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Mental Models in Narrative Comprehension

GORDON H. BOWER AND DANIEL G. MORROW

Readers of stories construct mental models of the situation and characters described. They infer causal connections relating characters' actions to their goals. They also focus attention on characters' movements, thereby activating nearby parts of the mental model. This activation is revealed in readers' faster answering of questions about such parts, with less facilitation the greater their distance from the focus. Recently visited as well as imagined locations are also activated for several seconds. These patterns of temporary activation facilitate comprehension.

THIS ARTICLE IS A REVIEW OF RESEARCH ON HOW READERS or listeners construct mental models of the situation a writer or speaker is describing. This skill is the basis of language comprehension. Cognitive psychologists and education specialists focus on research in reading comprehension, because it involves many components of intelligence: recognition of words, decoding them into meanings, segmenting word sequences into grammatical constituents, combining meanings into statements, inferring connections among statements, holding in short-term memory earlier concepts while processing later discourse, inferring the writer's or speaker's intentions, schematization of the gist of a passage, and memory retrieval in answering questions about the passage. Thus, the study of comprehension has become for cognitive psychologists what the fruit fly became for geneticists, a means of investigating many issues (*1*). We describe studies of comprehension of elementary narratives or stories that have a simple structure. We do not distinguish studies based on reading from those based on listening, since the input modality is irrelevant to the points at issue.

Most researchers agree that understanding involves two major components (*2, 3*). First, readers translate the surface form of the text into underlying conceptual propositions. Second, they then use their world knowledge to identify referents (in some real or hypothetical world) of the text's concepts, linking expressions that refer to the same entity and drawing inferences to knit together the causal relations among the action sequences of the narrative. The reader thus constructs a mental representation of the situation and actions being described. This referential representation is sometimes called a mental model or situation model. Readers use their mental model to interpret and evaluate later statements in the text; they use incoming messages to update the elements of the model, including moving the characters from place to place and changing the state of the hypothetical story world. Readers tend to remember the mental model they constructed from a text, rather than the text itself (*2, 3*). The bare text is somewhat like a play script that the reader uses like a theater director to construct in imagination a full stage production. Throughout the story the narrator directs the reader's focus of attention to a changing array of topics, characters, and locations, thus making these elements temporarily more available for interpreting new information.

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Narrative Components

The internal representation of a narrative contains two major parts. First, an internal representation includes descriptions of the cast of characters, their occupations, relationships, and personal traits. These are important because they usually explain the characters' goals, plans, and actions as the plot develops. Second, the representation includes a mental map of the physical settings in which the actions occur. The settings provide enabling (or constraining) conditions for the actions.

Simple narratives usually center around a main character who has a complicated problem to solve, and the story describes his or her actions in overcoming obstacles to the solution. Readers assume that characters' actions can be explained by their goals and plans as played out within the constraints of the situation. By such explanations, readers build a network of causal connections among the events in the story—from some initiating events (for example, the rustlers steal cattle) through the various goals, subgoals, and actions of the main character (the sheriff chases them), overcoming obstacles (they shoot at him), arriving at some final resolution (he captures the rustlers and retrieves the cattle). Each goal is viewed as causing some actions that lead to outcomes.

Readers consider events on this main causal chain to be the most significant parts of a story. Trabasso and his associates (*4*) analyzed many simple narratives, asking whether each event (described in a story statement) was enabled or caused by earlier events, or enables or causes later events. In a coherent story, the enabling events and causes form a web of connections among other events and conditions. A statement's number of connections determines how centrally important readers consider it to be. This connectivity in turn determines the likelihood that a given statement (or event) will be recalled and included in subjects' brief summary of the story (*4*). Thus, causal connectivity provides a highly valid predictor of what readers will judge to be the gist of a narrative.

Goals and plans as causes. Because the most important causes of actions in narratives are the characters' goals, we investigated how readers search in memory for goals to explain actions (*5*). For example, plans and actions vary in their familiarity (or typicality) for achieving common goals. As might be expected, people understand a typical plan more quickly than an atypical one. Readers take longer to understand an unexpected action in light of an actor's goal as the number of subgoal inferences required to connect that action to the goal increases. Thus, we understand immediately why a hungry man would eat a pizza, but it takes an extra step of time to deduce why he might look in the yellow pages of the phone book. We know also that in a story of conflict, readers attribute competence and noble motives to the character with whom they identify, attribute opposite traits to his or her adversary, and distort their recollections to justify these attributions (*6*).

