fig. 1).

We assume that memory elements of the model that are currently in focus will receive strong activation, so that information about them (such as their location) will be highly accessible and primed. We expect this activation to spread to other elements in a gradient according to their distance in the model from the focus. Moreover, the activation on a focused element should reveal a temporal gradient, decaying over time as it fades out of the foreground once the topic shifts.

Each of these predictions has been confirmed in several experiments in which priming was measured by the time to answer “yes” to probe questions about the location of objects in the building. The speed of answering questions about objects in the current location room was the fastest; the next fastest was answering questions about objects in the room just-left ("path"); the next fastest were answers for objects in the "source room" from which the movement began and in the room just ahead of the current room where the character will likely move next; and the slowest answers were to questions about objects even more distant from the current focus point. The absolute slowest answers were for questions asking about an object in a memorized building not involved in the current story. Moreover, if the character moved into a room in which the text described him as carrying out a prolonged activity, activation of the just-preceding path and source rooms decayed quickly towards the baseline level (see Rinck, Bower, & Wolf, 2000; Rinck, Hähnel, Bower, & Glowalla, 1997; Zwaan, 1996). This rapid decay could even be accelerated by simple time adverbials, such as: “Two minutes (versus two hours) later, he finished his work here.”

As noted, the first several reports we published on this spatial priming in narratives used the probe reaction time measure. An objection to that procedure is that it frequently interrupts readers with test questions about locations of objects. This may cause them to read "unnaturally," attending far more to movements and locations than they normally would. Perhaps, then, the observed distance effects might reflect only participants’ conscious expectations regarding the frequent tests about the location of objects.

In response to that objection, we looked for similar distance effects in anaphor resolution times during participants’ normal reading (Rinck & Bower, 1995). In those experiments, as part of line-by-line reading of a story, participants read a critical sentence that referred to an object located at varying distances from the current focus. An example would be when the character in one room remembered or thought about an object in another room, as in: “Wilbur remembered that the radio in the library needed to be repaired.” These critical sentences were not marked or set off in any special manner from the participants’ viewpoint. Nonetheless, the time participants...
required to read these critical anaphor sentences showed the same distance gradient as seen before: time to resolve the anaphor (here, the *radio*) was greater the farther back that object was in the movement sequence (Rinck & Bower, 1995). These distance effects in anaphor resolution times have been observed repeatedly since those earlier experiments (e.g., Bower & Rinck, 2001; Rinck, Bower, & Wolf, 1998).

D. **Explaining Spatial Distance Effects**

How might we explain these distance effects in theory? A simple way to think about focus is in analogy to a spotlight shining into a dollhouse. The mental model might be thought of as an inner stage or dollhouse that readers construct in working memory. Thus, when a character is in focus, it is as though the spotlight shines on him or her, and it spreads its “illumination” in a spatial gradient around the focal point in the model. Objects located in or near the spotlight can be “seen” (accessed) more quickly than those on or beyond its fringes; items farther away take more time to verify because the spotlight must be moved to them.

This analogy is rather similar to recent proposals, such as that of Barsalou (1999; in press, a; in press, b), that knowledge should be represented as perceptual (or sensory-motor) memories. Barsalou has demonstrated how mental simulation of events, such as a character moving through a building, could be represented in working memory and how mental simulation of perceptual events would explain a number of cognitive phenomena. One minor failing of this analog representation is that our probe reaction time data indicate that distances in readers’ model of our building are “chunked” into discrete “rooms” along allowable paths rather than processed as straight-line, Euclidean, metric distance (Rinck, Hännel, Bower, & Glowalla, 1997).

An alternative approach would be the concept of spreading activation in an associative network, such as the one depicted in Figure 2. In this approach, the relevant information might be represented in long-term memory as a hierarchically organized network of nodes and links (upper part of Fig. 2) that encode the spatial layout that an experimental participant would have memorized before reading the texts.

As the participant is reading, he or she is presumably entering into working memory (lower part of Fig. 2) pieces of text, such as: “Wilbur walked from the repair shop to the experiment room.” Such sentences in working memory will activate the long-term memory nodes for the locations mentioned (e.g., the repair shop and experiment room). In addition, the reader will draw a few nearly automatic inferences, such as: “Wilbur is now located in the experiment room.” This inference will cause more activation...
to be placed on the experiment room—where Wilbur is now—than remains on the repair shop he just left. Activation on a room node presumably spreads to memory nodes representing the associated objects in that room. Due to this spreading activation, participants are quicker to retrieve the corresponding test proposition from memory; in this way, the spread of activation facilitates verification of the probed fact (e.g., “The Xerox machine is in the experiment room”). This facilitation presumably increases with the amount of activation that has accumulated on this long-term memory proposition just before the probe question occurs.

We have investigated many variables affecting priming in this paradigm (for reviews, see Bower & Morrow, 1990; Bower & Rinck, 1999). With appropriate adjustment of parameters (e.g., decay of activation after the focus moves elsewhere), this network theory can explain our results in a general, qualitative way. So far as we can determine, this network model can provide parallel predictions to those that derive from the “spotlight” analogy or mental simulation theory. In certain respects, one’s preference between the two theoretical positions is reminiscent of the preferences expressed during the former controversy regarding analog imagery versus propositional representations of knowledge (e.g., Kosslyn, 1980; Pylyshyn, 1973).

E. GOAL ACTIVATION OF OBJECTS IN MENTAL MODELS

In the experiments reviewed in the preceding text, we demonstrated differential activation of objects depending on whether they are foregrounded as something the protagonist was thinking about. This was especially prominent in our anaphor resolution studies, in which a room was mentioned as being thought about by the protagonist. Clearly, another way to get readers to appreciate what is on a character’s mind is to attribute an active goal (wish, desire, plan) to that character. Thus, if the story states that the character is hungry, we can expect that items in the building associated with eating would be assigned priority in the protagonist’s consciousness, and consequently in the reader’s model of the protagonist. Thus, the reader’s knowledge of locations of food items in the building should be activated and ready to be referred to, so long as the actor’s “satisfy hunger” goal persists as part of the focus. Similarly, if the protagonist needed to make a phone call, telephones should be primed; if he needed to check his slides, the projector should be primed; and so on. The experiments to be reported test these intuitions, specifically examining the influence of the character’s goals and their current status (or disposition) upon the accessibility of goal-related objects in the situation model.

F. PREVIOUS RELEVANT RESEARCH

Considerable earlier research on story understanding has examined how the protagonist’s goals affect accessibility of goal-related information from the story; we will briefly review this work. As an early example, Dopkins, Klin, & Myers (1993) showed that a protagonist’s goal established earlier in a text becomes active again in memory at the point in the story where that goal is being achieved. Similarly, Huitema, Dopkins, Klin, & Myers (1993) demonstrated that reading about a character’s purposeful actions is likely to reanimate a corresponding goal of the character, even if the goal was stated much earlier and had been backgrounded by intervening material. One consequence of such reactivation is that readers were slower to read about an action that was inconsistent with the goal compared to a consistent action. Presumably, the inconsistent action prompted the reader’s additional thought to rationalize it.

Further, several studies have compared the accessibility of goal elements depending on their current status or disposition in the protagonist’s mind. Suh and Trabasso (1993) and Trabasso and Suh (1993) found that a narrative character’s unsatisfied, active goals are more accessible in reader’s memory than are that character’s completed goals. Similarly, Lutz and Radavansky (1997) showed that failed goals (that the character still pursues) are more accessible than completed goals, and the latter in turn are more accessible than neutral information. This finding was replicated for both younger and older participants in experiments reported by Radavansky and Curiel (1998). Finally, Albrecht and Myers (1995) found that readers only noted the inconsistency of a current action with a postponed goal if the goal had been reinstated just before the action or if the surface distance between the goal and action was very short. Such studies demonstrate that readers generally tend to keep track of goal information that might be used to explain and predict the protagonist’s actions. Most priority is accorded to the character’s active, unsatisfied goals. More generally, the goals of the main character are of critical importance to the way readers create and update situation models of narrative texts.

G. CONTRIBUTION OF THE PRESENT EXPERIMENTS

The experiments reported here extend previous research on protagonist goals in several directions. First, previous studies have exclusively focused on the accessibility of goals (or goal statements) themselves, whereas we will measure the accessibility of objects relevant to achieving the goals. This is a fairly straightforward extension since previous research has shown that readers often infer the instruments that are typically used to perform described actions, such as brooms for sweeping and knives for cutting (e.g.,
Just & Carpenter, 1987; McKeon & Ratcliff, 1981). Therefore, it may be assumed that readers will also infer objects that are prototypical for planned actions rather than performed actions. Inferring these objects should make them highly accessible in the reader’s memory, similar to the high accessibility caused by spatial proximity to the protagonist.

Since we wished to test several goal-related probes for each story, our texts were designed to introduce different momentary, minor goals (at various text locations) that were then tested with probe questions. These momentary goals interrupted the overarching goal that motivated the character throughout a given story. For example, in the story illustrated in Table 1, Wilbur’s overarching goal is to clean up all the rooms in the laboratory building in preparation for tomorrow’s inspection by the Board of Directors. But while doing that lengthy chore, Wilbur is interrupted by the spontaneous thought that he needs to prepare copies of his handout for his speech to the lab directors the next day. Therefore, he interrupts his overarching goal (of cleaning up the building) in order to quickly pursue this interrupting goal of preparing Xerox copies of his hand-out.

Once that momentary goal is dealt with (and we have probed accessibility of some object related to that goal), the text states that Wilbur returns to his overarching goal of cleaning up the building. Then, several lines later, the character thinks of another momentarily interrupting goal, such as to telephone his wife regarding errands to do on his way home after work; once that momentary (telephoning) goal is dealt with, he returns again to the overarching goal. In this manner, we were able to introduce and test several different momentary goals within a single story, thus increasing the number of observations and statistical power of the critical conditions. So, in the following, we use the phrase “goal relevance” to refer to the relevance of the test object to the momentary, interrupting goal that has just been introduced in the storyline.

A second aim of these experiments is to examine the combined effect of varying different aspect of the situation model. By varying an object’s relevance to the protagonist’s momentary goal independent of its spatial proximity to him or her, it is possible to determine the relative importance of these two variables as well as their potential interactions. The latter point is of particular interest because it is possible that the effects of spatial proximity are caused to some degree by goal relevance: objects near to where the protagonist has just moved may be more accessible because, over thousands of prior experiences, readers have acquired the belief that objects near to where a person has just moved are more likely to be relevant to his or her current goal than are more distant objects. Thus, one aim of the experiments was to examine whether spatial proximity affects the accessibility of objects over and above the objects’ relevance to the protagonist’s goals.