Readers set up in memory a goal list for each character and monitor how story events relate to those goals, perhaps adding a goal or moving the character closer to completing a goal or deleting a goal. Readers take longer to understand an action in a story as the number of independent goals the actor has increases (*5*). As each action occurs, the reader scans the goal stack for that actor, searching for some goal that would explain it. This slowing due to monitoring multiple goals is lessened if an action can be viewed as satisfying several goals at the same time. Such studies of goal monitoring and action explanation shed light on the process by which people comprehend actions in real life as well as in stories.

Spatial Models

Let us turn now to the second aspect of models—namely, the representation of spatial situations. The spatial model includes a mental map of the places, landmarks, and objects as they are laid out in space and the locations of the characters as they move about. The description of the spatial layout and of the characters' movements should be consistent for the narrative to be coherent. For example, if a text earlier described Oak Street as north of Bill's location, the story cannot later have him get directly there by walking south. Johnson-Laird (*2*) has proposed that a text or description is coherent only if it enables a suitably educated reader to construct at least one internally consistent model of the situation. The suitably educated condition is needed since many texts use specialized jargon comprehensive to an expert but not to a novice (for example, a radio announcer's description of a football game is gibberish to non-fans).

Several approaches are used in studying situation models. One approach is to examine the real-time process by which readers or listeners construct a situation model as they read (or hear) spatial descriptions phrase by phrase. We know, for example, that the internal construction proceeds more easily if each new part is added into a definite place in the developing representation (*7*). In this way the reader (or listener) can construct a single, unitary map and not have to hold in fragile short-term memory several map fragments whose relations have not yet been specified.

A related approach is to examine the properties of the situation model as it is updated, and this is the approach we used in our investigations into mental maps of spatial layouts. We studied how readers update their mental model as they follow the actions of characters in their movements from one place to another in pursuit of their goals. We suggest that readers construct in imagination a sort of theater stage or "doll house" with landmarks and rooms filled with expected objects, plus any special objects mentioned in the text.

Focus in spatial models. Narrators tell a story from a particular perspective, usually that of the main character or protagonist. Readers focus attention on the protagonist whose actions usually determine the "here-and-now" point in the progress of the narrative. Language provides many ways to shift focus to another person, place, or time. This is usually done by explicit mention, as in "Later, back at the ranch, John was emptying the safe. . . ." The person and place so mentioned then move to the foreground until the topic is shifted again (*8*).

Morrow *et al.* (*9*) examined some psychological consequences of this shifting focus of attention within the reader's mental model. The protagonist's movement through space may be thought of as a shifting "spot of light" that moves over corresponding parts of the reader's mental model. Let us consider two different consequences of this shifting focus of attention.

An object or topic in the foreground can be referred to readily later by pronouns and definite noun phrases. Pronouns smooth the flow of text, but pose for the reader the momentary problem of finding their referent. A useful strategy is to look first for the referent among the foreground concepts, usually something recently mentioned or associated with it. In a sentence like "John broke the window. It cut him," the word *him* refers to the mentioned actor and *it* refers to the associated glass. The impact of attentional focus on referent selection can best be seen, however, when the choice is linguistically ambiguous. Among possible referents, readers will select the one nearest to the current focus of attention, which is usually closest to the currently important actor. In a sentence such as "John walked past the car up into the house. The windows were dirty," readers take the windows to refer to those of the house where John is now located. Such selections depend on where the actor is, not which object was mentioned most recently. If the first sentence had been "John walked into the house after passing the car," it is still the house windows that are dirty. On the other hand, the sentence "John was walking past the car on his way to the house" locates John nearer the car, so that the windows would now refer to those of the car. Morrow (*10*) showed that this principle of proximity consistently predicted people's referent choices; when in doubt, readers assume that the referent is near the focus of attention, which is typically near the currently important actor.

Memory access to focused concepts. Concepts in the focus of attention should be more active in memory and thus more readily retrieved. We think this greater accessibility explains in part the proximity bias in selecting referents. Memory accessibility can be investigated most easily in cases where the focus of attention is on a protagonist who is located within a mental map. We have studied priming of memory objects near the focused character, a technique adapted from McNamara and his associates (*11*).

We asked whether objects in the current focus of attention would be more accessible than other objects in the subject's memory and whether activation of an object that was formerly in the foreground gradually dissipates once the focus moves to other places or topics. The increased accessibility would reflect subconscious activation of representations of objects near the focus of attention in the mental map. The activation should be greatest for objects at the character's location but should decline in a gradient toward more distant objects.