Table 1

| TABLE 1 |
|-----------------|-----------------|-----------------|
| EXCERPT OF TEXT AND TEST PROBES PRESENTED IN EXPERIMENT 1 AND EXPERIMENT 2 |

| Prior set up: Wilbur, the research lab manager, has just learned that the Board of Directors will be inspecting the lab tomorrow, so he wants to clean up the lab so it will look good for the inspection. The text continues . . . | “Wilbur made a long list of things that needed to be done to make the research center decent-looking for the visiting directors.” |
| 1. Motion Sentence Then Wilbur walked from the repair shop into the experiment room. 2a. Goal Sentences for Relevant Object in Location Room (Xerox Machine in Experiment Room) Looking at his list, he noticed that he had wanted to make copies of his presentation hand-out for the directors. He decided to make the copies immediately before he forgot. 2b. Goal Sentences for Relevant Object in Source Room (Camcorder in Repair Shop) He remembered that he had wanted to practice his presentation by videotaping the talk he had to give to the directors. He decided to go and start setting that up immediately before he forgot. 2c. Control Sentence for Semantically Associated Object in Location Room (only in Exp. 2) Looking around, he saw copies of experimental materials lying on the floor. 2d. Control Sentence for Semantically Associated Object in Source Room (only in Exp. 2) Looking around, he saw instructions for making videotapes lying on the floor. 3a. Location Room Probe XEROX MACHINE—EXPERIMENT ROOM 3b. Source Room Probe CAMCORDER—REPAIR SHOP 4a. Sentence Following Location Room Goal Sentences After he had finished that task, he made sure that the experimenters would be busy conducting studies tomorrow so the directors would see how industrious they were. 4b. Sentence Following Source Room Goal Sentences After he had finished that task, he returned and made sure the experimenters would be busy conducting studies tomorrow so the directors would see how industrious they were. 4c. Sentence Following both Types of Control Sentences (only in Exp. 2) After that, he made sure the experimenters would be busy conducting studies tomorrow so the directors would see how industrious they were. |

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

This question was addressed in Experiments 1 and 2 reported in the following text.

Finally, we wished to extend previous results regarding the effects of the current status or disposition of the goal. Compared to active and completed goals, the effect of postponed goals on accessibility has hardly been studied. In Experiments 3, 4, and 5 reported in the following text, we investigated whether objects relevant to considered-but-postponed goals become
deactivated and as inaccessible as objects relevant to already completed goals. Moreover, we studied the time course (immediate versus delayed) of accessibility for active, completed, and postponed goal objects, thereby hoping to separate slower, passive decay processes from faster, active inhibition processes.

Since these experiments have not been published elsewhere, we feel it is necessary to describe the methods and procedures more fully than one typically finds in review chapters of this series. We feel this level of detail is required for anyone who wishes to replicate or extend the current experiments. To allow for easier reading, however, we have omitted the detailed statistical values in the results sections. They are available from the first author upon request. In the following, any effect or difference described as “significant” is statistically significant at least at the alpha \( \alpha = 0.05 \) level.

II. Activation Caused by Goal Relevance and Spatial Distance in Situation Models

The general goal of this experiment was to investigate how the accessibility of objects is affected by goal relevance and spatial proximity in situation models. To achieve this goal, the spatial proximity of objects to the focus of attention (e.g., to the location of the protagonist) was varied independently of the relevance of these objects to the protagonist’s momentary goal. In general, all the following experiments followed the procedure introduced by Morrow and his associates (Morrow, Greenspan, & Bower, 1987; Morrow, Bower, & Greenspan, 1989) and modified by Rinck and Bower (1995). First, participants studied the layout of a research center until they were able to reproduce it perfectly. Then, they read a series of unrelated narratives taking place in the research center. While reading, the accessibility of objects located in the research center was measured with probe tests. These test objects were located either spatially close to the protagonist or spatially far from him or her. Independently, the tested objects were sometimes relevant to achieving the momentarily current goal of the protagonist or sometimes irrelevant to the current goal.

A. Method

Forty students of Stanford University, 27 of them students of Introductory Psychology, participated in the experiment, either to fulfill a course requirement or to receive a small monetary payment. In the first part of the experiment, participants learned the layout of the research center depicted in Figure 1. This layout was also used in the following experiments.

Participants studied the layout until they could perfectly reproduce all room and object names in their correct locations and answer questions about these locations. Subjects typically took about 25 minutes to learn the building map to criterion.

In the second part of the experiment, participants read 15 narratives (3 practice narratives, followed by 12 experimental narratives) presented one sentence at a time on the screen of a microcomputer, controlled by the “RSVP” software (Williams & Tarr, No date). Presentation of the sentences was self-paced: 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 in preparation for important visitors, to look for a lost book, to look for a thief, etc.).

Distributed across the 12 experimental texts, 20 experimental “blocks” of sentences were presented. Each block started with a critical motion sentence (see Table I), describing 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). At the end of the motion sentence, the location room was the current location of the protagonist and presumably the focus of attention. Across stories, the 20 motion sentences were distributed equally over the 10 rooms of the building to ensure that each room served as the source room and location room with equal frequency.

As Table I illustrates, each motion sentence was followed by a pair of goal sentences. The goal sentences served to establish a momentary goal of the protagonist that would activate exactly one of the objects located in the building because it was particularly relevant to achieving the goal. The goal sentences always implied the relevant object without mentioning it explicitly. In one version of the goal sentences (see Sentence 2a in Table I), the goal-relevant object was located in the current location room, for example, “Looking at his list, he noticed that he had wanted to make copies of his presentation hand-out for the directors. He decided to make the copies immediately before he forgot.” These sentences should activate the Xerox machine that is spatially near to the protagonist (e.g., both are now in the experiment room). Alternatively, the goal sentences could activate an object (in the “source room”) that was farther from the protagonist’s current location, as in Sentence 2b in Table I. “He remembered that he had wanted to practice his presentation by videotaping the talk he had to give to the directors. He decided to go and start setting that up immediately before he forgot.”
These sentences should activate the camcorder located in the repair shop (e.g., in the source room two rooms away from the protagonist’s location). Each participant read either version 2a or 2b of the goal sentences. The control sentences 2c and 2d were not used in this experiment but in Experiment 2 to be described later.

Directly after the goal sentences, accessibility of a learned object was measured by an object-room probe (see Table I). As the name implies, these test probes consisted of an object name and a room name presented in capital letters, and participants had to decide as quickly as possible if the named object was located in the named room at this point in the narrative. They responded by pressing the key labeled “Yes” or the key labeled “No” on the computer’s keyboard. For the 20 experimental probes following the goal sentences, the correct answer was always “yes.” Noncritical false test probes were scattered throughout the texts to balance the number of “yes” with “no” answers.

The texts and probes were arranged so that the probed object could either be the one activated by the momentary goal just described or the object that would have been activated by the other goal (that remained unmentioned in this story). For instance, the goal sentences shown in Table I could be followed by either the probe “XEROX MACHINE—EXPERIMENT ROOM” or “CAMCORDER—REPAIR SHOP.” Each individual participant received only one of the two possible probes. For participants who read the two goal sentences about making copies, the first probe would test the accessibility of a close and relevant object, whereas the second probe would test a distant and irrelevant object. On the other hand, for participants who read the two goal sentences about videotaping the talk, the first probe would test the accessibility of a close but irrelevant object, and the second probe would test a distant but relevant object. This way, all four combinations of spatial proximity and goal relevance could be tested at each test point in the texts. Each participant judged five test probes in each of the four conditions. Across participants, each object was used equally often in each of the four conditions. Full combination of spatial proximity (object located in location room vs source room) and goal relevance (relevant vs irrelevant) yielded a $2 \times 2$ design. Both factors were varied within participants.

Two other non-experimental types of test probes were also presented to the participants. Each story contained one “protagonist probe” which consisted of the name of the protagonist and a room name. In addition, a total of 20 “filler probes” were presented and distributed over the 15 stories. These probes paired the name of a previously learned object, a recently introduced object, or a recently introduced person with a room name. Both of these probe types were included to ensure that participants would integrate information learned from the layout with updated information newly introduced into the narrative (see Wilson, Rinck, McNamara, Bower, & Morrow, 1993). Also, the majority of these 35 test probes required a “no” response, so the overall ratio of “yes” and “no” responses was balanced (30 yes vs. 25 no).

To ensure that participants read the narratives for comprehension, we had them answer three yes/no questions immediately after reading each narrative. These questions queried such details as the reason for certain actions, the location of certain activities, and the order of actions. Participants could earn a larger monetary bonus for answering increasingly more of these comprehension questions correctly. Participants were instructed to read carefully, but at their normal speed. Sentence reading times, probe reaction times, question-answer times, and correctness of the answers were all recorded by the computer. After reading all 15 narratives, participants completed a short questionnaire about their reading strategies and features of the narratives. They were then paid whatever bonus they had earned, and debriefed. Participants took about 45 minutes to read the narratives and answer the questions.

B. Results and Discussion

The probe reaction times observed in Experiment 1 are displayed in Figure 3. The $2 \times 2$ analysis of variance (ANOVA) of the reaction times yielded a significant effect of spatial proximity, with the placement of objects in the location room being verified significantly faster than those in the source room. Goal relevance also produced a significant effect, with objects relevant to the current goal being more accessible than irrelevant objects. These two factors were additive, with no interaction between them.

![Fig. 3. Mean probe reaction times observed in Experiment 1.](image-url)
To summarize, the results of the first experiment suggest that the accessibility of objects represented in the situation model depended on two independent variables: the objects’ spatial proximity to the focus of attention (i.e., to the protagonist’s current location), and the objects’ relevance to the protagonist’s momentarily current goal. Thus, both physical and mental aspects of the described situation affected the way readers focused their attention during comprehension. Interestingly, distance and goal relevance affected accessibility additively, without any hint of one variable depending on the other: relevant objects close to the protagonist were most accessible, whereas irrelevant objects far from the protagonist were least accessible, with near-irrelevant objects and far-relevant objects falling in between.

Importantly, the effect of goal relevance occurred despite the fact that relevant (instrumental) objects were never explicitly mentioned in the sentences that introduced the protagonist’s momentarily interrupting goal (Table I). We avoided name repetitions by carefully choosing the wording of the goal sentences. For instance, Sentence 2a in Table I contains the verbal phrase “wished to make copies” instead of “wanted to xerox;” thus avoiding any surface similarity to the probe item “Xerox machine.” Similarly, in Sentence 2b, “by videotaping the talk” was used instead of “by recording the talk” to avoid any similarity with the probe item “camcorder.” The same procedure was used with all versions of all goal sentences. Thus, the current results support the claim that readers made instrumental inferences of objects that could be used to achieve the protagonist’s momentary goal.