How might we conceive of this process? If we represent the memorized map as a hierarchical tree structure of nodes (objects, rooms, and buildings) with labeled links (paths, distances, or geometric relations), then moving the focus would correspond to moving the "here-now" pointer from one node to another, activating it, and spreading activation to nodes linked to the new location (*11*. Facts attached to activated nodes can be readily retrieved to answer questions. In terms of the alternative spotlight metaphor, the subject can readily answer questions about objects in the spotlight, whereas questions about objects outside the spotlight require more time. The distance-from-focus gradient suggests two possible metaphors: (i) a fuzzy spotlight that scatters light in a gradient around its center, with peripheral objects requiring closer checking to verify an answer, or (ii) a sharply defined spotlight that must be moved from its current location to that of a named object, and the time to traverse the path in the model is longer with greater distances. Both metaphors correspond to plausible models of attentional focus (*12*).

In our first experiment (*9*), 40 Stanford University undergraduates memorized the layout of two different buildings, a warehouse and a research center (Fig. 1). Each building had four rooms, each with four labeled objects. Subjects studied and reproduced the two layouts until they could recall both perfectly. These buildings were the locations in which the later stories took place; we assumed that subjects' mental maps of the spaces would correspond closely to the blueprints they had studied and that they would use the story to update the locations of the actors.

After memorizing the maps, subjects read a set of eight stories, each 19 lines long, with four stories taking place in each of the two buildings. Each story introduced a new character who had a goal, such as to search the rooms for a possible burglar or to clean up the rooms for the director's inspection. The story described the character's thoughts, plans, and actions as he or she moved from one room to another in one of the buildings. Our focus hypothesis led us to be especially interested in the "movement" statements, such as "Wilbur walked from the reception room into the library." The place the character just left was called the source room and the place he has just entered was the goal room. We expected the reader's mental representation of the goal room, on which the focus now centered, to be more active than the representation of the source room. For comparison, we asked questions about another room in the same building or even a room in the other building. The mental representation of another room in the same building should be slightly activated because the story is about activities occurring there. Mental representations of rooms in the other building should be least activated because those locations were not mentioned in the current story.

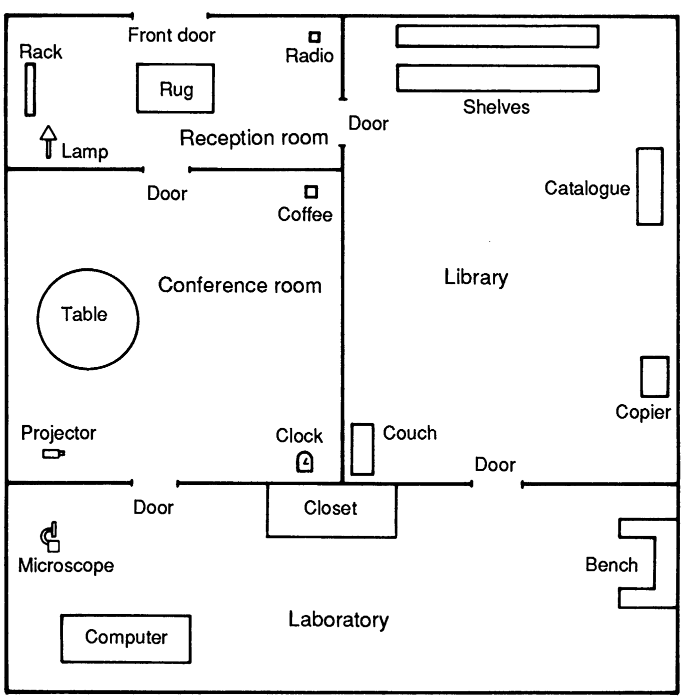


Fig. 1. Spatial layout of the research building memorized by subjects. Reprinted from (*9*), with permission of Academic Press.

To test these predictions, we examined subjects' times to answer simple questions about the locations of objects. Subjects sat at a computer terminal, pressing the space bar to present the story sentences to themselves one by one on the computer screen. Periodically, the subject's line-by-line reading was interrupted by a pair of test words (objects) rather than the next line of text. Subjects were instructed to decide whether the two objects were in the same room (with each other) or different rooms, and so indicate by pressing one of two keys marked Same or Different. Subjects were asked to answer as quickly as possible while minimizing errors. A probe test immediately followed each of the four movement sentences scattered throughout each 19-line story, yielding 32 response times per subject. Roughly half of these referred to objects in the same room and half to objects in different room.