III. Activation Caused by Goal Relevance, Spatial Distance, and Semantic Association

Unfortunately, there is an alternative explanation of the goal relevance effect in Experiment 1. The apparent accessibility of relevant objects might be due to mere semantic association between words in the text such as copies and Xerox machine (and similarly, between videotaping and camcorder). According to this semantic association hypothesis, neither a representation of the protagonist’s goals nor an inference about goal-relevant objects is necessary to explain the faster access to goal-relevant objects we observed in Experiment 1. If this semantic association hypothesis was correct, then the nearby use of words such as copies in the story should suffice to activate the concept Xerox machine, even in the absence of any goal implying that the protagonist intended to use the Xerox machine located in the research center.

To test this hypothesis, we included a third type of sentence in Experiment 2. Instead of stating one or the other momentary interrupting goal (e.g., intending to make copies or videotape a talk), these control sentences simply contained the critical words (e.g., copies or videotapes) but without stating or implying a new momentary goal or intention of the protagonist. If such mere semantic associations are sufficient for the increased accessibility of goal-relevant objects, the same increase in speed should be observed following control sentences containing such words merely associated with the object as when a goal is attributed to the protagonist.

A. METHOD

Thirty-six students of Stanford University from the same sources participated in the experiment. None of them had participated in the previous experiment. The narratives were very similar to the ones of the previous experiment (see Table I), differing mostly with regard to the goal sentences. In addition to the goaldirected sentence pairs like 2a and 2b, control sentences like 2c and 2d could be shown to the participants (see Table I). To test word association to the location room object, sentence 2c: “Looking around, he saw copies of experimental materials lying on the floor,” was presented. Likewise, sentence 2d “Looking around, he saw instructions for making videotapes lying on the floor,” was presented to test word association to the object in the source room.

Individual participants read either 2a, 2b, 2c, or 2d, and they answered the question which room the test probe was presented to each participant. Therefore, each participant encountered three test probes in each of the six experimental conditions that resulted from full combination of goal relevance (relevant, irrelevant, or simply word associated) and spatial proximity (close: the location room vs. far: the source room). The six experimental conditions may be illustrated with the sample sentences in Table I: (1) close goal-relevant: sentence 2a and location room probe; (2) irrelevant close object: sentence 2b and location room probe; (3) merelyl associated close object: sentence 2c and location room probe; (4) relevant far object: sentence 2b and source room probe; (5) irrelevant far object: sentence 2a and source room probe; (6) merely associated far object: sentence 2d and source room probe.

B. RESULTS AND DISCUSSION

The probe reaction times observed in Experiment 2 are displayed in Figure 4. The $2 \times 3$ ANOVA of these reaction times yielded a large effect of spatial proximity: objects in the location room were significantly more accessible
distances from their last explicit mention in the text. These results were taken to suggest that the protagonist's uncompleted goals are kept active in the reader's working memory, whereas completed goals are not. Completed goals lose activation, either by passive decay or by some kind of inhibition process. This deactivation would be a useful strategy because readers can usually assume that completed goals will no longer be motivating (and need to explain) the protagonist's upcoming actions. However, these earlier findings were measuring the accessibility of the goal statements themselves rather than instrumental objects associated with a goal-related plan. Therefore, one purpose of Experiment 3 was to extend these earlier findings to objects relevant to these goals.

Our second purpose was to compare active goals and completed goals to a third type of goal status, namely, goals that are introduced and considered momentarily but then postponed. In narratives as well as real life, a goal one considers may be postponed for several reasons. A common reason is that a top-level goal (e.g., buy a car) must be delayed until after some preconditions or sub-goals are achieved (e.g., obtain the money for the purchase). This type of postponement, of higher-level goals to pursue sub-goals, was studied by Suh and Trabasso (1993). In these cases the top-level goal remains very active in the protagonist's (and reader's) mind because it motivates the upcoming sub-goal activities. In fact, this top-level goal becomes most available at the moment that the near-final action succeeds in achieving the penultimate sub-goal (Suh & Trabasso, 1993).

A second type of postponement occurs when in the course of pursuing one goal and plan the character suddenly thinks of some unrelated goal. The character could pursue this unrelated goal but only by interrupting and diverting from his earlier goal plan. In such cases, the character may postpone pursuing the interrupting goal, delaying it until some future time after he has completed the present goal.

It is this second type of postponed goal that we wished to investigate in our experiments. We wondered what level of activation would be placed on (or persist on) a considered-but-postponed goal and its related objects. On the one hand, a postponed goal should not be kept highly accessible in working memory because the protagonist's near-term behavior will be guided (and explained) by completely different goals. On the other hand, the postponed goal is a wish the character still harbors, so readers should perhaps not totally dismiss it because it may well be reactivated at a later stage.

Experiment 3 was designed to investigate how the current status of a goal affects the accessibility of objects relevant to it. To this end, the texts and test probes used in the previous experiments were modified in the following way: all tested objects were goal-relevant, they were tested immediately after
the momentary goal and its status had been described, and the momentary goal status was described as either active, completed, or postponed. Moreover, spatial distance of the tested object to the current location of the protagonist was varied independently of goal status, with the tested object being located in the source room or the current location room.

A. METHOD

Forty-two new students of Stanford University from the same source participated in the experiment. For this experiment, three different versions of the goal sentences were created. In the active goal version, the two sentences elaborated the interrupting, momentarily active goal, stressing its importance. These sentences were identical to the ones used in the previous experiments. In the completed goal version, the first sentence was identical, and the second one was changed to indicate that the momentarily interrupting goal had been achieved and the character was returning (or had returned) to pursuing his original, overarching goal. For this example, the second sentence read: “He made the copies quickly and after that, went back to his task of checking the research center.” In the postponed goal version, the first sentence was also identical. The second sentence read: “He decided to make the copies later because checking the research center was more important.” This indicates that the momentarily-considered goal was postponed in favor of the original overarching goal. All test probes following these goal sentences referred to objects relevant to the momentarily interrupting goal.

A total of 18 experimental blocks were included in the experimental texts. Three blocks were presented in each of the six experimental conditions, resulting from full combination of the within-subject factors of spatial proximity (tested object in location room vs. source room) and goal status (the momentarily interrupting goal was either active, completed, or postponed). In all the participants, each block was presented equally as often in each experimental condition.

B. RESULTS AND DISCUSSION

The probe reaction times observed in this experiment are shown in Figure 5. As in the previous experiments, the $2 \times 3$ ANOVA of these reaction times yielded a large effect of spatial proximity: objects in the location room were significantly more accessible than objects located in the source room. The effect of goal state was significant as well, whereas the interaction was not. Planned comparisons revealed that objects relevant to postponed goals were significantly less accessible than objects relevant to active goals or objects relevant to completed goals. The active and completed goal-status conditions did not differ significantly. In general, the effect of goal status was weaker than expected, and much weaker than the strong effect of spatial distance in the situation model.

V. Delayed Effects of Active, Completed, and Postponed Goals

This experiment was designed to extend the results of the previous experiment that showed only a weak effect of goal state and yielded no significant difference between active goals and completed goals. This weak effect of goal status may be due to the fact that the accessibility of objects was tested immediately following the sentences describing the status of the goal. It seems likely that readers will keep the most recently read information in working memory; therefore, the goal concepts mentioned in it may be highly accessible for a brief time, independent of their goal status (see Glenberg, Meyer, & Lindem, 1987, for such a finding). Differences in accessibility may take some time to develop; if that is the case, they would be more evident when testing occurs at a brief delay after the goal sentences.

Two conclusions may be drawn from this argument. First, the fact that postponed goals yielded longer reaction times even if tested directly following the goal sentences suggests that active inhibition rather than passive decay of activation may be involved in processing postponed goals. This hypothesis was tested in Experiment 5. Second, the small and
nonsignificant reaction time difference between objects relevant to active goals and those relevant to completed goals should increase if the accessibility of these objects is tested after a delay, allowing the completed goal to fade from working memory. This hypothesis was addressed in Experiment 4 by inserting one additional sentence between the goal-status sentences and the following test probe.

A. METHOD

Forty-two new students of Stanford University from the same source participated in the experiment. The texts used in Experiment 4 were identical to those of Experiment 3, except for the introduction of an intervening sentence between the sentences describing the goal status and the following test probe. For active goals, the intervening sentence elaborated the goal and stressed its importance. For completed goals, the intervening sentence elaborated the initial, overarching goal to which the character was returning. For postponed goals, the sentence described the overarching goal as more urgent than the postponed goal. For instance, after the goal sentence “Looking at his list, he noticed that he had wanted to make copies of his presentation hand-out for the directors,” the complete sequence for the active goal then read: “He decided to make the copies immediately because otherwise he would probably forget it. He knew how important it was to have it done well before the directors arrived.” For the completed goal, the two sentences read: “He made the copies quickly and after that, went back to his task of checking the research center. He had to make sure that everything was being checked, cleaned, and repaired.” For the postponed goal, the sentences read: “He decided to make the copies later because checking the research center was more important. First, he had to make sure that everything was being checked, cleaned, and repaired.”

B. RESULTS AND DISCUSSION

Figure 6 depicts the probe reaction times for this experiment. As before, the $2 \times 3$ ANOVA of these reaction times yielded a significant effect of spatial proximity: objects in the location room were significantly more accessible than objects located in the source room. The effect of goal status was significant as well. Planned comparisons revealed that, unlike the previous experiment, active goals now yielded faster accessibility overall than both completed and postponed goals. Objects relevant to completed goals did not differ in accessibility from objects relevant to postponed goals. To summarize, delaying the test of accessibility by one sentence had the expected result: the effect of goal status was stronger than in the previous experiment, and active goals yielded greater accessibility than both completed and postponed goals.

VI. The Time Course of Activation Caused by Active, Completed, and Postponed Goals

Comparing the results of Experiments 3 and 4 suggests interesting differences in the time course of activation for active, completed, and postponed goals. The accessibility of objects relevant to momentarily active goals did not appear to decrease over the temporal intervals (or intervening sentences) investigated here. The accessibility of objects relevant to completed goals decreased slowly; it was significantly lower than the accessibility of active-goal objects only after the insertion of an additional sentence. In contrast, objects relevant to postponed goals were less accessible than active-goal objects immediately after stating that the goal was being postponed.