The same-room probes after motion sentences are of most interest. The same-room objects could come from the goal room, the source room, some other room in the same building, or some room in the other building. Examples for a statement like "Wilbur walked from the library into the reception room" would be goal (lamp, radio), source (copier, shelves), other (computer, bench), and other building (fork-lift, scales). (Fig. 1) The different-room probes involved objects from two different rooms, sometimes from different buildings. To induce readers to keep track of the current location of the protagonist, we occasionally probed for his or her location relative to some object ("Wilbur, lamp" would be a same-room probe related to the motion sentence above).

Our theory predicts that the times for responding to same-room probes should be shortest for objects from the goal room, next from the source room, then from the other room, and longest for objects from a room in the other building. The average response times show that the four conditions are ordered as predicted (Fig. 2). The difference between goal and source rooms is especially large, with the remaining differences progressively smaller. In interpreting such results, alternative explanations must be ruled out. One alternative explanation for the quick answers to goal-room questions is recency of mention of this room, just before the probe question. However, we found that the times for answering questions was shortest for the goal room even when the source room was mentioned more recently, just before the probe. That is, the sentence "Wilbur walked into the goal room from the source" yielded the same goal advantage as the sentence "Wilbur walked from the source room into the goal room."

We found too, that incidental mention of a location in passing did not move the focus of attention to that location if it was irrelevant to the current thoughts and actions of the protagonist. Examples are the incidental mention of the reception room in the story sentence "Wilbur went into his office to review the messages that had come in earlier for him at the reception room." After such a sentence, representations of objects in the office would be more activated than objects in the reception room (*13*).

Major versus minor characters. An interesting question is whether readers can divide their attention between two characters, a major and a minor one in the story. Do they allocate more attention to the major character, somewhat as though they have a beam splitter that divides the spotlight so that it shines with different intensities on the two characters? To test this, we had subjects read stories that introduced a major character who later enlisted the help of a minor character to achieve some goal (*14, 15*). At several points throughout the narrative, a critical sentence described movements of the two characters, as in "The major character went into room A after the minor character had gone into room B," (or with the two clauses in reverse order). A test probe followed such sentences, naming the major or minor character plus an object from the building, half the time from the same room as the named character. The reader was asked to decide whether the object was in the same room as the character named in the probe.

Questions about objects near the major character were answered more quickly (2.46 s) than those about objects near the minor character (2.62 s). This difference was larger when the major character was mentioned in the first, main clause (0.25 s), but it appeared even when the major character was mentioned second (0.07 s). This influence of order is expected, since a rule of discourse is that the main theme tends to be mentioned first in the main clause (*7*). This influence of order aside, the results suggest that readers of narratives tend to focus more on main characters than on minor characters.

Intermediate locations. Another question of interest is whether intermediate landmarks or objects along a path between source and goal locations would be activated in memory by the character's passing them. Does he or she leave tracks or a trail of activation? Our subjects learned building layouts in which in order to walk from room A to another room C, one had to pass through an intervening room B (*14, 15*). In the narratives, subjects occasionally read sentences of the form "The character walked from room A into room C." Next, a probe test presented the names of two objects from room A, B, C, or some other room in the building, which was chosen so as to be as physically close to room C as was the intermediate room B.

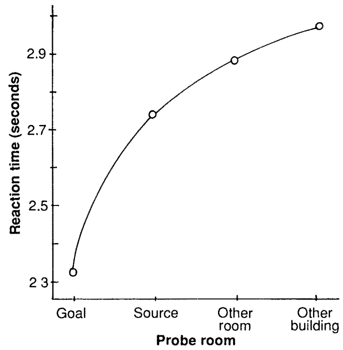
What results can be anticipated? If mental representations of places are activated only if they are explicitly mentioned in the narrative, then questions about objects in rooms C and A will be answered quickly (with the usual goal-source difference), whereas questions about room B will be answered as slowly as control questions about the other room. But if readers imagine the character moving along the path, from A through B to C, then the levels of activation should be greater for room C (goal), and then, in order, B, A (source), and the other room. This ordering supposes that activation of places in the mental model decays with time elapsed since they were in focus. Our results showed the predicted gradient (Fig. 3). The speed of responses to questions about room B exceeded that to questions about room A despite the fact that A but not B had recently been mentioned. The activated representation of objects in room B was provided by the reader's memory of the spatial layout and, apparently, the process of tracing the character's movement from A to C. Thus, readers focus on locations along the movement path of the actor, even when these locations are inferred rather than mentioned in the text.