These results suggest that different processes may be involved in the way readers deal with postponed versus completed goals. The decrease in accessibility of completed-goal objects may be explained by a gradual decay of activation, whereas the fast drop in accessibility of postponed-goal objects suggests that readers actively inhibit a postponed goal and their relevant objects. Inhibition, or suppression, has been suggested as an explanation for several phenomena in text processing (e.g., Gernsbucher
& Faust, 1991). For instance, Gernsbacher (1990) has suggested that individual differences in reading comprehension appear to be related to differences in people's ability to suppress irrelevant information, rather than the ability to keep relevant information active. Similarly, the poorer working memory of the elderly (compared to younger) subjects has been hypothesized to be due to their poor ability to inhibit irrelevant information (Zacks & Hasher, 1994; Zacks, Radvansky, & Hasher, 1996). This suggests, incidentally, that elderly subjects should have greater difficulty dismissing considered-but-postponed goals.

Following this line of reasoning, Experiment 5 was designed to investigate the time course of accessibility of objects that are instrumental for momentarily active, completed, and postponed goals. To increase the goal-to-probe variation of delay, either zero or three sentences were inserted between the description of the status of the momentary goal and the test probe. Because this experiment needed to collect many observations on the effects of this delay on the accessibility of objects relevant to active, completed, and postponed goals, spatial distance was not varied.

A. Method

Thirty-six new students of Stanford University participated in the experiment. The texts of Experiment 5 were similar to those of Experiments 3 and 4, except that the number of sentences inserted between the goal sentences and the goal-related test probe was systematically varied. For each participant, one-half of the experimental test probes were presented immediately after the goal-status sentences, as in Experiment 3. For the other one-half of the tests, three sentences were inserted between the goal sentences and the test probe. As in Experiment 4, these intervening sentences either elaborated the active goal or, in the cases of completed and postponed goals, elaborated the overarching goal. As before, a total of 18 experimental blocks were included in the experimental texts. Three blocks were presented in each of the six experimental conditions, resulting from full combination of the within-subject factors of “number of intervening sentences” (zero vs. three) and “goal status” (active, completed, or postponed goal). In all participants, each block was presented equally as often in each experimental condition.

B. Results and Discussion

The probe reaction times observed in this experiment are shown in Figure 7. The 2 × 3 ANOVA of these reaction times revealed that objects were significantly more accessible if tested immediately after the goal sentences than after three intervening sentences. Goal status also yielded a significant effect, with objects relevant to active goals being more accessible than those relevant to postponed goals. More importantly, the interaction was also significant. Planned comparisons revealed that for active-goal objects, the number of intervening sentences had no effect: they were highly accessible even after three intervening sentences. There was also no effect of test delay for postponed-goal objects; their accessibility was low, both after zero and three intervening sentences. Finally, the accessibility of completed-goal objects decreased significantly with the number of intervening sentences: after zero intervening sentences, these objects were as accessible as active-goal objects and more accessible than postponed-goal objects. In contrast, after three intervening sentences, completed-goal objects were as inaccessible as postponed-goal objects and less accessible than active-goal objects.

This pattern of results accords with the hypothesis outlined earlier: objects relevant to active goals are kept highly accessible even over a delay of three intervening sentences, whereas objects relevant to completed goals lose accessibility over such a delay, and objects relevant to postponed goals are inhibited quickly, having low accessibility even when tested nearly immediately. Interestingly, the interaction between active and completed goals over zero versus three sentences (Fig. 7) is rather similar to that between these goals when the objects are in the location versus source room (Fig. 6). It is as though, for completed goals, the effect of the passage of time due to intervening thoughts is equivalent to that produced by the passage of time implied by movement in space.
VII. General Discussion

To summarize, the experiments reported here indicate that readers use goal information about the character in addition to spatial information to focus their attention on the most relevant parts of their situation model, that is, on the physical and mental “here and now” of the protagonist. Experiments 1 and 2 showed that spatial proximity of objects to the current location of the protagonist as well as the relevance of these objects to the protagonist's momentarily current goal increased the objects' accessibility in memory. These two factors had additive effects on accessibility, so that close, relevant objects were most accessible while distant, irrelevant objects were least accessible. Experiments 3 to 5 addressed the time course of accessibility of objects relevant to a character's active, completed, or postponed goals. The results of these experiments suggest that objects relevant to an active goal remain highly accessible, at least over several intervening sentences; that the accessibility of objects relevant to a completed goal decays over several intervening sentences; and that objects relevant to a postponed goal are inhibited almost immediately.

This pattern of accessibility provides a clear answer to the questions raised in the preceding text. The accessibility of completed goals and objects relevant to them seems to decay passively, as the protagonist returns to pursuing the main goal. In contrast, postponed goals and the objects relevant to achieving them seem to be actively and quickly inhibited, as if not to interfere with the processing of the remaining, (active) main goal. However, it should be noted that this result was observed for momentarily interrupting goals that the protagonist postpones in order to pursue his or her overarching top-level goal. Future research will have to reveal whether similar processes are involved when the top-level goal itself must be delayed until after some subgoal has been achieved. Research by Suh and Trabasso (1993) indicates that in this case, the top-level goal remains active in the protagonist's (and reader's) mind because it motivates and explains the subgoal activities.

The present results also answer the question of whether the spatial priming of objects in the situation model is in reality just a kind of “potential goal relevance” effect in disguise. As we noted earlier, readers may direct their internal focus to places where significant events are likely to occur. Thus, when a character moves to some location, the objects in that location may be activated because readers would normally expect them to be relevant to the character's goal. This strategy is shaped and supported by the arrangement of human living spaces in which different parts of a building, say a residence, are set aside to satisfy recurrent goals, as revealed in our labeling of such rooms as the eating area, bedroom, laundry, toilet, and entertainment center.

According to this speculation, spatial priming in narratives would be a derivative of readers' subconsciously expectations that characters go to a place in order to carry out some goal-plan with the people or objects there. This hypothesis would be in accord with the recurrent finding that relevance in narrative comprehension is largely determined by the goals and plans of the central characters.

However, several considerations argue against this “derivative hypothesis.” First, one can observe graded spatial priming among objects according to their distance (even when outside a story context) when there are neither characters nor goals (McNamara, 1986; Rinck, Williams, Bower, & Becker, 1996). Merely focusing attention on one location within a map primes the availability of items at nearby locations. A second argument against the “derivative hypothesis” comes from the present results that indicate that priming by spatial proximity combines additively with priming by goal relevance. For clearly relevant objects and clearly irrelevant objects alike, spatially close objects were more accessible than distant objects. Thus, it seems that the effects of spatial proximity cannot be explained simply by assuming that spatially close objects derive their activation because they are potentially more relevant to the character's goals than are distant objects.

Given the pattern of results observed here, the obvious question is why and how spatial proximity and goal relevance affect accessibility of objects represented in the situation model. It is not clear how the spotlight model of perceptual simulation would account for these goal effects. However, an explanation is easily constructed in terms of the associative network model of Figure 2 (Bower & Rinck, 1999, 2001). Recall that the assumptions contained in this model regarding direct inferences and spreading activation suffice to explain the distance effect and the intermediate-room effect in spatial priming (that we have described repeatedly).

To account for the observed effects of goal relevance on accessibility in this network model, we begin with the plausible assumption that readers track the character's active goal stack, specifically by retaining it in working memory (see, e.g., Schank and Abelson, 1977). These goals reference plan structures that exist in long-term memory that specify inferences about instrumental objects typically used in that plan. For instance, readers know that a Xerox machine can be used for making photocopies, a camcorder for making videos, and so on. The diagram of the likely goal-related links among nodes depicted in Fig. 8 is an expanded version of the network shown in Fig. 2.

Figure 8 illustrates how the goal active in working memory sends activation to the goal-plan structure in long-term memory, which in turn transmits activation to the associated relevant instruments—such as the
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Fig. 8. An expanded version of the associated network shown in Fig. 2, incorporating goal-based activation and inferences. The recent goal statement ("Wants-To") is in working memory along with the recent movement sentence and inferences due to that movement. The goal statement activates the corresponding goal-plan structure in long-term memory and that transmits activation to nodes representing relevant instruments.

Xerox machine in this example. The activation arriving at the goal-relevant object will add to the activation coming from the room location node that has also been activated by its concept in working memory. These additive effects on reaction time are just what we found throughout the experiments reported here. Moreover, activation caused by these instrumental inferences will be maintained at high arousal so long as the current goal is active. This elevated goal-activation will decay once the goal is completed and the character moves on to another goal.

Furthermore, we must assume that the initial activation of a mentioned goal will be suppressed or inhibited almost immediately when the goal is postponed in favor of a different goal. It is as though the postponement sentence acts like a "forget" signal, causing the participant to expunge the postponed goal from working memory (cf. Bjork, 1970; Zacks & Hasher, 1994; Zacks, Rodvansky, & Hasher, 1996). As a consequence, we would expect participants to exhibit very little memory for the postponed goal sentences of the story when tested later. More research will be needed to test this hypothesis.

The effects we have observed for both spatial proximity and goal relevance clearly favor constructionist models of text comprehension (Gernsbacher, 1990; Graesser, Singer, & Trabasso, 1994; Singer, Graesser, & Trabasso, 1994). Both spatial and goal-related information are important aspects of the situation described or implied by the text compared to surface 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. Among these are the studies by Bower and Rinck (2001), Rinck and Bower (2000) and Rinck, Bower, & Wolf (1998) mentioned in the preceding text as well as a study by Haenggi, Gernsbacher, & Bolliger (1994), who manipulated both emotional and spatial inconsistencies contained in short narratives. The most comprehensive, multidimensional studies of situation models were reported by Zwaan and his colleagues (Zwaan, Langston, & Graesser, 1995; Zwaan, Magliano, & Graesser, 1995; Zwaan, Radvansky, Hillard, & Curiel, 1998). Their results supported the event-indexing model of narrative comprehension. In those studies, the authors investigated the slowing of sentence reading times produced by textual discontinuities of temporal, spatial, and causal relations as well as discontinuities related to the protagonist and his or her goals. However, by using naturalistic texts, those studies were per force correlational rather than experimental in nature, with sentence reading times being fit by multiple regression equations. The authors' conclusions about effective variables were then based on the relative sizes of the regression coefficients for predicting sentence reading times. But such correlational methods are inherently limited in their power to infer causal effects. We believe that in the future, more experimental studies will be needed that vary different dimensions of situation models independently of one another using carefully controlled texts, as we have done here for spatial proximity and goal relevance.
One take-home message from these investigations is that adults are remarkably flexible and adaptive in how they retrieve and use their background knowledge during narrative comprehension. They reveal substantial adaptability in selecting for use mainly the information that is highly relevant to the ongoing situation described by the text, and ignoring information which is momentarily irrelevant. Of the factors that determine relevance, so far we have identified spatial and temporal proximity as well as goal relevance. Together, these factors are skillfully tracked by readers to guide their focus of attention as they construct and update their situation models from texts.

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