One must be cautious in generalizing this "intermediate places" effect, since our demonstration is only for one middle room and in a context where readers expect queries about locations of objects (often in rooms near the protagonist). For example, it is implausible that activation would spread over all model points covering motion between large distances (for example, a flight from Los Angeles to New York). People can "jump" in their mental model from one location to a distant one without scanning along intermediate points. Kosslyn (*16*) found that suitably instructed subjects could either move the focus of a mental image by continuous scanning of a path from start to finish, or by a discrete jump in the mental image. Our ABC experiment apparently induced continuous scanning in our readers because this scanning was an important part of building the mental model.

Mental location. Another question is whether the reader's attentional focus is determined by the protagonist's physical location or by "mental location," the place the protagonist is thinking about. A simple experiment (*14, 15*) was arranged wherein, after learning a building layout, subjects read narratives that included critical sentences locating the character at a given room before stating that he or she "thought about (some activity) in room B," such as painting the walls there or rearranging its furniture. After reading such sentences, readers would be interrupted with a question about objects in the character's physical location, mental location, or some other room in the building. The results showed a shorter answer time for objects at the character's mental location (2.18 s) than those at the character's physical location (2.36 s) or some other room (2.35 s). Control experiments ruled out recency of mention as an explanation for the faster responses about mental locations. The results suggest that readers take the character's perspective; they follow the character's thoughts, activating mental images of the same things that the character is thinking about. Although the character is often thinking about parts of his or her immediate surroundings, our results show that readers also focus on whatever topic is foremost in the character's mind. Moreover, readers will focus more on a mental location than the character's physical location if the former is more relevant to the character's current plan.

This experiment raises several issues for later research. Some questions concern the effect of the character thinking about several places (painting the kitchen and bathrooms), or about objects not in the map (his car), or about abstract topics (disarmament). Furthermore, this ordering of mental over physical locations probably depends on the significance for the plot of the two places. In some narratives the physical location of the character is more significant than the mental location. For example, an unsuspecting character might be sitting on a ticking time bomb about to go off while thinking about painting the garage. There is little doubt that readers would focus on the bomb, not the garage.

The principle underlying such examples is that readers direct their attention to places where significant events are likely to occur. The significant events of a story are usually those that facilitate or block the goals and plans of the protagonist. Those goals cause us to expect certain actions. Consequently, locations, instruments, and objects associated in memory with such actions will be somewhat activated and primed (*17*). For example, if the protagonist is hungry, then images of places and objects associated with eating will be activated. According to this general view, when a character moves to some location, the objects there would be activated in memory because we would normally expect them to be relevant to the character's goal. This strategy is shaped and supported by the



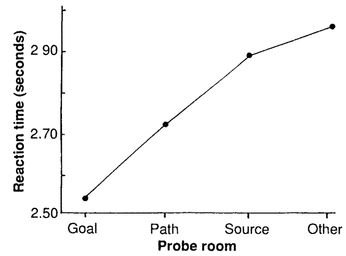


Fig. 2 (left). Time to decide that two objects are located in the same room depending on the room's relation to the focus of attention. The standard errors of the means are approximately 5.4% of the mean reaction times. Adapted from (*9*), with permission of Academic Press. **Fig. 3 (right).** Same-room decision times for objects in the goal, path, or source rooms, or some other equally close room. The standard errors of the means are approximately 4.4% of the mean reaction times. Adapted from (*14*), with permission of Academic Press.

general ecology of our environment in which different parts of a building, say a residence, are set aside to satisfy recurrent goals, as revealed in our labeling of rooms as the kitchen, bedroom, laundry, and toilet. By this idea that spatial priming is a likely derivative of goal-based priming, we have returned to our earlier point, that relevance in narrative comprehension is largely determined by the goals and plans of the central characters. Readers use the characters' goals to draw causal connections amongst events and to focus attention on actors, places, and objects likely to be relevant to achieving or thwarting those goals.

Closing Comment

Although we have concentrated on understanding narratives, the central issues touch on a wide range of problems, including the means by which people understand their social world. The principles readers use to explain and understand the actions of storybook characters are much the same as those they use to understand people's actions in everyday life. We build mental models that represent significant aspects of our physical and social world, and we manipulate elements of those models when we think, plan, and try to explain events of that world. The ability to construct and manipulate valid models of reality provides humans with our distinctive adaptive advantage; it must be considered one of the crowning achievements of the human intellect.

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